

RESEARCH RESONANCE

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Research & Innovation Division



GM UNIVERSITY

P. B. Road Davanagere, Karnataka - 577006

PREFACE

It gives us immense pleasure to present Volume 2, Issue 2 of GMU ***Research Resonance***, the official multidisciplinary research bulletin of GM University. This edition represents another important step in our mission to cultivate a dynamic and inclusive research ecosystem across all disciplines of study at our university.

GM University continues to be a thriving hub of innovation, where faculty, scholars, and students are actively engaged in cutting-edge research and meaningful inquiry. Research Resonance serves as a platform to spotlight these diverse contributions-offering readers a glimpse into path ground breaking work spanning Computer Science, Artificial Intelligence, Internet of Things, Information Security, Electronics and Communication, Electrical Engineering and many more emerging fields.

As the world continues to face complex challenges, the importance of knowledge-sharing and collaborative inquiry cannot be overstated. With this edition, we reaffirm our commitment to encouraging interdisciplinary dialogue, nurturing novel ideas, and driving impactful research that transcends traditional academic boundaries.

We sincerely thank all the contributors-authors, peer reviewers, and editorial team members-for their dedication, pioneering efforts, scholarly excellence, and unwavering support. Your contributions are instrumental in maintaining the high standards and vision of this publication. We are equally grateful to our readers, whose curiosity and engagement inspire us to continually raise the bar.

We invite you to explore the pages of this issue and discover the remarkable research being conducted at GM University. May this edition spark new insights, foster collaborations, and inspiration as we continue our shared pursuit of knowledge and discovery.

Sincerely,
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UniProject – Digital Project Hub for Universities: Empowering Student Innovation

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ABSTRACT

The UniProject – Digital Project Hub for Universities is an innovative web-based platform designed to connect students, teachers, and universities in a shared digital ecosystem that nurtures academic excellence and fosters innovation. Recognizing the need for a centralized space to facilitate collaboration, knowledge sharing, and recognition of student achievements, UniProject bridges academic institutions and the creative aspirations of their students. It provides a robust repository where students can upload, categorize, and showcase academic and creative projects. The system features role-based access for visitors, students, teachers, and administrators, offering personalized functionalities. Visitors can explore publicly available projects, students can manage and display portfolios, teachers can mentor and evaluate, and universities can monitor and promote talent. UniProject's intuitive design ensures seamless navigation, secure authentication, and efficient project management. It includes advanced search capabilities, project categorization, feedback mechanisms for mentorship, and analytics to track impact. Encouraging inter-university collaboration, it fosters a competitive yet supportive academic culture by enabling institutions to share innovative practices. Empowering students to present projects to a wider audience and receive constructive feedback, UniProject bridges the gap between learning and real-world application. By motivating students to excel, it provides universities with a digital showcase of academic and research achievements. Ultimately, UniProject redefines how academic contributions are shared, appreciated, and utilized to build a stronger, more innovative future.

Keywords: Digital Project Hub, Academic Collaboration, Knowledge Sharing, Student Portfolio

1. INTRODUCTION

In today's academic and professional world, innovation and collaboration are essential for progress. Universities engage students in projects to apply theoretical knowledge, enhancing critical thinking and problem-solving skills. However, the lack of a centralized platform to manage and share these projects limits visibility, recognition, and collaboration.

UniProject – Digital Project Hub for Universities bridges this gap by creating an integrated digital space for students to upload, showcase, and collaborate on projects. It encourages interdisciplinary and inter-institutional interactions, fostering innovation and knowledge-sharing. The platform includes project management tools for organizing work, milestone tracking, and collaboration across institutions. Plagiarism detection ensures academic integrity, promoting originality and excellence.

By addressing fragmented project documentation, UniProject connects students, faculty, and external stakeholders, increasing project impact. It transforms academic project management, supporting every stage from conception to dissemination.

The platform also enhances career opportunities by showcasing student work to recruiters and industry professionals. Institutions benefit from improved knowledge exchange and better collaboration among departments. With UniProject, students gain a global stage for their ideas, inspiring future innovations.

Its user-friendly interface ensures accessibility for students across various disciplines and skill levels. By fostering a culture of continuous learning and teamwork, UniProject prepares students for real-world challenges.

2. LITERATURE SURVEY

[1] Traylor et al. – Using Integrated Platforms for Learning
Author: Traylor et al Year: 2003

Traylor et al. proposed an integrated learning platform to enhance student collaboration across engineering disciplines. The platform facilitated the development of critical skills such as interdisciplinary teamwork, communication, and creative problem-solving. The study highlighted that students could benefit greatly from an integrated system that not only provided academic resources but also promoted collaboration with peers and mentors from different fields.

[2] Correll et al. – Project-Based Learning in STEM Education Authors: Correll et al Year: 2022

Correll et al. explored how project-based learning (PBL) positively impacts student learning, particularly in STEM education. The study emphasized that PBL fosters critical thinking, creativity, and a deeper understanding of complex subjects such as artificial intelligence and robotics. By involving students in hands-on projects, PBL not only improves subject comprehension but also prepares them for challenges outside the classroom. However, the study also pointed out that managing these projects effectively requires proper tools for collaboration, communication, and resource management.

[3] Williamson et al. – Peer Learning and Research Outcomes Authors: Williamson et al Year: 2018

Williamson's research focused on the positive effects of peer learning on research outcomes, particularly in academic settings with diverse student populations. The study demonstrated that peer learning significantly enhances critical thinking, collaborative skills, and overall academic achievement. However, it also highlighted the challenges posed by cultural differences, communication barriers, and the varying levels of academic readiness among peers.

[4] Bahari, S. I. N., & Matore, M. E. – Peer Learning Framework in STEM Education

Authors: Bahari, S. I. N., & Matore, M. E Year: 2023

This study analyzed the role of peer learning in improving student

outcomes in STEM education, emphasizing the need for digital platforms that encourage communication, collaboration, and mutual learning. Bahari and Matore highlighted that peer learning improves not only the academic performance of students but also their communication and critical thinking skills. The research identified several challenges that prevent effective peer learning, including institutional silos and lack of collaboration tools.

[5] Makwana, J. L. – Collaborative Learning and Digital Platforms Authors: Makwana, J. L. Year: 2015

Makwana's research on collaborative learning through digital platforms focused on the importance of providing students with the tools to manage projects, share resources, and communicate effectively. The study demonstrated that students who engage in collaborative digital environments show increased productivity, creativity, and understanding of complex concepts, especially when these platforms integrate features that support project tracking, resource management, and team-based work.

[6] Prasanth, S., & Rajshree, R. – A Survey on Plagiarism Detection in Academic Platforms

Authors: Prasanth, S., & Rajshree, R Year: 2014

Prasanth and Rajshree's survey on plagiarism detection in educational systems emphasized the critical role that automated tools play in ensuring academic integrity. They reviewed various plagiarism detection algorithms, including string matching, fingerprinting, and semantic analysis, highlighting their importance in maintaining the credibility of academic work. Their work also noted the challenges of dealing with vast amounts of data and ensuring the detection system is both accurate and scalable.

[7] Kumar et al. – Personalized Learning with Recommendation Systems

Authors: Kumar et al Year: 2022

Kumar and his colleagues explored the potential of recommendation systems to personalize learning experiences. Their research demonstrated that by analyzing student behavior, preferences, and academic performance, recommendation systems could provide tailored learning pathways and suggest resources, projects, and mentors that match students' interests. The study suggested that recommendation algorithms, when integrated into educational platforms, could significantly improve engagement, learning outcomes, and student satisfaction.

[8] Baharuddin et al. – Challenges in Academic Resource Sharing Authors: Baharuddin et al Year: 2019

Baharuddin's study identified key barriers to effective academic resource sharing, including data silos, lack of interoperability between systems, and insufficient access to interdisciplinary content. The research highlighted the importance of creating centralized platforms where students, educators, and institutions can share academic materials, research papers, and project resources in a collaborative and open manner.

[9] Singh et al. – Role of Digital Platforms in Academic Collaboration Authors: Singh et al Year: 2021

Singh et al. examined the role of digital platforms in facilitating academic collaboration. The study demonstrated that digital tools for task tracking, document sharing, real-time communication, and progress monitoring significantly improve the efficiency and success of collaborative projects. By enabling seamless interaction between students, faculty, and external mentors, digital platforms foster collaboration that can lead to innovative solutions and academic success.

[10] Sharma et al. – Scalability and Security in Educational Platforms Authors: Sharma et al Year: 2020

Sharma et al. explored the technical challenges related to the scalability and security of educational platforms. They emphasized that, as digital platforms scale to accommodate large numbers of users, they must ensure secure data handling, user authentication, and compliance with privacy regulations. The study underscored the importance of implementing robust security measures to protect sensitive user data and academic content.

3. WORKING PRINCIPLE

The System Development Life Cycle (SDLC) is the process of developing and changing processes, as well as the models and methodologies used to construct an application and a software development process [3]. It involves the following steps:

A. Preparation: Needs evaluations, feasibility studies (both scientific and technological), and scheduling are also carried out as part of the planning phase.

B. Analysis: Direct observation is used during the research process to look at the problems that arise and are found in the materials, software, and hardware.

C. Design: At this point, the application will be explained in detail regarding the design phase of each component.

D. Implementation: The code is brought to life at this stage by selecting components and planning the software (coding/coding).

E. Testing: Testing is carried out at this point to see if the framework created satisfies the user's needs; if it does not, the next phase is iterative, i.e. returning to the previous stages. And the test is designed to identify and eliminate flaws in the device so that it can truly assist users in their everyday activities.

F. Maintenance: The system's operation starts at this stage, and minor repairs can be made if necessary.

4. PRIMARY OBJECTIVE

- To develop a centralized platform for project uploads and showcase.
- To facilitate inter -university collaboration through forums, chat and file sharing.
- To implement plagiarism detection to ensure submission originality.
- To develop a recommendation system for personalized project and resource suggestions.
- To utilize data analytics to monitor activity and provide insights vis admin dashboards.

5. SCOPE

The testing phase of the UniProject system is a critical step in ensuring that the platform meets all functional, performance, usability, and security requirements. This phase is designed to validate core features, assess system reliability, evaluate performance under different conditions, and ensure a smooth user experience. By conducting thorough testing, the system can be refined to provide an efficient and seamless experience for all users.

One of the primary objectives of testing is feature validation, which involves checking essential functionalities such as user authentication, role-based access control, project management, and collaboration tools. Each feature must operate correctly and consistently to ensure that users can effectively engage with the platform.

Another key focus is system reliability, where different modules are tested to ensure smooth integration and uninterrupted interactions. Any potential errors or inconsistencies in the system's operation must be identified and addressed to prevent disruptions that could impact user experience.

Performance and scalability testing evaluates how well the platform functions under varying workloads. This ensures that UniProject can handle an increasing number of users and projects without compromising speed or efficiency. Load testing helps determine the platform's capacity and prevents potential slowdowns or crashes.

Security is also a vital aspect of testing, ensuring that all user data and platform processes are protected. Testing involves verifying authentication mechanisms, data encryption, and protection against security threats such as unauthorized access or data breaches.

Lastly, user experience testing is conducted to confirm that the interface is intuitive, accessible, and meets user expectations. A well-designed and user-friendly interface enhances engagement and ensures that users can navigate the platform effortlessly.

By focusing on these key areas, the testing phase ensures that UniProject delivers a high-quality, secure, and efficient digital ecosystem for students, educators, and institutions.

6. SOFTWARE REQUIREMENTS

To ensure smooth development and deployment of the UniProject platform, the following software components are required.

1. Operating System:

The system is designed to be compatible with Windows 10 or higher, Linux, and macOS. These operating systems provide a stable environment for development and deployment, ensuring flexibility across different platforms.

2. Web Server:

A web server like Nginx or Apache is required to handle HTTP requests and serve content efficiently. These servers manage client requests, distribute resources, and optimize the platform's performance, ensuring reliability and scalability.

3. Code Editor/IDE:

For efficient development, Visual Studio Code or PyCharm is recommended. These Integrated Development Environments (IDEs) provide powerful tools for writing, debugging, and testing Python/Django applications, streamlining the development process.

4. Programming Language:

The platform is built using Python, a versatile and widely-used programming language. Python is known for its simplicity and efficiency, making it ideal for backend development, data processing, and integration with machine learning tools.

5. Backend Framework:

The Django framework is used for server-side logic. Django provides a robust, scalable, and secure environment for developing web applications, offering built-in authentication, database management, and a modular structure for efficient development.

6. Frontend Technologies:

The user interface is developed using HTML, CSS, JavaScript, and Bootstrap. HTML structures the content, CSS styles the design, JavaScript enhances interactivity, and Bootstrap ensures responsiveness for a seamless user experience across devices.

7. Additional Technologies:

The platform integrates Machine Learning (ML), Natural Language Processing (NLP), Artificial Intelligence (AI), and Data Analytics to enhance features like project recommendations, plagiarism detection, and automated feedback mechanisms. These technologies improve efficiency and add intelligent automation to the platform.

8. Database:

SQLite is used for structured data storage and efficient querying. SQLite is a lightweight yet powerful database, well-suited for handling student projects, user profiles, and platform interactions while maintaining fast data retrieval.

By integrating these software components, UniProject ensures a high-performance, secure, and user-friendly digital platform for students, educators, and institutions.

7. METHODOLOGY

The development of the "UniProject - Digital Project Hub for Universities" follows a structured approach. First, Requirement Gathering and Analysis involves identifying stakeholders (students, faculty, admins), conducting surveys, and defining functional (project management, collaboration, analytics) and non-functional (performance, security) requirements. Next, Research and Literature Review helps understand existing platforms, recommendation systems, and best practices. In System Design and Architecture, wireframes, mockups, and prototypes are created and refined based on feedback. The Development phase includes front-end (HTML, CSS, JavaScript) for a user-friendly interface, back-end (Python, Django) for authentication, recommendation system, and plagiarism detection, and a database to manage user interactions. Deployment ensures the platform is hosted securely and made accessible. User Training and Support provides guidance and technical help, while Evaluation and Iteration involves monitoring, user feedback collection, and continuous improvements for better functionality and user experience.

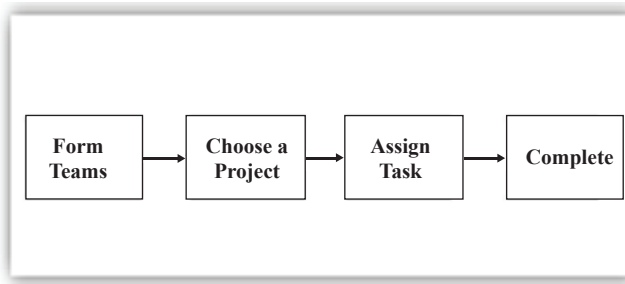


Fig1. Flow Chart

The UniProject Flow begins with forming teams based on shared interests or goals. Once a team is established, they choose a project that aligns with their objectives. Tasks are then assigned to team members to ensure clarity and productivity. The team works collaboratively to complete the assigned tasks, focusing on achieving the project goals efficiently. Finally, the completed project is delivered, emphasizing teamwork and successful execution.

The UniProject Flow starts with team formation, where students connect based on shared interests, skills, or project goals. Once the team is established, they select a project that aligns with their academic or innovative objectives. After finalizing the project, tasks are assigned to team members, ensuring clear roles and responsibilities for better coordination and efficiency. The team then works collaboratively, utilizing project management tools, discussion forums, and resource-sharing features to stay organized and productive. As tasks are completed, progress is tracked to ensure milestones are met. Finally, the project is delivered, where teams submit their work, receive feedback, and showcase their innovations, fostering a culture of learning, teamwork, and success.

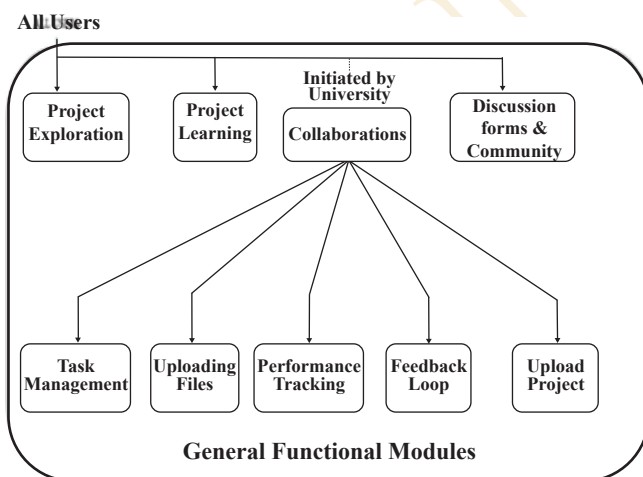


Fig 2: User Diagram for UniProject

The platform supports all users with modules like Project Exploration, Project Learning, Collaborative Research & Development, Discussion Forums, and Blogs, along with features like Task Management, Real-Time Polls, and Performance Tracking.

The Collaborative Research & Development module, initiated by universities, fosters innovation and collaboration, enabling effective project management, communication and teamwork among users.

8. IMPLEMENTATION

Models define the structure of the database. They represent tables and store data like text, numbers, or relationships. Django automatically creates and manages these tables.

Views handle what happens when a user requests a page. They fetch data from models, apply logic, and return a response, such as an HTML page or data for an API.

URLs connect web addresses to views. They define which function should run when a user visits a specific link, ensuring correct navigation.

Forms manage user input. They collect, validate, and process data, making sure it is correct before storing it in the database.

These components work together to make Django applications efficient and well-structured.

Templates define how data is displayed to users. They are HTML files with Django-specific syntax, allowing dynamic content like database records or user input to be inserted into web pages.

Admin Interface is a built-in tool for managing database content. It lets administrators add, edit, and delete records easily without writing extra code, making management efficient.

Settings is a configuration file that controls the project's behavior. It includes database connections, installed apps, static files, middleware, and other essential settings for the application.

9. RESULTS AND DISCUSSION

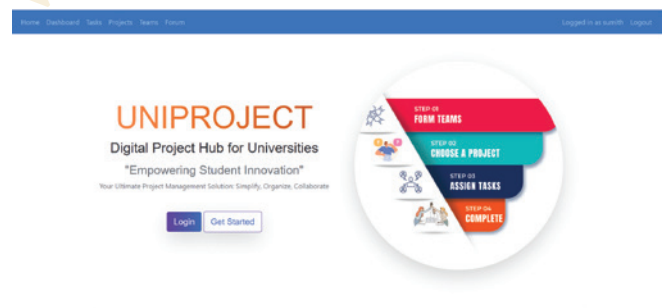


Fig 3: Home Page for UniProject

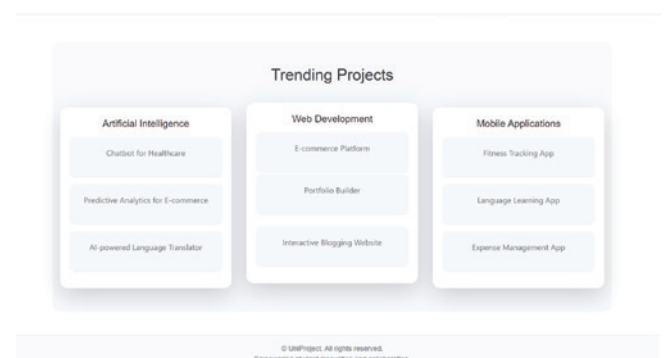
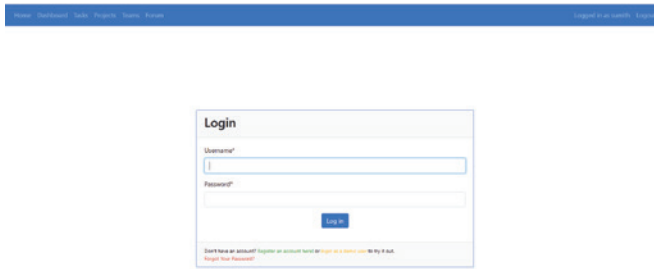


Fig 4: Trending Projects



The login page features a simple form with fields for 'Username' and 'Password'. Below the fields is a 'Login' button. A small message at the bottom states: 'Don't have an account? Register an account here or login as a guest user. No fee to do. Forget Your Password?'

Fig 5: Login Page

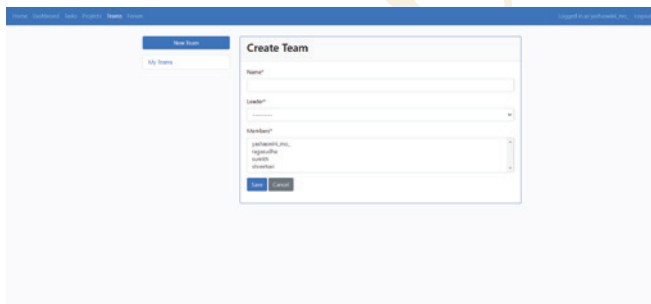
This is the step where users provide necessary details, such as username and password, to create an account on a platform. It enables personalized access and secure use of features.



The registration page includes fields for 'First name', 'Last name', 'Username', 'College Name', 'University Name', 'Roll number', 'Email address', 'Password', and 'Password confirmation'. It also has a 'Register' button and a link for users who already have an account.

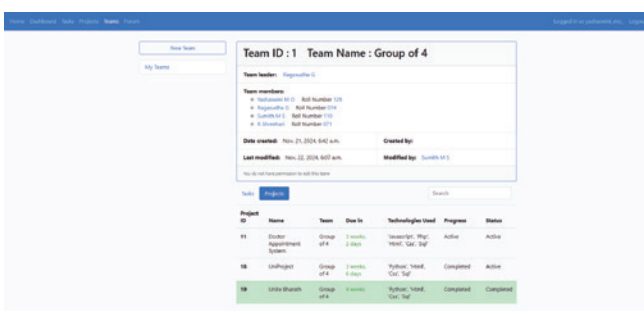
Fig 6: Registration

Registration is the process where users provide necessary details, such as email and password, to create an account on a platform. It enables personalized access and secure use of features.



The 'Create Team' page shows a form to create a new team. It includes fields for 'Name', 'Leader', and 'Members'. There are 'Add' and 'Cancel' buttons. Below the form, it says 'You do not have permission to add this team'.

Fig 7: Create Team Page in UniProject



This screenshot shows the 'My Team' details for 'Team ID: 1' and 'Team Name: Group of 4'. It lists team members with their names, roll numbers, and email addresses. Below this, it shows a list of projects with columns for Project ID, Name, Team, Due In, Technologies Used, Progress, and Status.

Fig 8: My Team Details with Projects

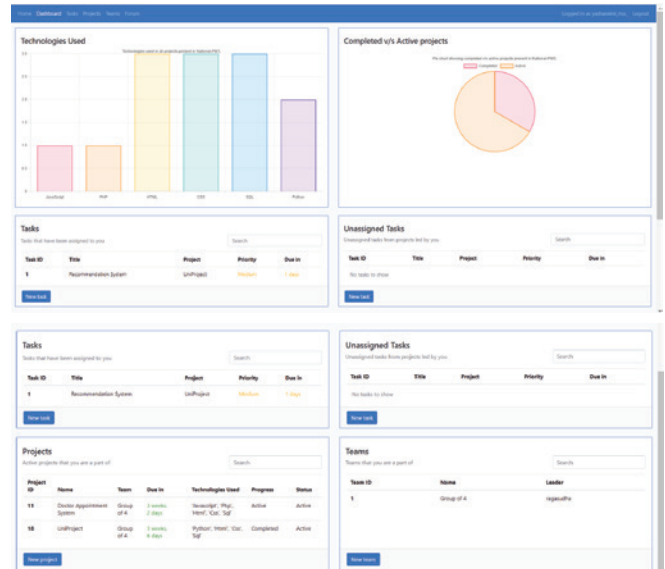
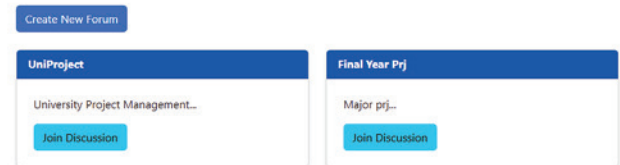


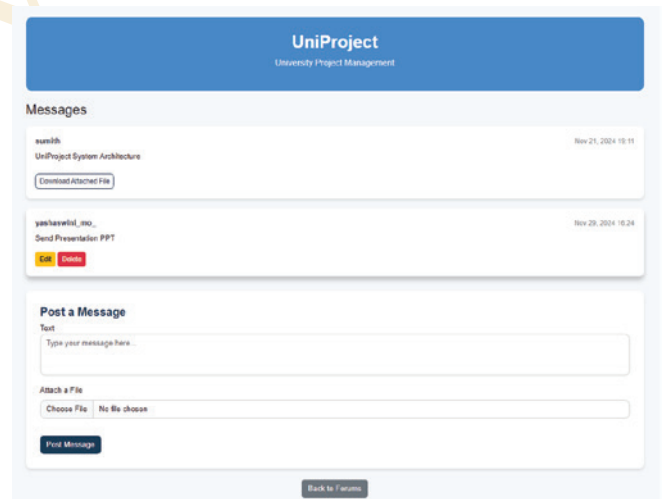
Fig 9: Dashboard in UniProject

Collaboration Hub



The forum page is titled 'Collaboration Hub' and features a 'Create New Forum' button. It displays two forum topics: 'UniProject' and 'Final Year Prj', each with a 'Join Discussion' button.

Fig 10: Forum Page in UniProject



The forum discussion page shows a message from 'sashish' titled 'UniProject System Architecture' with a 'Download Attached File' button. Below this is a 'Post a Message' section with a text area and an 'Attach a File' section with a 'Choose File' button.

Fig 11: Forum Discussion Page

10. APPLICATIONS OF THE PROJECT

Students can create and manage projects, share resources, and engage in teamwork using integrated collaboration tools. Interdisciplinary collaboration enables students from diverse academic fields to work together on innovative solutions.

The recommendation system helps students discover projects, mentors, and resources that align with their interests and career aspirations.

Faculty and administrators can monitor project progress, review submissions, and assess performance using built-in tools.

11. CONCLUSION

The proposed Online Integrated Platform for Student Projects tackles key academic challenges by fostering collaboration and innovation. It serves as a centralized repository where student projects can be categorized and showcased, increasing their visibility and impact. By incorporating features like discussion forums, real-time chat, and file sharing, the platform facilitates cross-institutional collaboration, encouraging diverse perspectives and knowledge exchange. A plagiarism detection system ensures the originality of work, while an advanced recommendation system enhances user experience by suggesting relevant projects and resources based on interests and activities. Additionally, data analytics provide administrators with valuable insights into trends and engagement, enabling continuous platform improvement. Beyond project sharing, the platform strengthens academic and professional growth by incorporating mentorship features that connect students with faculty and industry experts for guidance and support. It promotes interdisciplinary projects, allowing students to collaborate across various fields and expand their skill sets. By bridging institutional gaps and fostering a culture of knowledge-sharing, the platform empowers students to achieve academic excellence while enhancing community engagement. Through these comprehensive features, the platform transforms academic project management, creating an innovative and future-ready learning environment.

12. REFERENCES

- [1] Traylor, Roger & Heer, Donald & Fiez, "Using an integrated platform for Learning (TM) to reinvent engineering education", Institute of Electrical and Electronic Engineering, Vol. 46, pp.,409- 419.10.1109/TE.2003.818749, 2003.
- [2] Correll S.M., Anusha P., Basha S.M., Anusha P., Bhargavi S. and Indu K., Pravallika K., "Text and Image Plagiarism Detection", Journal of Critical Reviews, Vol.9, No.4, pp.230- 242,2022.
- [3] Williamson, Swapna & Becejac, Laila, "The Impact of Peer Learning within a Group of International Post-graduate Students–A Pilot Study", Athens Journal of Education, Vol.5,7-27. 10.30958/aje.5-1-1,2018.
- [4] Kumar P., Yadav S. and Kaur G., "Online Integrated Platform for Projects Taken Up by the Students of Various Colleges", International Journal for Technological Research in Engineering, Vol.9, No.10, pp.51-53,2022.
- [5] N. Bleiel, "Collaborating in GitHub," 2016 IEEE International Professional Communication Conference (IPCC), 2016, pp. 1-3.
[doi: 10.1109/IPCC.2016.7740497](https://doi.org/10.1109/IPCC.2016.7740497).
- [6] Greene, Joseph. "Project management and institutional repositories: A case study at University College Dublin Library." New Review of Academic Librarianship 16.S1 (2010): 98- 115.

Smart and Efficient Ration Material Distribution System

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ABSTRACT

A smart and efficient ration distribution system leveraging modern technology to streamline the public distribution of essential goods. This project aims to address challenges in traditional ration distribution methods by implementing a digital platform that integrates face authentication, inventory management, and real-time data analytics. The system will enhance transparency, reduce fraud, minimize wastage, and improve overall efficiency in the supply chain. Key features include automated beneficiary identification, digital recordkeeping, and data-driven decision-making for optimal resource allocation. By modernizing the ration distribution process, this project seeks to ensure fair and timely access to essential commodities for eligible citizens while reducing administrative burden and costs.

Keywords: Ration, Rice Sugar, Beneficiary, Face Recognition

1. INTRODUCTION

Traditional ration distribution systems often face challenges such as fraud, inefficiency, and lack of transparency. This project addresses these issues by implementing a technologically advanced solution that automates and streamlines the entire process from customer identification to ration distribution and data management. PDS (Public Distribution System) is also called as ration distribution system, which is one of the commonly disputable issues which are involved in malpractices. Public Distribution System of India facilitates supply of rice, ragi, wheat, cooking oil to the Below Poverty Line (BPL) periodically on a monthly basis. Smart Ration Card is a replacement of the normal ration card, which is normally used to supply food grains and other provisions by the Government at a subsidized cost to a specific class of people in the society. The setting up of the Foodgrains Prices Committee in 1964 strengthened the position of the PDS. The total number of ration shops increased from around 50,000 in 1960 to around 3,50,000 by 1990-91 and the quantity of foodgrains distributed increased from about 5 million tonnes in 1960-61 to about 16 million tonnes in 1990-91.

The government committed itself to announce a minimum support price (MSP) to promote agriculture and the stocks procured were to be used towards meeting the needs of the PDS. If procurement fell short, the government was to resort to imports and other measures such as monopoly procurement, and levy on farmers Food insecurity is a situation of limited access to safe and healthy food while food security refers to a situation when 'all people, at all times, have physical, social, and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.

2. PROBLEM STATEMENT

In the current ration distribution system, people are facing problems with the server, It leads to long wait to receive their ration. Sometimes, the system is unable to recognize fingerprints, which is a major issue. Additionally, due to a lack of proper information about ration arrival, people are unable to collect their ration on time. The interference of middlemen also results in beneficiaries not receiving the proper quantity. To overcome these problems, we are developing a smart and efficient ration distribution system with a fast response.

The current ration distribution systems are prone to several inefficiencies:

1. Lack of Transparency: Manual record-keeping can lead to errors, fraud, and discrepancies in distribution.
2. Manual Errors: Human involvement in weighing, data entry, and tracking often results in inaccuracies.
3. Resource Wastage: Improper management may lead to the wastage of ration stock.
4. Accessibility Issues: Beneficiaries may face long queues, delays, and unavailability of stocks during peak times.
5. Inefficient Monitoring: Authorities lack real-time monitoring tools to oversee ration distribution operations.

3. OBJECTIVES

The Smart and Efficient Ration Distribution System aims to revolutionize public distribution by addressing inefficiencies and ensuring equitable access to resources. This system integrates advanced technologies like facial recognition for secure and efficient customer identification, eliminating fraudulent activities and ensuring that benefits reach the right individuals. Automated dispensing units will distribute rations based on predefined categories and entitlements, accurately measuring and recording quantities to minimize manual errors.

4. MOTIVATION

A smart and efficient ration distribution system aims to improve the traditional Public Distribution System (PDS) by leveraging technology for transparency, accessibility, and efficiency.

5. LITERATURE REVIEW

[1] Jinali Goradia, Sarthak Doshi (December 2015) Automated Ration Distribution System Ration Distribution System means distribution of essential commodities to a large number of people. It is done by the government. Public distribution system is one of the widely controversial officers that involves corruption and illegal smuggling of goods. All these happen because every job in the ration shop involves manual work and there are no specific high-tech technologies to automate the job. Our main objective here is to automate the process of the distribution. The classical method involves customer to tell the person handling the ration shop outlet, the amount of the commodity he/she needs and the type too.

The person working then measures the commodity and gives it to the customer. In our version of the system, we will develop an embedded system project where we will have the customer to input the amount he requires and the system made will automatically collect that much amount in a container. It is a new concept which takes into account the various social, economic and general aspects relating to technical as well as day to day disciplines.

[2] Karthik.C , Vivek Narayan S P , Kukku Jacob , Akshatha A R , Chandru.A.S (2018) EFFICIENT RATION PRODUCT DISTRIBUTION SYSTEM

USING RFID. The present ration distribution framework has the downside like wrong products, low processing speed, queuing system for long in ration shop. The proposed framework replaces the manual work in all area ration shops. The public distribution framework is based on smart ration card innovation that replaces ordinary ration card system. Aadhaar card are given instead of conventional ration cards. Smart card based automatic ration shop is novel approach, precise automated strategy of proportion convenience. In this venture we are introducing smart card and GSM notification, for Slot and Re-slot allocation of product purchase.

[3] Nikhil Pathania (2017) Smart Ration Distribution System. The Public Distribution System (PDS) of today is one of the widely controversial issues that involves malpractices such as corruption and illegal trafficking of goods. In this paper, the analysis for use of "Smart Ration Distribution System & quote; is presented. This proposed project based on Radio Frequency Identification (RFID) technology aims to minimize the malpractices by replacing conventional ration cards with the RFID tags. The database of customers, provided by the Government Authority is stored in the microcontroller. The customer is required to scan the RFID tag to RFID reader and the microcontroller then checks for details of the customer with the stored database of the customer in microcontroller to allow for material (ration) dispensation. After successful verification, customer needs to enter the type of material as well as quantity of material through keypad. After proper material dispensation to the consumer, the microcontroller sends the information to customer as well.

[4] Vaibhav Avasthy , Dr. S. Rekha(2022) Automatic Ration Distributions Based on RFID Technology. The current Indian government is taking all possible measures to transform India into a DIGITAL INDIA. Today's India is heavily reliant on automation. As India is a developing country, many poverty line people depend on public distribution system (Ration) for their livelihood. The present public distribution system involves a lot of corruption in the civil supply, including variations in the quantity of the ration items supplied, the need to wait in line for an extended period of time, which was inconvenient and time-consuming for a consumer, and the distribution of ration items to those without ration cards for highervalued goods. This project implements radio frequency identification technology (RFID) for ration distribution in a smart and secure way. The system utilizes RFID technology to enable seamless and automated tracking, authentication, and distribution of ration items to eligible beneficiaries. The key components of the proposed system are RFID tags, readers, and backend

databases, which includes communication protocols and security measures to ensure data integrity and confidentiality. The system also incorporates features such as real-time monitoring, and automated alerts for potential fraud or anomalies.

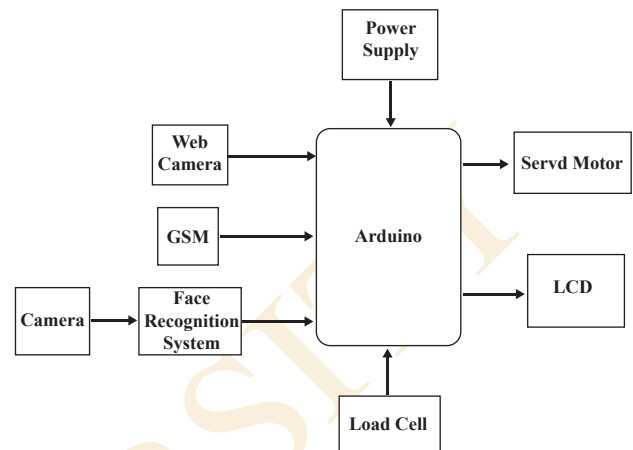


Fig 1: Workflow

The system captures the customer's face using a camera upon arrival. Facial recognition software matches the face to stored profiles for identification. The system then retrieves the customer's ration category and entitlement information. A separate camera captures images of the ration materials for quality assessment. Afterward, the system dispenses the appropriate ration quantity. Load cells measure and verify the distributed amount. The transaction details are recorded and uploaded to the cloud. Finally, customers receive updates via email and SMS about their ration collection.

1. **Arduino (Central Controller):** The Arduino microcontroller acts as the central processing unit, interfacing with multiple input and output components.
2. **Power Supply:** Provides electrical power to the Arduino and connected modules.
3. **Input Components** Camera: Captures images or video for the Face Recognition System. Face Recognition System: Processes images from the camera and determines identity based on stored data. Web Camera: May be used for additional video input or monitoring.
4. **Output Components:** Servo Motor Can be used for mechanical movements (e.g., opening a gate, locking/unlocking a system). LCD Display Shows system status, detected users, weight measurements, or alerts.
5. **System Functionality:** The camera captures images, which are processed by the Face Recognition System. If authentication is successful, Arduino controls the servo motor (e.g., unlocking a door). The load cell measures weight, which is displayed on the LCD.

7. HARDWARE REQUIREMENTS

7.1 Gear Motor



Fig 2: Gear Motor

Gear motors are an integrated system combining a motor with a gear train to deliver increased torque and controlled speed. They are crucial for tasks requiring precise motion control and load-handling capabilities. In the Smart & Efficient Ration Distribution System, gear motors are used to operate the dispensing mechanism efficiently and accurately, ensuring that the ration quantity is dispensed as per predefined measurements.

7.2 Arduino

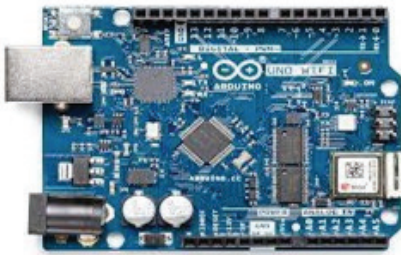


Fig 3: Arduino

Arduino is an open-source electronics platform based on easy-to-use hardware and software. It is widely used for prototyping and developing electronic systems due to its simplicity, flexibility, and large community support.

7.3 Load Cell



Fig 4: Load cell

A load cell is a transducer that converts mechanical force into an electrical signal. It is widely used in systems requiring precise weight measurement, making it a critical component of the Smart & Efficient Ration Distribution System. In this system, the load cell ensures accurate dispensing by measuring the weight of the material being distributed. It plays a key role in maintaining the reliability and efficiency of the ration distribution process.

7.4 Load Cell Amplifier

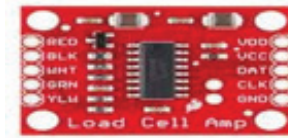


Fig 5: Load Cell Amplifier

A load cell amplifier is an electronic device used to amplify the small analog voltage signal generated by a load cell to a level that can be processed by microcontrollers or other data acquisition systems. Since the output signal from a load cell.

7.5 LCD Display



Fig 6: LCD Display

An LCD (Liquid Crystal Display) is a flat-panel display technology that uses liquid crystals to modulate light and create images or text. In the Smart & Efficient Ration Distribution System, an LCD display is used to provide a user-friendly interface.

7.6 I2C Module



Fig 7: I2C Module

The I2C (Inter-Integrated Circuit) module is a communication protocol-based interface designed to simplify the connection between microcontrollers and peripheral devices such as sensors, displays, and EEPROMs.

7.7 Push Button



Figure 4.7: Push Button

A push button is a simple yet essential input device used to provide momentary user interaction within an electronic system. It is a mechanical switch that makes or breaks an electrical connection when pressed.

7.8 GSM Module



Fig 8: GSM Module

A GSM (Global System for Mobile Communications) module is a crucial component used to enable communication between a microcontroller-based system and mobile networks. It allows the system to send and receive SMS messages, make calls, and perform other telecommunication functions. In the Smart & Efficient Ration Distribution System.

7.9 Motor Driver



Fig 9: Motor Driver

A motor driver is an essential electronic component that controls the operation of motors in embedded systems and robotics. In the Smart & Efficient Ration Distribution System, a motor driver is used to control the direction and speed of the motors that dispense materials, provide movement in robotic arms, or handle other mechanical tasks.

8. SOFTWARE REQUIREMENTS

8.1 Arduino IDE

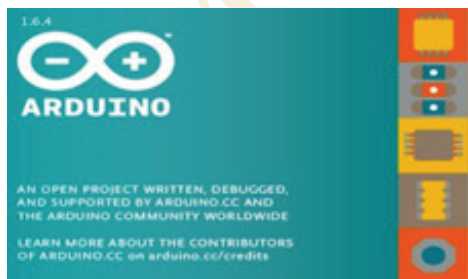


Fig 10: Arduino IDE

Arduino is an open-source prototype platform that utilizes user- friendly hardware and software. It comprises a circuit board, known as a microcontroller, that can be programmed, and a pre-installed software called Arduino IDE (Integrated Development Environment) for writing and uploading code to the physical board.

The Arduino Integrated Development Environment (IDE) is a free, open-source platform that allows users to write, compile, and upload code to Arduino boards, including the ESP8266 NodeMCU utilized in our smart hydroponics project.

8.2 Jupyter Notebook

Jupyter Notebook is an open-source, web-based interactive development environment primarily used for data science, scientific computing, and machine learning. It allows you to write and execute Python code (and other languages, such as R, Julia, and more) in an interactive format with visual outputs.

9. RESULTS AND DISCUSSION



Fig 11: Smart & Efficient Ration Distribution System

The Smart & Efficient Ration Distribution System represents a significant advancement in public distribution technology. By integrating facial recognition, automated measurements, quality control, and cloud-based data management, it addresses key challenges in traditional systems. While demonstrated on a small scale, the project showcases the potential for large-scale implementation, promising to revolutionize ration distribution by enhancing efficiency, reducing fraud, and improving overall user experience. As technology continues to evolve, this system lays the groundwork for future innovations in public service delivery.

10. ADVANTAGES, DISADVANTAGES AND APPLICATIONS

Advantages

1. Enhanced Security: Facial recognition ensures that only eligible individuals receive rations, significantly reducing fraud.
2. Improved Efficiency: Automated processes streamline distribution, reducing wait times and administrative burden.
3. Accurate Distribution: Load cell integration ensures precise measurement of distributed goods.
4. Quality Assurance: Automated quality checks help maintain the standard of distributed items.
5. Transparency: Real-time data uploading and cloud storage provide a clear audit trail.

Disadvantages

1. Initial Cost: Implementation requires significant upfront investment in technology and infrastructure.
2. Internet Dependency: Reliable internet connectivity is crucial for real-time operations and cloud uploads.
3. Privacy Concerns: Facial recognition and data storage may raise privacy issues among users.

Applications

1. Public Distribution System: Implementation in government-run ration shops for efficient distribution of subsidized food grains and essential commodities.
2. Disaster Relief: Quick and accurate distribution of supplies in emergency situations and natural disasters.
3. Refugee Camps: Managing and distributing resources in refugee camps or displacement centers.

11. CONCLUSION

The Smart & Efficient Ration Distribution System exemplifies how cutting-edge technology can transform public service delivery. Beyond just facial recognition, the system incorporates features such as automated weight and quantity measurement for precise ration distribution, ensuring fairness and minimizing human error. Integrated quality control mechanisms verify the standards of distributed items, safeguarding against substandard supplies.

12. FUTURE WORK

- Expansion to accommodate a larger customer base
- Integration with government databases for wider implementation
- Development of a mobile application for customer-side interactions
- Implementation of blockchain for enhanced security and transparency
- Incorporation of AI for predictive inventory management.

13. REFERENCES

- [1] Vinayak T. Shelar, Mahadev S. Patil, "RFID and GSM based Automatic Rationing System using LPC2148" International Journal of Advanced Research in Computer Engineering & Technology (IJARCET) Volume 4 Issue 6, June 2015.
- [2] S.Valarmathy, R.Raman, FahimAktar, "Automatic Ration Material Distribution Based on GSM and RFID Technology" I.J Intelligent System and application 2013,11,47-54.
- [3] Vikram Singh "Smart ration card", Volume 4, No. 4, April 2013 Journal of Global Research in Computer Science.
- [4] S. Sukhumar, K. Gopinathan, "Automatic Rationing System Using Embedded System Technology" International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering, 2013, Vol. 1, Issue 8, pp. 339-342.

IoT Based Smart Irrigation System

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ABSTRACT

Agriculture plays a major role for the well-being of a nation. Regions that are rich with water and soil content will be able to produce food items ranging from rice, wheat, cereals, pulses, vegetables, and fruits. Some of the crops need more amount of water while some agroforestry kinds of agriculture do not need water after some time. As the population is increasing by day the water requirement is also increasing. The environmental factors are also playing a major factor in depreciation of freshwater reserve and ground water. Our globe consists of 96% saline water which are in the oceans and only 3% is the freshwater reserve which caters to the whole of the population of the globe. At this point when the population is increasing, and freshwater reserve are decreasing there is a dire need of conserving water in agricultural practices using modern technique and advanced technologies. Agriculture plays a vital role in the development of agricultural countries. Some issues concerning agriculture have been always hindering the development of the country. Consequently, the only solution to this problem is smart agriculture by modernizing the current traditional methods of agriculture. Hence the method is making agriculture smart using automation and IoT technologies. Internet of Things (IoT) enables various applications of crop growth monitoring and selection, automatic irrigation decision support, etc. We proposed ESP8266 IoT Automatic irrigation system to modernize and improve the productivity of the crop.

Keywords: Smart Agriculture, IoT-based Irrigation, Water Conservation, Automation in Farming

1. INTRODUCTION

The world population is projected to reach approximately 9.6 billion by 2050, placing immense pressure on the agricultural sector to meet the escalating demand for food. This challenge is further compounded by extreme climate conditions, the growing impacts of environmental change, and the ecological strain caused by conventional farming methods. Addressing this issue requires innovative solutions that can boost productivity while mitigating the environmental footprint of agriculture. The integration of advanced technologies, such as the Internet of Things (IoT), into farming practices is proving to be a transformative step forward. These smart farming technologies are designed to optimize various aspects of agricultural production, from efficient fertilizer usage to improving the operational efficiency of farm machinery. Such advancements are essential for reducing waste and increasing the overall productivity of the farming sector.

Smart farming, characterized by its reliance on high tech systems and capital-intensive solutions, focuses on growing food sustainably and cleanly for the global population. At its core is the use of modern Information and Communication Technologies (ICT), which enable data-driven decision-making and automation. In IoT-based smart farming, interconnected sensors play a pivotal role. These sensors monitor critical agricultural parameters such as light intensity, humidity, temperature, and soil moisture. The data collected from these devices is analyzed in real time, allowing farmers to remotely oversee field conditions and implement timely interventions. Automated irrigation systems, for instance, ensure that water is delivered precisely when and where it is needed, significantly reducing water waste compared to traditional methods. The ability to monitor and control farming operations from virtually anywhere enhances efficiency and provides a competitive edge.

The benefits of IoT-based smart farming are particularly evident in its ability to transform traditional agriculture into a more efficient and sustainable system. Large-scale farms can use these technologies to optimize the use of resources such as water, fertilizers, and pesticides, which are critical for improving crop yields. Advanced analytics enable farmers to predict and address potential issues before they impact productivity, reducing losses and increasing profitability. Moreover, IoT solutions are not limited to large-scale operations; they also support small-scale and organic farming. By providing tools to monitor environmental conditions, these technologies help smaller farms maintain sustainable practices while improving crop quality and yield. Community gardens and urban farms also benefit, as IoT systems enable efficient resource management in confined spaces.

In addition to crop production, IoT-based smart farming has transformative implications for livestock management. Smart devices can track animal health, monitor movement patterns, and optimize feeding practices, ensuring better productivity and animal welfare. For instance, wearable sensors for livestock can detect early signs of illness, allowing for prompt treatment and reducing the risk of disease outbreaks. This not only enhances the efficiency of livestock farming but also contributes to food safety and sustainability. By leveraging IoT technologies, farmers can achieve a more integrated approach to managing both crops and livestock, maximizing the productivity of their operations while reducing environmental harm.

Overall, smart farming offers a path toward a more sustainable and resilient agricultural system. By optimizing resource usage, reducing chemical inputs, and conserving water, IoT-based technologies help mitigate the environmental impact of farming. These practices support the global effort to combat climate change while ensuring

that the growing food demands of the population are met. As the agricultural sector continues to adopt smart farming solutions, it not only enhances productivity and profitability but also contributes to a future where food production is environmentally friendly, efficient, and sustainable.



Fig 1: IoT Based Smart Irrigation System

The primary objectives include:

- To develop the Precision irrigation is the system can deliver the right amount of water and to the plant's root zone at the right time.
- To reduce water and water wastage.
- To save time and effort.
- To reduce the impact of drought and climate change on crop yield.
- To develop system that can provide data-driven insights that help with irrigation strategies, crop selection, and resource management.

2. LITERATURE REVIEW

Smart irrigation using IoT and automation has gained significant attention in modern agriculture to optimize water usage and improve crop productivity. Traditional irrigation methods often lead to excessive water use and inefficiencies. Recent studies have explored sensor-based systems, AI-driven decision-making, and cloud-integrated solutions to enhance irrigation efficiency and sustainability.

Gungor and Hancke (2009) discussed industrial wireless sensor networks (WSNs), emphasizing real-time data collection and energy-efficient communication for precise irrigation. Taneja and Bhatia (2018) developed an Arduino-based automatic irrigation system, using soil moisture sensors to regulate water flow, minimizing human intervention. Nayaka (2019) introduced Artificial Neural Networks (ANNs) to predict water needs based on real-time sensor data, improving accuracy and reducing water wastage.

Several researchers have integrated IoT and cloud computing for efficient water management. Robles (2019) implemented an IoT-based smart water management model, utilizing real-time monitoring to reduce wastage. Mundada and Pooja (2019) explored WSN-based smart irrigation, which precisely delivers water based on soil conditions. Zhang et al. (2019) demonstrated IoT-driven precision agriculture, integrating environmental sensors for adaptive irrigation strategies.

Cloud-enabled smart irrigation has further improved efficiency Kumar and Shukla (2021) developed an IoT-based

system with cloud integration, allowing farmers to remotely monitor and control irrigation. Jha and Maiti (2022) proposed an energy-efficient IoT framework, utilizing low-power sensors to optimize water and energy consumption, making irrigation more sustainable.

Despite advancements, challenges remain, such as high energy consumption, connectivity issues, and environmental variability affecting sensor accuracy. Future research should focus on enhancing dataset diversity, developing AI-driven predictive models, and improving low-power IoT solutions for sustainable and automated irrigation systems.

3. METHODOLOGY

The IoT-based smart irrigation system is designed using a microcontroller with a built-in Wi-Fi module, which serves as the central control unit. It processes input from various sensors and controls the irrigation pump via a relay system. The soil moisture sensor, connected to the GPIO pin, continuously monitors soil moisture levels and sends real-time data to the microcontroller. When the moisture level drops below a predefined threshold, the system triggers the relay board, activating the water pump for a specified duration before automatically switching it off.

The NodeMCU, connected to the internet, updates moisture data on the cloud, allowing farmers to remotely monitor and control the system from anywhere. Cloud services not only enable real-time data access but also facilitate future upgrades for controlling additional agricultural components. The system operates on an isolated power supply, ensuring reliable deployment across large agricultural fields.

Designed for drip irrigation and indoor precision agriculture, the system integrates multiple sensors to enhance automation. A rain sensor sends alerts to mobile devices, helping farmers take preventive actions against potential crop damage. The LDR (light sensor) detects low sunlight and automatically activates LED grow lights to support crop growth. A temperature and humidity sensor continuously monitors atmospheric conditions, providing valuable data for optimizing irrigation and environmental control.

All sensor data is transmitted via Wi-Fi to a mobile device through a local network, enabling real-time monitoring of field conditions. This automated and sensor-driven approach ensures efficient water management, reduces manual intervention, and enhances crop productivity while supporting sustainable agricultural practices.

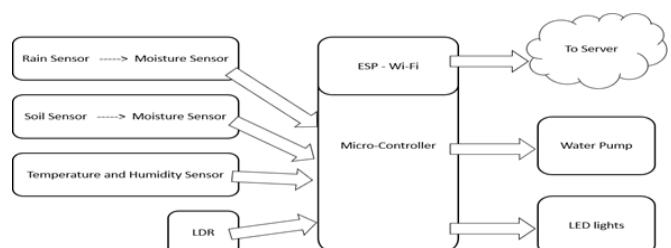


Fig 2: Block Diagram of an IoT-Based Smart Irrigation System

4. RESULTS AND DISCUSSION

The IoT-Based Smart Irrigation System demonstrated significant improvements in water management and automation, making it a highly efficient solution for modern agriculture. The soil moisture sensor, integrated with the microcontroller, ensured precise water usage by activating the irrigation pump only when moisture levels fell below a set threshold. This led to a substantial reduction in water wastage, particularly in drip irrigation systems, where water is delivered directly to the plant roots with minimal loss. The system's ability to conserve water aligns with the growing need for sustainable agricultural practices in the face of declining freshwater reserves.

The incorporation of real-time monitoring and cloud connectivity further enhanced the system's effectiveness. With the ESP Wi-Fi module, farmers could monitor critical data, such as soil moisture levels and environmental conditions, remotely through a mobile device. This feature allowed for proactive decision-making and reduced the dependency on physical presence in the field. The ability to remotely control the system provided convenience and flexibility, especially in large agricultural setups, saving time and labor costs for farmers.

Automation of environmental controls added another layer of efficiency to the system. The LDR (light sensor) enabled the automatic activation of LED grow lights during low sunlight, ensuring consistent light availability for crops grown in indoor or low-light conditions. Similarly, the temperature and humidity sensor provided real-time atmospheric data, which could be used to maintain optimal environmental conditions for plant growth. These features collectively improved crop productivity by addressing specific growth requirements in a timely and automated manner.

Despite its successes, the system encountered a few challenges. Factors such as variability in sensor accuracy due to environmental fluctuations and the dependency on consistent internet connectivity could occasionally affect performance. However, these limitations are addressable with further enhancements, such as integrating advanced sensors and utilizing edge computing to reduce reliance on constant connectivity. Overall, the system proved to be a scalable and cost-effective solution for farmers, promoting efficient water use, automation, and sustainable farming practices.

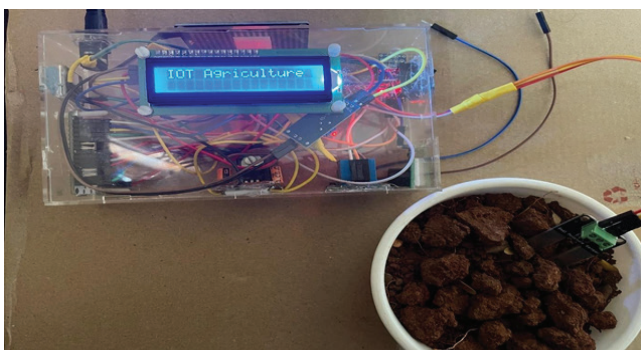


Fig 3a: IOT Based Smart Irrigation System

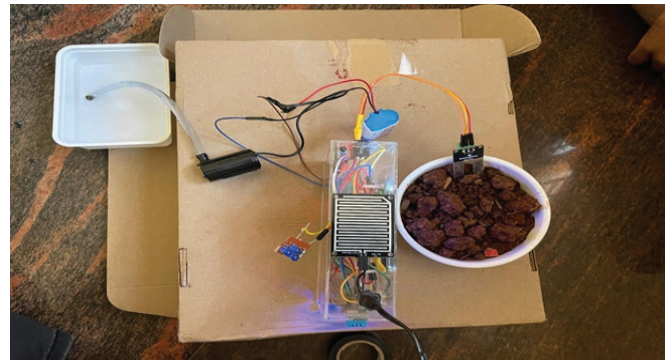


Fig 3b: Water Pump to Controls the flow of water for irrigation based on sensor data



Fig 3c: Grow Light to support plant growth in low-light conditions

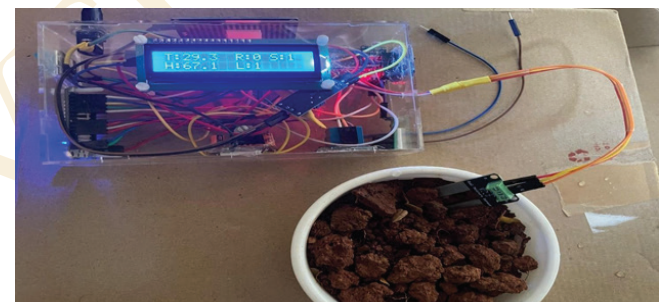


Fig 3d: Display of Key Environmental Parameters

5. CONCLUSION

The "Automated Agriculture Monitoring System" has been successfully designed and tested, integrating all hardware components effectively to ensure optimal functionality. The system leverages IoT technology to enable precise monitoring and control of agricultural parameters such as soil moisture, temperature, and humidity. By automating irrigation and utilizing Wi-Fi for real-time data monitoring and remote control, the system ensures efficient water use and stable agricultural production. This approach not only conserves resources but also enhances crop productivity and simplifies farm management, proving to be a more efficient solution than traditional irrigation methods.

6. FUTURE WORK

Future enhancements to the system could focus on integrating advanced technologies to make it more efficient and user-friendly. Machine learning models can be used to analyze historical data and predict irrigation needs, optimizing water use based on weather, soil conditions, and crop type. Solar panels can be integrated to power the system in remote areas, ensuring energy efficiency. A user-friendly IoT-enabled mobile app can offer real-time monitoring, push notifications, and system control. Blockchain technology can

track water usage, promote transparent resource management, and incentivize efficient water use through smart contracts. Additionally, incorporating fertigation systems and nutrient- monitoring sensors would enable precise nutrient management, further enhancing agricultural productivity and sustainability.

7. REFERENCES

- [1]. Pro Green Irrigation, "Pro Green Irrigation: Your Lawn Sprinkler Professionals," 2017. [Online].
<https://progreenirrigation.com/>.
- [2]. V. C. Gungor and G. P. Hancke, "Industrial wireless sensor networks: Challenges, design principles, and technical approaches," *IEEE Trans. Ind. Electron.*, vol. 56, no. 10, pp. 4258–4265, Oct. 2009.
- [3]. J. Gutierrez, J. F. Villa-Medina, A. Nieto- Garibay, and M. A. Porta-Gandara, "Automated irrigation system using a wireless sensor network and GPRS module," *IEEE Trans. Instrum. Meas.*, vol. 63, no. 1, pp. 166–176, Jan. 2014.
- [4]. K. Taneja and S. Bhatia, "Automatic irrigation system using Arduino UNO," in *Proceedings of the 2017 International Conference on Intelligent Computing and Control Systems, ICCCIS 2017*, 2018, vol. 2018–Janua, pp. 132–135.
- [5]. Krishna Anne, K. R V Siva Naga Durg, R. Krishna Muddineni, and S. Gowtham Peri, "Smart irrigation using WSN based on IOT," *Int.J. Eng. Technol.*, vol. 7, no. 2.8, p. 331, Mar. 2018.
- [6]. D. J. Nayaka, "Water usage approximation of Automated Irrigation System using a IOT and ANN's," in *2018 2nd International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC)* I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), 2018 2nd International Conference on, 2019, pp. 76–80.
- [7]. HydroPoint Data Systems, "What is Smart Irrigation?," 2019. [Online].
<https://www.hydpoint.com/what-is-smart-irrigation/>.
- [8]. T. Robles et al., "An internet of things-based model for smart water management," in *2014 28th International Conference on Advanced Information Networking and Applications Workshops*, 2014, pp. 821–826.
- [9]. Meeradevi, M. A. Supreetha, and J. N. Pooja, "Design of a smart water-saving irrigation system for agriculture based on a wireless 555555 sensor network for better crop yield," in *Lecture Notes in Electrical Engineering*, 2019, vol. 500, pp. 93–104.
- [10]. F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "A survey on sensor networks," *IEEE Commun. Mag.*, vol. 40, no. 8, pp. 102–105, Aug. 2002.

The Future of Cloud Computing: Benefits and Challenges

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ABSTRACT

This paper explores the transformative impact of cloud computing on modern IT infrastructure, outlining its benefits, challenges, and the trajectory it is expected to follow in the coming years. The discussion incorporates recent industry advancements, case studies, and future trends such as edge computing, AI integration, and zero-trust security models. Furthermore, implementation strategies for various industries such as healthcare and finance are considered. By synthesizing academic and industrial insights, this paper aims to guide stakeholders in leveraging cloud technologies more effectively while addressing inherent risks.

Keywords: Cloud Computing, Edge Computing, AI, Server less, Zero Trust, Hybrid Cloud, Multi-cloud, IaaS, PaaS, SaaS, XaaS, Security, Cloud Implementation, Data Compliance.

1.INTRODUCTION

Cloud computing, originally conceptualized in the 1960s through time-sharing systems, has evolved into a dominant force in digital transformation. Modern cloud computing enables scalable, on-demand access to computing resources via the internet, reducing the need for costly physical infrastructure. As of 2024, leading platforms such as AWS, Microsoft Azure, and Google Cloud have redefined enterprise IT landscapes through flexible service models like IaaS, PaaS, and SaaS. Cloud computing is not just a technological shift but a catalyst for digital innovation. Its impact spans personal productivity, enterprise automation, real-time data analytics, and global digital inclusion.

2. LITERATURE REVIEW

Earlier literature describes cloud computing as a disruptive model that reshapes IT economics by promoting elasticity, resource pooling, and service-oriented architecture. Studies by Mell and Grance (2011) laid the foundational definition of cloud computing. Recent studies (Gartner, 2023; Forrester, 2024) suggest cloud adoption is increasingly driven by AI and ML workloads, as well as regulatory compliance mandates. New research from ACM (2023) discusses cloud-native patterns and container orchestration as critical developments. Researchers are also exploring the intersection of cloud computing and quantum computing as a future growth area, emphasizing the need for adaptable architectures.

3. CLOUD ARCHITECTURE AND SERVICES

Cloud architecture comprises the frontend (client interfaces and apps) and backend (datacenters, virtual machines, orchestration systems). Components include:

- Client Infrastructure: Graphical interfaces to interact with the cloud.
- Application Layer: The user-facing layer where applications are hosted.
- Cloud Services: Including IaaS, PaaS, and SaaS.
- Runtime Environment: Supports the execution of applications and processes.
- Storage Systems: Ensures secure and scalable data storage.

- Infrastructure and Management Tools: Virtualization, load balancing, orchestration, and monitoring.
- Security & Compliance Modules: Firewalls, identity management, and encryption.

ARCHITECTURE OF CLOUD COMPUTING

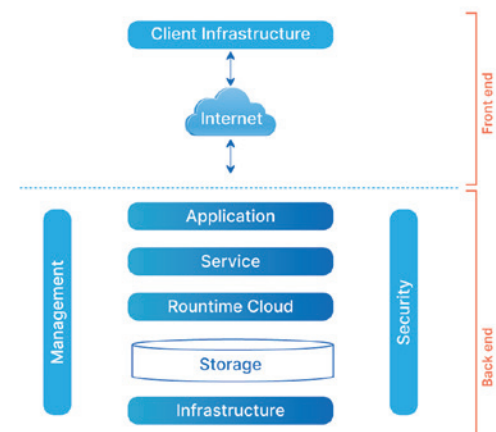


Fig 1: Cloud Architecture

Recent paradigms such as Serverless and Function-as-a-Service (FaaS) allow developers to focus solely on writing business logic without managing infrastructure. Cloud-native architectures also emphasize microservices, containerization (e.g., Docker), and orchestration frameworks like Kubernetes.

Table 1: Comparison of Cloud Service Models

Service Model	Managed By Provider	Managed By User	Use Case
IaaS	Networking, Storage, Servers	Applications, Data, Runtime	Hosting websites, backup and recovery
PaaS	Infrastructure, Runtime, OS	Applications, Data	Application development and deployment
SaaS	Everything	None	Email, CRM, collaborative tools

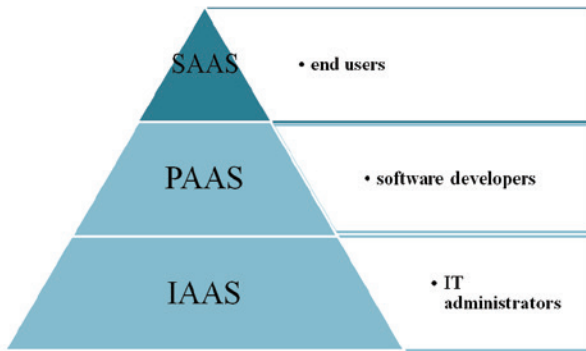


Fig 2: Cloud Service Models

4. FUTURE BENEFITS

- **Edge Computing:** Processes data closer to the source, reducing latency for real-time applications such as autonomous vehicles and smart factories.
- **AI and ML Integration:** Cloud platforms now offer dedicated AI services (e.g., AWS SageMaker, Azure Cognitive Services) for automation, analytics, and insight generation.
- **XaaS Expansion:** Beyond IaaS, PaaS, SaaS, cloud services now include BaaS (Backup), DRaaS (Disaster Recovery), and even Security-as-a-Service.
- **Business Agility:** Enables rapid experimentation and scaling, essential in a competitive digital market.
- **Sustainability and Green Computing:** Cloud providers are investing in renewable-powered datacenters and efficient resource usage.
- **Enhanced Collaboration:** Cloud tools like Microsoft 365 and Google Workspace improve remote work productivity.
- **Serverless Architectures:** Lower operational overhead and support event-driven computing.

5. CHALLENGES AND CONSIDERATIONS

- **Security and Compliance:** Increasing demand for Zero Trust Architecture, confidential computing, and adherence to GDPR, HIPAA, and CCPA.
- **Cost Management:** Complex pricing models often lead to unexpected expenses; FinOps practices are emerging to optimize spend.
- **Data Sovereignty:** Multinational companies must manage cross-border data flow under diverse legal constraints.
- **Hybrid and Multi-Cloud Complexity:** Orchestration, interoperability, and unified visibility remain technical hurdles.
- **Skill Gaps:** Rapid evolution outpaces workforce training; demand for certified cloud professionals continues to rise.
- **Performance Monitoring:** Ensuring uptime, latency control, and continuous delivery across environments.
- **Interoperability Standards:** Lack of universal APIs and metadata handling impedes seamless migration.

6. CASE STUDIES

- **Netflix:** Uses AWS for content delivery and global scalability.
- **Pfizer:** Runs simulations on Azure for faster drug discovery.
- **Spotify:** Migrated to Google Cloud to improve data analytics and user personalization.
- **NASA:** Uses hybrid cloud for mission control and public science data dissemination.
- **Zoom:** Scaled massively during the COVID-19 pandemic through a cloud-native architecture on Oracle Cloud Infrastructure.

Sample Implementation: Hybrid Cloud Strategy in Healthcare In the healthcare sector, privacy regulations and data sensitivity drive the need for hybrid cloud solutions. A sample implementation involves storing patient medical records in a private on-premises cloud to ensure data compliance, while using public cloud resources for running analytics and machine learning models to predict patient outcomes.

Implementation Steps:

1. Use OpenStack for creating the private cloud infrastructure.
2. Integrate with Microsoft Azure for compute-intensive analytics.
3. Ensure secure VPN tunnels and federated identity access.
4. Apply HIPAA-compliant encryption methods both in-transit and at rest.

This model ensures both agility and regulatory adherence, making it a preferred approach in sectors dealing with sensitive data.

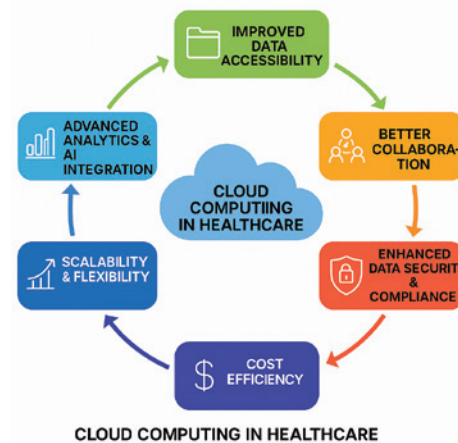


Fig 3: Benefits of Cloud Computing in Healthcare

7. CONCLUSION

Cloud computing is a foundational technology for digital innovation, offering scalability, agility, and operational efficiency. However, to unlock its full potential, organizations must address architectural, security, and financial challenges. Future success depends on strategic multi-cloud management, zero-trust implementation, and continuous workforce upskilling. As cloud technologies mature, their integration with AI, 5G, and edge networks will define the next frontier of computing. Further research into cloud-native design, sustainability practices, and federated AI models will be crucial in shaping future-ready cloud ecosystems.

8. REFERENCES

- [1] Gartner, "Cloud Computing Trends and Forecasts," 2023.
- [2] Forrester, "State of Cloud Adoption," 2024.
- [3] Microsoft Azure Blog, "Future of AI-Powered Cloud," 2023.
- [4] Amazon Web Services, "AWS Sustainability Report," 2024.
- [5] Red Hat, "Hybrid Cloud Infrastructure Management," 2023.
- [6] IBM Cloud Docs, "Zero Trust in Enterprise Cloud," 2024.
- [7] Cloud Security Alliance (CSA), "Best Practices in Cloud Governance," 2023.
- [8] Accenture, "Edge Computing Use Cases and Architectures," 2023.
- [9] Tutorialspoint, "Cloud Computing Architecture Overview," 2023.
- [10] OpenStack Foundation, "Private Cloud for Regulated Industries," 2023.
- [11] ACM Digital Library, "Containerized Cloud-Native Design Patterns," 2023.
- [12] Toxigon, "Trends and Predictions for Cloud Evolution," 2024.
- [13] Techlaner, "Multi-Cloud and Security Landscape," 2024.
- [14] ComputeSphere, "Green Cloud Metrics for Enterprises," 2024.

PayCrypt- a Cryptocurrency Payment Webapp

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ABSTRACT

With the rapid evolution of digital payments, ensuring security, transparency, and decentralization has become a major challenge. PayCrypt is a blockchain-powered cryptocurrency payment system designed to offer a secure and efficient alternative to traditional payment gateways. Developed using the Laravel framework, PayCrypt leverages smart contracts to facilitate trustless transactions, eliminating intermediaries and reducing operational costs. By integrating cryptographic encryption and decentralized ledger technology, the system enhances security while ensuring transparency in financial transactions. PayCrypt provides a user-friendly interface that enables seamless peer-to-peer transactions with real-time processing. The system ensures low transaction fees and high scalability, making it suitable for various financial applications, including e-commerce, remittances, and merchant payments. This paper explores the architectural design, security mechanisms, and practical use cases of PayCrypt, highlighting its potential to revolutionize digital payments by bridging the gap between blockchain technology and everyday financial transactions.

Keywords: Cryptocurrency Payments, Blockchain Technology, Decentralized Finance (DeFi), Payment Gateway Alternative, Cryptographic Encryption.

Abbreviations

DeFi Decentralized Finance
DApp Decentralized Application
KYC Know Your Customer
BTC Bitcoin
API Application Programming Interface
PoS Proof of Stake
PoW Proof of Work
UI/UX – User Interface / User Experience

1. INTRODUCTION

The rise of digital payments has revolutionized the financial sector, enabling fast and convenient transactions worldwide. However, traditional payment gateways still face significant challenges, including high transaction fees, security vulnerabilities, and reliance on centralized authorities. These limitations hinder financial inclusivity and create barriers for global transactions. PayCrypt is a blockchain-based cryptocurrency payment system designed to address these issues by providing a decentralized, secure, and efficient alternative to conventional payment methods. By leveraging blockchain technology and smart contracts, PayCrypt eliminates the need for intermediaries, ensuring peer-to-peer transactions that are transparent, immutable, and tamper-proof.

Built using the Laravel framework, PayCrypt integrates cryptographic encryption to enhance security while maintaining a user-friendly interface for seamless transactions. The system supports multiple cryptocurrencies, allowing users to send and receive payments without worrying about currency conversion or banking restrictions. With decentralized ledger technology, every transaction is recorded on the blockchain, making it verifiable and resistant to fraud. This not only enhances trust between parties but also reduces the risks associated with centralized payment systems, such as data breaches and unauthorized access.

One of the key advantages of PayCrypt is its integration of smart contracts, which automate and enforce payment agreements without requiring third-party intervention.

This ensures that transactions are executed only when predefined conditions are met, enhancing the reliability and efficiency of financial operations. Additionally, PayCrypt minimizes transaction costs by eliminating intermediaries such as banks and payment processors, making it an ideal solution for cross-border transactions, e-commerce, and business-to-business (B2B) payments.

The adoption of cryptocurrency-based payment systems like PayCrypt can transform the financial landscape by promoting financial inclusion, especially in regions with limited access to traditional banking services. Users can store, send, and receive payments securely, while merchants benefit from lower processing fees and instant settlements. Furthermore, PayCrypt offers an intuitive and accessible platform for both individuals and businesses, ensuring that cryptocurrency adoption becomes more practical for everyday transactions.

This paper explores the architectural design, security mechanisms, and practical applications of PayCrypt in modern financial ecosystems. It highlights the benefits of decentralization, security, and efficiency in digital payments and discusses the potential impact of blockchain-powered payment systems on the future of global finance. By addressing the limitations of traditional payment methods, PayCrypt paves the way for a more secure, transparent, and borderless financial ecosystem.

In summary, PayCrypt is a decentralized cryptocurrency payment system designed to facilitate secure, fast, and cost-effective transactions using blockchain technology. It enables individuals and businesses to send, receive, and store digital assets without the need for traditional banking intermediaries. Built on Ethereum and Tron blockchains, PayCrypt leverages smart contracts to ensure transparent and tamper-proof transactions, eliminating third-party risks. The platform integrates Laravel for backend processing, Web3.js/TronWeb for blockchain interactions, and AES-256 encryption for enhanced security.

2. RELATED WORKS

[1] "Cryptocurrency Open Innovation Payment System" by Yli-Huumo, J., Ko, D., Choi, S., Park, S., & Smolander. This study explores how cryptocurrency-based payment systems are driving financial innovation. It examines various blockchain protocols used for payments and evaluates their efficiency in terms of transaction speed, security, and cost-effectiveness. The research provides insights into how decentralized payments reduce reliance on traditional banking structures while improving financial inclusion. Additionally, the paper discusses the challenges associated with regulatory policies and scalability in crypto payment solutions.

[2] "Bitcoin Adoption in Online Payments: Examining Consumer Intentions " By Researchers from the SpringerOpen Business Journal :

This study investigates the factors influencing consumers' willingness to use Bitcoin for e-commerce transactions. It analyzes behavioral factors such as trust, perceived ease of use, transaction fees, and volatility concerns. The research, based on surveys conducted with over 500 online shoppers, reveals that security concerns and price fluctuations remain significant barriers to cryptocurrency adoption. However, increased merchant acceptance and regulatory clarity could improve adoption rates in the long run.

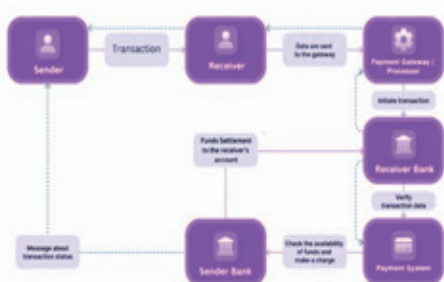
[3] "An Evaluation of Cryptocurrency PaymentChannel Networks and Their Privacy Implications" By Enes Erdin, Suat Mercan, and Kemal Akkaya :

This paper focuses on the privacy concerns surrounding cryptocurrency payment channels, such as Bitcoin Lightning Network and Ethereum's state channels. It evaluates how these solutions enhance transaction throughput while maintaining decentralization. The study highlights privacy vulnerabilities, including transaction traceability, address reuse, and off-chain payment tracking, and suggests cryptographic methods to enhance anonymity in payment networks.

[4] "Blockchain-based Payment Systems: A Bibliometric & Network Analysis" By Shlok Dubey :

This research provides a systematic review of blockchain-based payment systems through bibliometric and network analysis. By analyzing a large corpus of academic publications, the paper identifies key authors, research trends, collaboration networks, and future research opportunities in the field of blockchain payments. It discusses how smart contracts, decentralized finance (DeFi), and Layer-2 solutions are shaping the evolution of digital payment ecosystems.

3. METHODOLOGY



The PayCrypt system is designed using a blockchain-based decentralized architecture to facilitate secure and transparent cryptocurrency transactions. The methodology follows a structured approach, incorporating blockchain technology, smart contracts, cryptographic security, and an intuitive user interface to create a seamless digital payment ecosystem. The system is developed using the Laravel framework for backend logic, blockchain smart contracts for transaction automation, and cryptographic protocols for secure user authentication and data integrity. The methodology is structured into the following key phases:

1. System Architecture Design

PayCrypt follows a decentralized peer-to-peer (P2P) architecture to eliminate intermediaries and ensure direct transactions between users. The architecture consists of the following components:

- **User Interface (UI):** A web-based and mobile-friendly dashboard built using Laravel, allowing users to send, receive, and track payments
- **Blockchain Layer:** A public/private blockchain network that records transactions securely, ensuring transparency and immutability.
- **Wallet Management System:** A digital wallet system that allows users to store, manage, and transact cryptocurrencies.
- **Smart Contracts:** Self-executing contracts deployed on the blockchain to automate transaction processing and enforce agreements.

2. User Authentication and Wallet Management

- Users register and authenticate using a multi-factor authentication (MFA) system for enhanced security.
- A unique cryptographic key pair (public & private keys) is generated for each user, ensuring secure wallet access.
- Wallets support multiple cryptocurrencies, enabling seamless transactions across different blockchain networks

3. Smart Contract Implementation

Automated Payment Execution: Smart contracts are deployed to process transactions automatically when predefined conditions (such as payment confirmation or product delivery) are met

- **Escrow Services:** Secure escrow contracts hold funds until transaction terms are verified, reducing fraud risk.
- **Fee Management:** Smart contracts handle transaction fees dynamically, ensuring low-cost transactions compared to traditional payment gateways.

4. Transaction Processing and Security Mechanisms

- Transactions are signed digitally using users' private keys and broadcasted to the blockchain network for validation.
- The Proof-of-Work (PoW) or Proof-of-Stake (PoS) consensus mechanism (depending on the blockchain used) verifies transactions, preventing double-spending attacks.
- Transactions are recorded on an immutable ledger, ensuring tamper-proof records and enhancing trust.

5. Real-Time Payment Processing and Notification System

- PayCrypt provides real-time transaction confirmation by interacting with blockchain nodes to retrieve live transaction statuses.
- Users receive instant notifications via email, SMS, or in-app alerts upon successful payment processing.
- The platform includes a QR code payment system, allowing businesses to generate QR codes for quick cryptocurrency payments.

6. Performance Optimization and Scalability

- **Layer 2 Scaling Solutions:** The platform supports off-chain transaction processing and Layer 2 solutions (such as the Lightning Network) to improve transaction speed and reduce costs.
- **Load Balancing and Caching:** Implementing Redis caching and CDN-based optimization ensures faster response times and smooth user experience.
- **High Availability Infrastructure:** The backend is hosted on cloud-based, decentralized servers, ensuring 99.99% uptime for transactions.

7. Testing and Security Audits

- **Smart Contract Audits:** Before deployment, smart contracts undergo rigorous security audits to detect vulnerabilities.
- **Penetration Testing:** The system is tested for cyber threats, including phishing attacks, SQL injections, and brute-force attempts.
- **Bug Bounty Program:** A security program is introduced, inviting ethical hackers to identify potential vulnerabilities.

8. Deployment and Future Enhancements

- **Deployment:** The final version of PayCrypt is deployed on a live blockchain network, ensuring seamless global accessibility.
- **Future Enhancements:** Plans for incorporating AI-based fraud detection, machine learning-based transaction analytics, and DeFi-based lending features for further expansion.



Fig 1: Flow Chart

The flowchart for the Pay Crypt webapp illustrates the sequential steps involved in a typical cryptocurrency payment transaction. The process begins with the user initiating a payment by specifying the recipient and amount. The system then verifies the user's account balance and initiates the transaction. The transaction is then broadcasted to the blockchain network for processing. Upon successful validation and confirmation by the blockchain network, the system updates the user's wallet balance and records the transaction history. In case of errors or insufficient funds, the system displays appropriate error messages and guides the user accordingly. This flowchart helps visualize the logical flow of data and actions within the system, ensuring a clear and efficient payment process.

4. IMPLEMENTATION

The implementation of PayCrypt involves integrating blockchain technology, Laravel-based backend development, smart contracts, and cryptographic security mechanisms to create a seamless cryptocurrency payment system. The development follows a modular approach, ensuring scalability, security, and efficiency. Below is a detailed breakdown of the implementation process.



Fig 2: Sequence Diagram

In the cryptocurrency payment webapp, the sequence diagram illustrates the interactions between users and the system during a typical payment transaction. Initially, a user accesses the webapp and initiates a payment by specifying the recipient and amount. The system validates the user's credentials and retrieves their cryptocurrency balance. If sufficient funds are available, the system generates a transaction request and broadcasts it to the blockchain network. The network verifies and processes the transaction, updating the balances of both the sender and recipient. The system then notifies the user of the transaction status and provides a confirmation. Simultaneously, the system logs the transaction for auditing and security purposes. This sequence ensures a secure and transparent payment process, with each step clearly defined to maintain the integrity of cryptocurrency transactions.

Once the user is authenticated, the system retrieves the cryptocurrency balance from the connected wallet or on-chain ledger. If the user's balance is sufficient to cover the transaction amount and applicable network fees, the system generates a secure transaction request. This request is then digitally signed using the user's private key to ensure transaction authenticity and integrity.

Following the transaction request generation, the system broadcasts the transaction to the blockchain network for validation. The blockchain network nodes verify the transaction's legitimacy using cryptographic consensus mechanisms (e.g., Proof of Work or Proof of Stake). Once validated, the transaction is permanently recorded on the blockchain ledger, ensuring immutability and security. The system then updates the sender's and recipient's balances accordingly.

Upon successful completion of the transaction, the system provides real-time notifications to the user regarding the transaction status. A confirmation receipt with a unique transaction hash is generated, allowing the user to track the transaction on the blockchain explorer. Additionally, the system logs all transactions for security auditing, regulatory compliance, and dispute resolution.

This structured process ensures a seamless, secure, and transparent payment experience within PayCrypt. By leveraging blockchain technology, digital signatures, and real-time validation mechanisms, the system guarantees trust, efficiency, and decentralization in financial transactions.

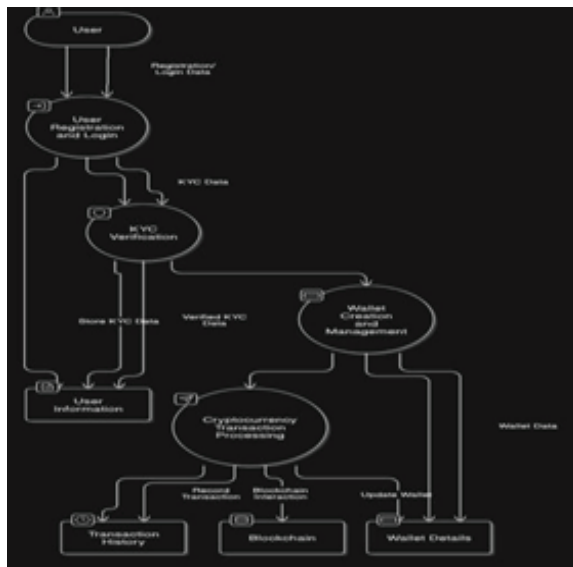


Fig 3: Data Flow Diagram

The Data Flow Diagram (DFD) for the PayCrypt webapp provides a visual representation of how data moves through the system during cryptocurrency transactions. At the highest level, the system consists of external entities, such as users, the blockchain network, and payment gateways. Users interact with the system by registering and logging in. Once authenticated, users can initiate payments by specifying the recipient and amount. The system processes the payment request, interacts with the blockchain network to execute the transaction, and updates the user's wallet balance. Payment gateways facilitate the exchange between fiat currency and cryptocurrency. Throughout the process, data flows securely between the database for user management, the blockchain for transaction processing, and the user interface for interaction. This DFD illustrates the key data flows and processes involved in enabling secure and efficient cryptocurrency payments within the PayCrypt webapp.

The blockchain network serves as a decentralized entity responsible for processing transactions and maintaining a tamper-proof record of all payments. Additionally, payment gateways facilitate the conversion of fiat currency to cryptocurrency for users who wish to fund their wallets using traditional banking methods. The data flow between these entities is secured using encryption and blockchain smart contracts, ensuring that every step of the transaction is both trustworthy and verifiable.

Throughout the process, the system interacts with various databases for user authentication, transaction history logging, and wallet balance updates. The user interface continuously updates in real-time, displaying transaction statuses, balance changes, and notifications regarding pending or completed payments. Security mechanisms such as two-factor authentication (2FA), multi-signature wallets, and encrypted APIs further enhance the safety of data transmissions within the system.

5. RESULTS

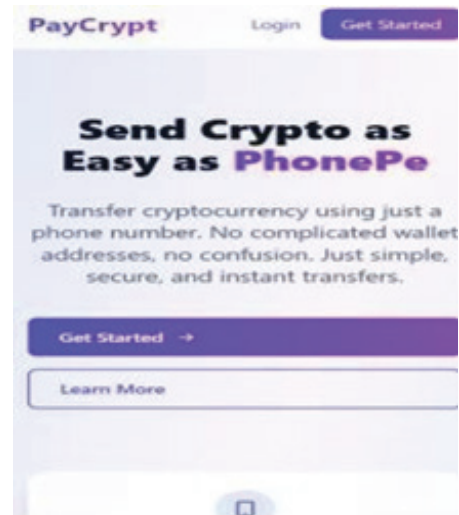


Fig 4: Landing Page.

Fig 4 illustrates the user interface of the The landing page of PayCrypt presents a modern and user- friendly interface, designed to highlight the platform's core functionality—seamless cryptocurrency transactions using just a phone number. The branding at the top features the PayCrypt logo, along with quick access options for Login and Get Started, making it easy for users to either sign in or create an account.

The main heading emphasizes simplicity and ease of use, comparing the transaction process to PhonePe, a well-known digital payment service, to make it more relatable. The supporting text clarifies that PayCrypt eliminates the need for complex wallet addresses, allowing users to send and receive crypto instantly, securely, and without confusion.

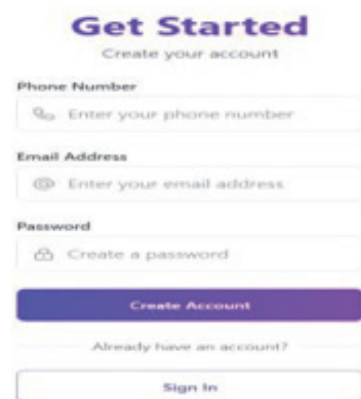


Fig5: Register page.

Fig5 illustrates The registration page of PayCrypt provides a simple and intuitive user interface for new users to create an account effortlessly. The header "Get Started" clearly indicates that this is the account creation process. Below the header, a short instructional text prompts users to enter their details to sign up.

The page includes three essential input fields:

1. Phone Number – Users enter their mobile number, which serves as a key identifier for transactions.
2. Email Address – An email is required for verification, notifications, and account recovery.

3. Password – Users create a secure password to protect their account.

A prominent "Create Account" button is displayed, guiding users toward completing the signup process. Additionally, for users who already have an account, there is a "Sign In" link at the bottom, ensuring easy navigation to the login page.

The modern and minimalistic design, along with a clear call to action and user-friendly input fields, ensures a seamless onboarding experience. This registration process aligns with PayCrypt's goal of providing secure, fast, and hassle-free cryptocurrency transactions using just a phone number.

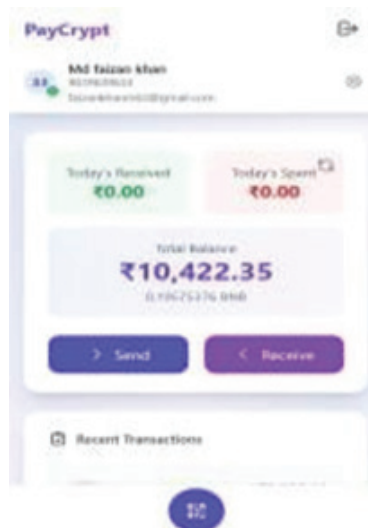


Fig 6: Dashboard page.

Fig6 illustrates the The PayCrypt Dashboard provides users with a clear and user-friendly interface to manage their cryptocurrency transactions efficiently. At the top of the screen, the user's profile information is displayed, including their name, phone number, and email address, allowing easy identification and personalization. A settings icon is also available, enabling users to customize their account preferences.

The dashboard highlights key financial details:

Today's Received Amount – Displays the total cryptocurrency received for the day.

Today's Spent Amount – Shows the total amount spent in cryptocurrency for the day.

Total Balance – Presents the user's available cryptocurrency balance, both in fiat currency (₹) and in BNB (Binance Coin).

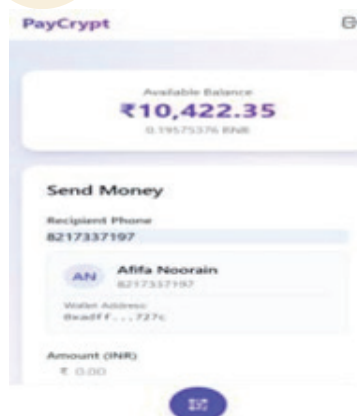


Fig7: Transaction page.

Fig 7 showcases the The PayCrypt Transaction Page is designed to facilitate seamless cryptocurrency transfers with a user-friendly interface. At the top of the screen, the user's available balance is prominently displayed in both fiat currency (₹) and cryptocurrency (BNB - Binance Coin), ensuring users are aware of their current funds before making a transaction. Key Features of the Transaction Page:

- 1) Recipient Phone Number Input: Users can enter the recipient's phone number to send money. This eliminates the need for complex wallet addresses and enhances ease of use.
- 2) Recipient Information Display: Once the phone number is entered, the system automatically fetches and displays the recipient's name, phone number, and linked
- 3) wallet address: This ensures accuracy and helps users verify that they are sending funds to the correct person.
- 4) Amount Input Field: Users can enter the amount in INR that they wish to send. The system will then calculate and convert this amount into cryptocurrency based on the current exchange rate before processing the transaction.
- 5) QR Code Scanner Button: At the bottom of the page, a QR code scanning option is available. This allows users to scan and send payments instantly, making transactions even more convenient.

6. CONCLUSION

PayCrypt revolutionizes cryptocurrency transactions by offering a seamless, secure, and user-friendly web application that simplifies digital payments. By eliminating the complexity of wallet addresses and enabling transactions via phone numbers, PayCrypt enhances accessibility and usability for both beginners and experienced crypto users. The integration of blockchain technology ensures security, transparency, and immutability, making every transaction reliable and tamper-proof.

With features like real-time balance updates, a streamlined transaction process, and QR code-based payments, PayCrypt bridges the gap between traditional digital payments and decentralized finance (DeFi). This innovation paves the way for broader cryptocurrency adoption, making it as convenient as using mainstream payment platforms like PhonePe or Google Pay. As digital currencies continue to grow, PayCrypt stands as a pioneering solution that empowers users with a faster, safer, and more efficient way to transact in the evolving financial ecosystem.

7. REFERENCES

- [1] Nakamoto, S. (2008). Bitcoin: A Peer-to-Peer Electronic Cash System.
- [2] Antonopoulos, A. M. (2017). Mastering Bitcoin.
- [3] Zheng, Z., Xie, S., Dai, H. N., Chen, X., & Wang, H. (2018). Blockchain challenges and opportunities: A survey. *International Journal of Web and Grid Services*, 14(4), 352-375.
- [4] Pilkington, M. (2016). Blockchain technology: Principles and applications. In F. Xavier Olleros & M. Zhegu (Eds.), *Research Handbook on Digital Transformations* (pp. 225-253). Edward Elgar Publishing.

Information Retrieval System Using Gen-AI

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ABSTRACT

The AI-powered Information Retrieval System integrates Generative AI with retrieval-augmented techniques to enhance question-answering from PDF documents. Leveraging the Google Gemini API, the system extracts, cleans, and segments text from uploaded PDFs, converting them into vector embeddings stored in a FAISS-based database. When users submit queries, the system performs a similarity search to retrieve relevant text chunks, ensuring responses are both accurate and contextually meaningful. Additionally, source references are displayed to enhance transparency and user trust.

This solution streamlines document-based information retrieval, making it highly effective for domains like academic research, legal documentation, and corporate knowledge management. By combining advanced AI-driven reasoning with precise text retrieval, the system delivers intelligent responses while maintaining credibility. Continuous improvements aim to further optimize accuracy, efficiency, and accessibility for users interacting with large-scale text data.

Keywords: Artificial Intelligence, Generative Artificial Intelligence, Facebook AI Similarity Search, Application Programming Interface, Natural Language Processing.

1. INTRODUCTION

The exponential growth of digital documentation, especially in the form of PDF files, has led to significant challenges in extracting meaningful insights efficiently. Traditional methods such as manual reading and keyword-based searches are often inadequate for handling large datasets, as they fail to provide contextually relevant responses. Additionally, users frequently encounter difficulties in retrieving precise information from multiple documents, especially when dealing with complex, technical, or domain-specific content. This lack of efficient information retrieval leads to time-consuming searches and reduced productivity, making it crucial to develop an advanced solution that can streamline access to relevant data while maintaining accuracy and reliability.

To overcome these limitations, an AI-powered Information Retrieval System has been designed, integrating Generative AI with Retrieval-Augmented Generation (RAG) techniques. The system allows users to upload multiple PDF documents, which are then processed to extract, clean, and segment their textual content into meaningful chunks. These text chunks are converted into vector embeddings using Google's Generative AI embedding model and stored in FAISS, a highly efficient vector database optimized for similarity-based retrieval. This approach ensures that when a user submits a query, the system performs a similarity search within the vector database to retrieve the most relevant text sections. The retrieved content, along with the user's query, is then passed to Google's Gemini API, which generates accurate and context-aware responses. This method enhances both precision and efficiency, ensuring that users receive well-structured, insightful answers tailored to their queries.

One of the key advantages of this system is its transparency and reliability. Unlike traditional AI-generated responses, which may provide unverifiable information, this retrieval-augmented approach ensures that every response is supported by its source document. Users can view the

specific sections from which the answers were derived, increasing trust and confidence in the system's outputs. This feature is particularly valuable for professionals working in academic research, legal documentation, corporate analysis, and other fields requiring precise, fact-based information retrieval.

Additionally, the system features a Streamlit-powered chat interface, providing a seamless and interactive user experience. Users can effortlessly upload documents, ask questions in natural language, and receive accurate responses in real time. The multi-document support further enhances the system's usability by allowing queries across multiple PDFs, making it highly applicable in enterprise environments, legal firms, research institutions, and corporate knowledge management systems.

Beyond efficiency and accuracy, the AI-powered Information Retrieval System also focuses on usability and accessibility. By leveraging natural language processing (NLP), the system enables users to interact intuitively, eliminating the need for complex search queries or manual filtering of large text documents. This accessibility ensures that even non-technical users can benefit from the system, making it an invaluable tool across various industries.

In summary, the AI-powered Information Retrieval System revolutionizes the way users interact with large-scale document repositories. By integrating cutting-edge AI models, vector-based retrieval techniques, and an intuitive chat-based interface, the system significantly improves information access, accuracy, and user experience. As AI continues to advance, future enhancements may include multi-language support, real-time document updates, and integration with cloud-based storage solutions, making this an essential tool for modern information retrieval needs.

2. RELATED WORKS

[1] J.N. Singh, Prashat Johri, Kumar, Aneesh Kumar & Muskan Singh (2022):

The authors present a comprehensive survey of Web Information Retrieval (IR) models, techniques, and challenges associated with modern retrieval systems. The study begins by examining traditional keyword-based retrieval models, emphasizing their foundational role in early search engines while identifying limitations such as poor handling of user intent and contextual ambiguity. It then explores advanced semantic search methodologies that incorporate Natural Language Processing (NLP) and semantic web technologies to improve contextual understanding and enhance user experience.

A significant focus of the paper is on context-aware retrieval systems, which leverage factors like user location, search history, and personalized query context to refine search results dynamically. Additionally, the paper discusses key challenges such as scalability, computational efficiency, and balancing retrieval speed with accuracy. By analyzing emerging trends in AI-driven search models, the study provides insights into the evolution of web IR technologies and outlines future research directions necessary to optimize retrieval efficiency and user satisfaction.

[2] Mladjan Jovanovic, Mark Campbell (2022):

This paper explores the emerging trends and future potential of Generative Artificial Intelligence (GenAI), highlighting its transformative role across industries. The study delves into advancements in Large Language Models (LLMs) and multimodal AI systems, which enable AI-driven generation of text, images, and other content forms. Key trends identified include hyper- personalization, where AI tailors responses based on user preferences; AI-augmented applications, which enhance decision-making processes; and autonomous AI agents, capable of executing complex tasks with minimal human intervention.

Furthermore, the paper examines the real-world impact of GenAI in fields like healthcare, where it aids in diagnostics and personalized treatment plans, and entertainment, where it drives creative content production. While the potential of GenAI is vast, the author also highlights critical ethical and regulatory considerations, emphasizing the need for responsible AI deployment to ensure fairness, security, and accuracy in generated content. The study underscores the necessity of continuous research to maximize AI's benefits while mitigating risks associated with its widespread adoption.

[3] Ipek Ozkaya (2023):

The study investigates the impact of Large Language Models (LLMs) on software engineering, analyzing both their advantages and challenges in software development processes. LLMs are shown to significantly enhance efficiency in coding, software design, and documentation generation, reducing development time and improving code quality. The authors highlight hybrid approaches, which integrate traditional software engineering methodologies with LLM-powered automation to maximize reliability while minimizing AI-related risks. One of the central concerns raised in the paper is the potential for LLMs to generate inaccurate or misleading code, which can lead to software

vulnerabilities. To address this, the study calls for continued research on AI model accuracy, best practices for AI-assisted development, and risk mitigation strategies. The findings emphasize that while LLMs present a paradigm shift in software engineering, their effectiveness hinges on responsible implementation and a balance between human oversight and AI automation.

3. METHODOLOGY

The Information Retrieval System leveraging Generative AI is designed to provide seamless interaction between users and digital documents. The system follows a structured workflow that ensures efficient document processing, query understanding, and response generation. Each stage in this process plays a critical role in transforming unstructured data into meaningful insights, enhancing both accuracy and user experience.

The process begins with PDF input, where users upload documents via a web-based interface. These files, which can include research papers, reports, and articles, are validated before processing. The system supports multiple file formats and provides users with guidance on size and format limitations. Once uploaded, the file is temporarily stored, and metadata such as file name, upload time, and size are recorded for management purposes. This initial step ensures that the documents are readily accessible for further processing.

Once the document is uploaded, the text extraction module processes the file to extract its textual content. For machine-readable PDFs, the system directly parses the text. During this stage, the system also removes irrelevant elements such as headers, footnotes, and page numbers that could interfere with query retrieval. Additionally, metadata such as author names, section titles, and keywords may be extracted to enhance search accuracy and document organization.

After text extraction, the content undergoes text chunking, where it is segmented into smaller, structured pieces. This is a crucial step, as lengthy documents contain extensive information, much of which may not be directly relevant to a user's query. The system segments text based on paragraphs, sentences, or predefined sections such as introductions and conclusions, ensuring that each chunk remains contextually cohesive. This segmentation optimizes retrieval performance by enabling precise matching between user queries and relevant document sections.

Following segmentation, the extracted chunks are transformed into vector embeddings and stored in FAISS (Facebook AI Similarity Search) for efficient indexing and retrieval. Using advanced embedding models from Google's Gemini API, the system converts textual chunks into dense vectors that capture their semantic meaning. Unlike traditional keyword-based searches, this method ensures that document understanding is based on context rather than just word similarity. The FAISS vector store supports approximate nearest neighbor (ANN) search, allowing rapid retrieval of relevant content, even when processing large datasets. By organizing and normalizing vector embeddings, FAISS enhances both search speed and accuracy.

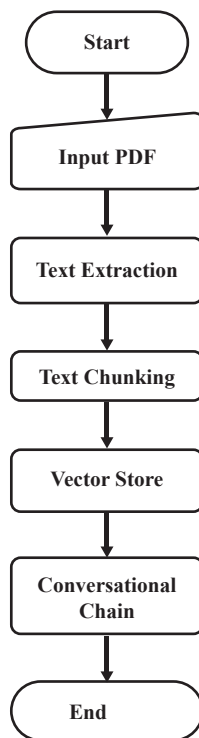


Fig 1: Flow Chart

Once documents are stored in the vector database, users can interact with the system by submitting natural language queries through the chat interface. These queries can range from simple factual questions to complex analytical requests, such as comparisons or summaries. The system classifies and vectorizes the query using the same embedding model that was used for document processing. This ensures consistency in query-document similarity measurement, allowing the system to retrieve the top N most relevant text chunks from FAISS. The ranked results are then passed to Google's Generative AI model, which synthesizes a coherent and context-aware response. The AI model may also highlight specific document sections or combine multiple chunks to construct a well-informed answer.

Finally, the generated response is formatted and displayed in a user-friendly manner. The system ensures that users receive clear, concise, and well-structured answers, with citations referencing the source document. Additional functionalities, such as follow-up queries and response refinement, enhance interactivity. Users can also view previous interactions, improving their ability to retrieve and verify information efficiently. The integration of document processing, similarity search, and AI-driven response generation creates a highly effective retrieval system that provides accurate, reliable, and real-time insights for users engaging with large-scale document repositories.

4. IMPLEMENTATION

The information retrieval process highlights the interaction between key components—the user, the system, the vector store, and the AI—working together to process queries and return relevant information. The process begins with user interaction, where a user submits a query through a frontend interface such as a web-based chat, search bar, or form.

The system is designed to be user- friendly, ensuring accessibility for non-technical users. The query, which can range from simple factual requests to complex analytical questions, is then sent to the backend for processing.

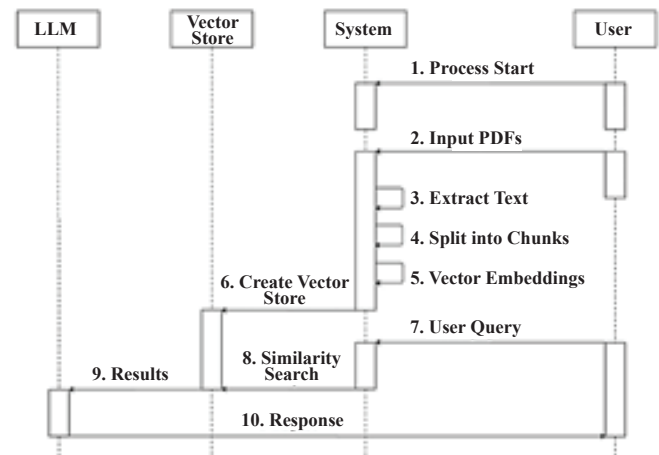


Fig 2: Sequence Diagram

The backend processing stage is responsible for interpreting the query and retrieving relevant information from a FAISS vector store or similar vector database. FAISS enables efficient similarity searches by storing document embeddings, which are dense vector representations of the text that capture semantic meaning. Instead of relying on simple keyword matching, FAISS retrieves documents based on contextual relevance. When a query is submitted, the backend searches the vector store for the most relevant embeddings and ranks the retrieved document segments accordingly. This ensures that only the most pertinent information is selected for further processing.

Once the relevant documents are retrieved, they are processed by an AI model, such as Google's Gemini API or OpenAI's GPT. The AI model analyzes the text, extracts key insights, and generates a contextually accurate response. This stage involves natural language understanding and generation, where the AI may apply techniques such as summarization, paraphrasing, or direct information extraction to craft a response that aligns with the user's intent. The AI synthesizes the retrieved content into a coherent, well-structured answer while maintaining relevance to the original query.

Following AI processing, the response delivery phase ensures that the generated answer is sent back to the frontend interface for display. The response is formatted for readability and may include structured text, bullet points, or highlighted document excerpts. To enhance transparency and trust, the system may also provide citations or relevant text sections that support the response, allowing users to verify the accuracy of the information. The user experience is further improved by allowing users to submit follow-up queries, review previous responses, or provide feedback on the quality of the answers.

The sequence of interactions between the user, backend, FAISS vector store, AI model, and frontend ensures that the system delivers accurate, context-aware responses in real-time. The integration of vector search for retrieval and AI- based language generation creates an efficient

information retrieval system that enhances usability, reliability, and transparency. Future improvements may include multi-turn conversations, real-time updates, and support for voice-based queries, further refining the overall user experience.

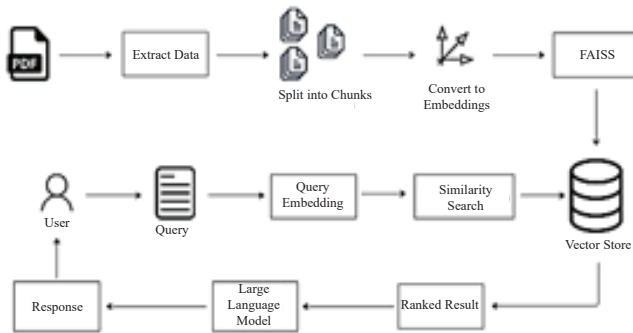


Fig 3: Data Flow Diagram

The data flow in an Information Retrieval System using Generative AI follows a structured pipeline from text extraction to response generation. It begins with PDF text extraction, where machine-readable text is parsed, and OCR is applied for scanned documents. Extracted text is then segmented into smaller chunks, making retrieval more precise. These chunks are converted into vector embeddings using models like BERT or GPT, which capture semantic relationships. The embeddings are stored in FAISS (Facebook AI Similarity Search), enabling fast similarity-based retrieval.

When a user submits a query, it is vectorized using the same embedding model and matched against stored vectors in FAISS using cosine similarity or other search techniques. The system retrieves top relevant text chunks, which are passed to a language model (e.g., Gemini, GPT) for contextual response generation. The model synthesizes a coherent and precise response, potentially including citations or source references for transparency. The response is then formatted and displayed on the frontend interface, allowing users to review, refine queries, or ask follow-up questions. This seamless integration of NLP, vector store, and AI-driven generation ensures an efficient and intelligent information retrieval experience.

5. RESULTS

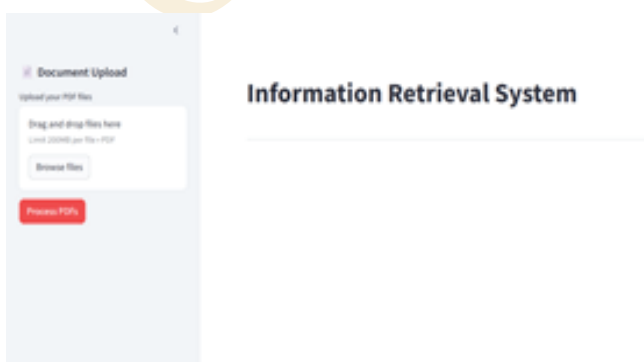


Fig 4: Front End.

Figure 4 illustrates the user interface of the Information Retrieval System built using Streamlit. The interface features a clean and interactive design, allowing users to upload PDF files, process documents, and interact with the system through a natural language Q&A feature. The layout ensures a user-friendly experience, with clear prompts guiding users to submit queries and retrieve relevant information efficiently.

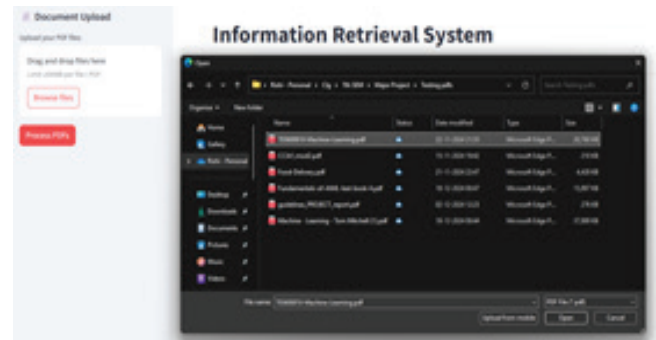


Fig 5: PDF Input to the System.

Fig 5 illustrates the file upload interface of the Information Retrieval System built with Streamlit. The interface features a clean and intuitive design, allowing users to select and upload PDF files for processing. On the left side, a panel provides options for drag-and-drop uploads, a "Browse files" button, and a "Process PDFs" option. The central section displays a file selection dialog box, enabling users to browse directories and choose specific PDFs, ensuring a seamless document upload experience.

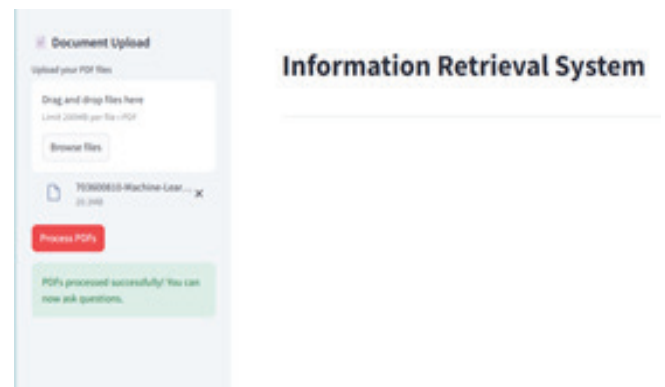


Fig 6: PDF Processing.

Figure 6 illustrates the PDF processing stage of the Information Retrieval System developed using Streamlit. The left panel displays the document upload section, indicating that a file has been successfully uploaded, along with details such as its name and size. After clicking the "Process PDFs" button, a green confirmation message appears, stating, "PDFs processed successfully!" This step ensures that the uploaded documents are ready for further interaction and query processing.

Information Retrieval System

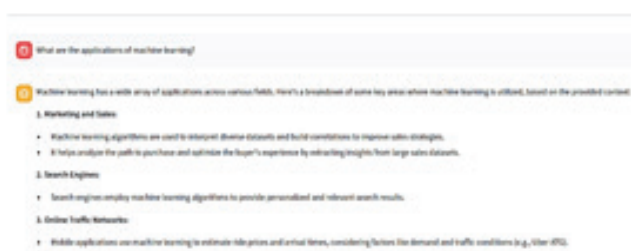


Fig 7: User Query and Response.

Fig 7 showcases the user interface of the Information Retrieval System built with Streamlit, enabling users to upload and process PDF files with a size limit of 200MB. The left panel features a file upload section, where users can drag and drop files or browse for them manually. A successfully uploaded file, "703600810-Machine-Learn..." (20.3MB), is displayed, confirming its readiness for processing.

The central section provides a question-and-answer interface, allowing users to submit queries related to the uploaded documents. For example, a query like "What are the applications of machine learning?" generates a detailed response, listing use cases in marketing and sales, search engines, recommendation systems, autonomous vehicles, medical diagnosis, and fraud detection. Additionally, a "View Source Documents" button enables users to verify the original document sources, ensuring transparency and credibility. This system offers a seamless and intuitive way to extract insights and interact with large-scale documents efficiently.

6. CONCLUSION

The successful completion of this project marks a significant advancement in information retrieval by integrating Generative AI for more intuitive and precise document-based search. Unlike traditional keyword-based retrieval systems, which focus on exact word matches without considering semantic meaning, this AI-powered approach leverages embeddings and vector similarity to understand both the user's intent and the document's context. The use of AI-driven question-answering further enhances the system by generating precise, context-aware responses, rather than simply retrieving documents. This ensures a dynamic and interactive user experience, making information retrieval more efficient, intuitive, and conversational. By transforming how users interact with large-scale documents, this project sets the foundation for more intelligent and context-aware AI-driven search solutions.

While the system has achieved remarkable progress, several enhancements can further broaden its capabilities:

- **Expanded Document Support:** Enabling compatibility with additional formats such as Microsoft Word, PowerPoint, and image files to enhance versatility.
- **Multilingual Capabilities:** Supporting multiple languages to make the system more accessible to a global audience.
- **Real-Time Collaboration:** Allowing multiple users to interact with the system simultaneously for improved teamwork and efficiency.

- **Advanced AI Conversations:** Enhancing multi-turn dialogue handling and context retention for a more natural and interactive user experience.
- **Integration with Other Services:** Connecting the system with external applications such as cloud storage, enterprise knowledge bases, and digital assistants to extend its functionality.

7. REFERENCES

- [1] J.N. Singh, Prashat Johri, Kumar, Aneesh Kumar & Muskan Singh (2022), "Wen Information Retrieval Models Techniques and Issues: Survey".
- [2] Mladjan Jovanovic, Mark Campbell (2022), "Generative Artificial Intelligence: Trends and Prospects".
- [3] Ipek Ozkaya (2023), "Application of Large Language Models to Software Engineering Tasks: Opportunities, Risks, and Implications".
- [4] Pavan Kalyan N (2024), "A comprehensive literature review on automated text summarization and evaluation using NLP approaches".

Advanced Footstep Power Generation

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ABSTRACT

Electrical energy is important and had been demand increasingly. A lot of energy resources have been wasted and exhausted. An alternative way to generate electricity by using a population of human had been discovered when walking. Walking is the most common human activity. When a person walks, they lose some energy. This wastage of energy can be used as renewable energy. In our project we propose the "Power Generation by Footstep", the aim of this project is to generate power by making use of piezoelectric to generate power. The system allows for a platform for placing footsteps. The piezo sensors are mounted on the platform to generate voltage from footsteps. The sensors are placed in such an arrangement so as to generate maximum output voltage. This project includes how it utilizes the power generated by footsteps. The aim of this proposed system is to design a non-conventional method of power generation that will augment the increasing requirement.

Keywords: Human Footstep, Piezoelectric Technology, Power Generation.

1. INTRODUCTION

1.1 Overview

Electricity has become an essential part of modern life, powering homes, industries, and technologies. As the global population grows and advancements in technology continue, the demand for electrical energy increases rapidly. However, traditional energy resources like coal, oil, and natural gas are depleting at an alarming rate. Moreover, these conventional energy sources contribute to environmental issues such as air pollution, climate change, and global warming. These challenges call for the development of alternative and renewable energy sources that are both sustainable and environmentally friendly.

One promising solution is to harness energy from everyday human activities, particularly walking. Walking is the most common activity performed by individuals in their daily lives, whether commuting, shopping, or exercising. During walking, mechanical energy is naturally generated and dissipated as waste. This energy can be captured and converted into usable electrical energy, providing an innovative approach to renewable power generation.

there are numerous ways to produce electricity like using wind, hydro, solar, biomass etc. and one of them is a footstep energy generation is the creation of footstep energy which could be a useful technique. The footstep power generation technique through piezoelectric sensors produces electrical force by changing mechanical energy of the movement of individuals on the floor to electrical energy. The benefits of piezoelectric force generation framework is that it is sheltered and secure to utilize, it doesn't make any issue or distress for the general population strolling through footpath, and it is absolutely chance free strategy.??

The "Power Generation by Footstep" project becomes smarter and more efficient with IoT integration. Piezoelectric sensors embedded in the platform generate electricity when people walk on it. This energy is displayed in real-time on an OLED screen, showing the voltage generated, while an LED bulb lights up using the power. IoT enables real-time monitoring of energy output and performance, providing

valuable insights through remote data access. This system is ideal for high-traffic areas, offering a practical and sustainable way to generate and utilize renewable energy while showcasing its benefits instantly.

1.2 Problem Statement

The global demand for electrical energy is escalating rapidly due to population growth and technological advancements. Traditional energy sources are depleting, while their reliance contributes to environmental issues like pollution and climate change. The need for alternative, sustainable, and environmentally friendly energy sources is paramount. Harnessing energy from everyday human activities presents a promising solution in some areas.

1.3 Objectives

- **Renewable Energy Generation:** To create an eco- friendly system that generates electricity using the mechanical energy produced by footsteps.
- **Utilization of Piezoelectric Technology:** To harness the piezoelectric effect for converting footstep pressure into electrical energy efficiently.
- **IoT Integration:** To enable real-time monitoring and display of generated voltage and system performance through IoT technology.

2. LITERATURE REVIEW

K. K. Selim, H. M. Yehia [1], "Human Footsteps-based Energy Harvesting Using Piezoelectric Elements" 2023, This paper's primary goal is to create a floor plan that harnesses the kinetic energy of human footsteps to produce electricity. By using inexpensive materials and a straightforward voltage doubler circuit to power tiny devices like wireless sensors or LED lights, the system seeks to lessen dependency on conventional power sources.

M. Logeshwaran, J. J. J. Sheela [2], "A High- Efficiency Power Generator by Footsteps Using Piezoelectric Effect" 2022, This paper's primary goal is to develop and put into use a piezoelectric generator system that transforms the mechanical energy of human footsteps into electrical power in a way that is both affordable and simple to install. Using piezoelectric sensors buried beneath flooring, the device seeks to capture and store energy. The electricity produced is then stored in a lithium-based battery and enhanced by a DC module for real-world uses, especially in crowded locations.

Selim, K. K., Smaili, I. H., Yehia [3], "Piezoelectric Sensors Pressed by Human Footsteps for Energy Harvesting" 2024, The main objective of this research is to create an affordable floor tile system that uses piezoelectric sensors to capture useful electrical energy from footsteps. With a maximum output of 249.6 milliwatts and a low cost of \$10.2 per tile, the system transforms kinetic energy into electrical energy that is then caught by a rectifying circuit and filter. This demonstrates its ability to power small devices, including LEDs.

W. A. Ching, M. J. Geotina, N. S. Gora [4], "Implementation of Piezoelectric Generator for Harvesting Energy for Different Types of Staircases with Automatic Switching Mechanism," 2018, The main objective of this research is to develop and deploy a renewable energy system that uses piezoelectric transducers to capture electrical energy from a person's footsteps on a freestanding staircase. Parameters such as step density, placement, and staircase height are used to simulate the system. It includes a relay and an inverter-based automatic transfer switch to create an affordable uninterruptible power source, as well as a charging circuit using an LTC3588-1 and XLC6009 boost converter to charge a lead-acid battery. A data logger is used to record the system's output voltage, which fluctuates depending on the parameters that are mentioned.

V. S. P. Nayak, V. S. K. Madasu [5], "Energy harvesting through footstep & it's efficient usage" 2017, This paper's primary goal is to create an environmentally friendly and energy-efficient system that uses piezoelectric crystals to capture mechanical energy, store it in a lead-acid battery, and use it locally to power fans and lightbulbs. As part of the move away from fossil fuels, the system makes effective use of the energy generated by the piezoelectric effect by integrating an Arduino board and a Bluetooth module for wireless control.

H. R. Patel and M. Patel [6], "Modelling of Piezoelectric Harvesting System," 2022, The main objective of this paper is to investigate the potential of piezoelectric materials to capture vibrational or foot energy and transform it into electrical energy. An electrical interface and a piezoelectric transducer make up the system, which controls the power produced. The goal of this technology is to create a sustainable electrical source by harnessing the rhythmic mechanical energy of human movement.

J. N. S. Quispe and A. C. Gordillo [7], "Implementation of an energy harvesting system by piezoelectric elements exploiting the human footsteps," 2017, This study's primary goal is to create an energy harvesting device that uses piezoelectric technology to transform the mechanical energy produced while walking into electrical energy. Low-power electronic devices can be powered by this captured energy.

P. R. Prasad, A. Bhanuja, L. Bhavani, N. Bhoomika and B. Srinivas [8], "Power Generation Through Footsteps Using Piezoelectric Sensors Along with GPS Tracking" 2019, This paper's primary goal is to create an energy collecting system that uses the piezoelectric effect to transform the lost energy from human footsteps into electrical energy. This is accomplished by using a smart shoe with GPS tracking and a network of piezoelectric sensors placed along walkways to power lighting. For a more effective energy generation and utilization system, the suggested model incorporates GPS functionality and compares various streetlight switching strategies.

A. Kamboj, A. Haque, A. Kumar, V. K. Sharma and A. Kumar [9], "Design of footstep power generator using piezoelectric sensors," 2017, This paper's primary goal is to develop a power generation system that captures energy from human footsteps using piezoelectric sensors. Utilizing this energy is the main goal in densely populated countries like China and India, where spaces like streets, train stations, and bus stops are congested. This technology seeks to provide a sustainable and effective power source for such high- traffic locations by transforming the mechanical energy from footsteps into electrical energy.

B. Gadgay, D. C. Shubhangi and H. Abhishek [10], "Foot Step Power Generation Using Piezoelectric Materials," 2021, This paper's primary goal is to present a model that uses piezoelectric sensors to capture energy from human motions like walking, hopping, and running. The mechanical energy of footsteps is captured by the system and transformed into electrical energy, which is then stored for later use, such as charging a cell phone or powering an LED. The approach is especially well-suited for densely populated regions with substantial foot traffic, such as India. In order to encourage environmentally friendly and sustainable energy consumption, the energy produced can also be used for street lights, billboards, gyms, and other public areas.

3. METHODOLOGY

3.1 Block Diagram

Power Generation by Footstep technology is based on the piezoelectric phenomenon, which converts mechanical pressure into electrical energy. Fig 1 shows the block diagram of "Power Generation by Footstep" technology.

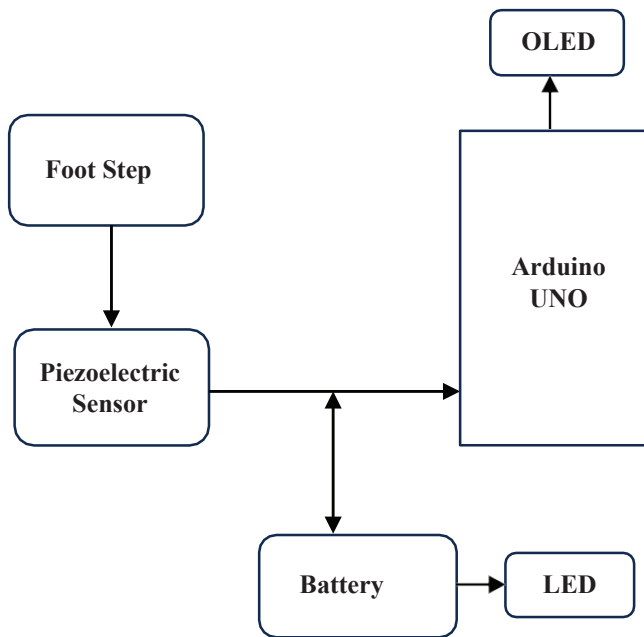


Fig 1: Block Diagram

A plate having piezoelectric sensors embedded in it is connected in parallel to maximize energy production. When footsteps create mechanical stress, the sensors generate electricity. This energy is stabilized by processing through a rectifier circuit and shown in real time on an OLED screen before being utilized to illuminate an LED bulb as a practical demonstration. Additionally, the system's IoT integration allows it to monitor and analyse data such as voltage output and total energy generated, providing a sustainable and innovative approach to renewable energy.

3.2 Functional Requirements

- **Energy Production:** When pressure is applied through footsteps, the system must use piezoelectric sensors to produce electrical energy.
- **The stabilization of voltage:** To create a steady DC voltage that can be used, the generated energy needs to be processed through a rectifier.
- **Monitoring in Real Time:** The generated voltage must be shown in real time on an LED screen by the system.
- **Energy Use:** As a demonstration, the system must use the energy it generates to power tiny gadgets like an LED lamp.
- **IoT Information Gathering:** Data like energy output and foot traffic should be gathered and sent by the system.

3.3 Non-Functional Requirements

- **Reliability:** Under typical usage conditions, the system must reliably produce and process energy.
- **Scalability:** More sensors should be able to be installed on the platform to generate more energy in busy places.
- **Performance:** The system needs to be able to manage constant foot traffic and send data to IoT platforms instantly.
- **Sturdiness:** The platform and sensors need to be strong enough to endure normal environmental factors and mechanical stress.
- **Security:** Secure protocols must be used in IoT connectivity to shield data from unwanted access.
- **Easy to Use:** The LED display, IoT application, and system interface should all be simple to use and intuitive.

- **Efficiency of Energy:** During operation, the system must minimize power loss and maximize energy conversion.
- **Cost-Effectiveness:** The system should balance initial expenses with long-term operational efficiency to assure affordability.

4. WORKING PRINCIPLE

4.1 Circuit Diagram and its Working

The "Power Generation by Footstep" technology converts the mechanical energy of footfall into electrical energy by using piezoelectric sensors. Fig 2 shows the circuit diagram of "Power Generation by Footstep" technology.

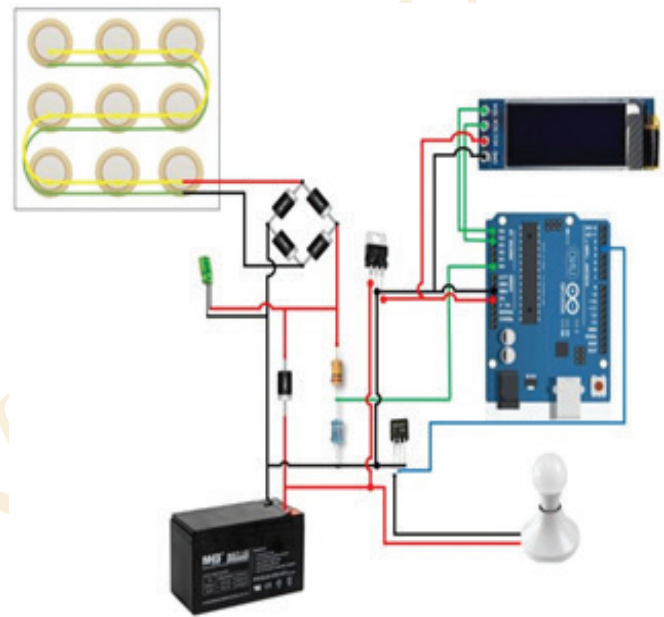


Fig 2: Circuit diagram

The process can be broken down using the following steps:

- **Footstep Platform:** A specially designed platform incorporates piezoelectric sensors. These sensors generate electricity in response to mechanical pressure from footsteps.
- **Piezoelectric Effect:** The piezoelectric sensors are compressed by the weight of a person walking on the platform. Under this pressure, the sensors distort, creating an electric charge, thanks to the piezoelectric effect, which converts mechanical energy into electrical energy.
- **Energy Collection:** The electrical output from the sensors is collected and passed via a rectifier circuit in order to convert the alternating current (AC) that the sensors provide into direct current (DC), which is suitable for powering devices.
- **Voltage Regulation:** To guarantee constant power production, irrespective of changes in pressure or the number of footsteps, the DC voltage is subsequently stabilized using a voltage regulator circuit.
- **Real-Time Display:** An LED panel shows the generated voltage, enabling users to observe the amount of energy produced at each stage. This encourages interaction with the system and offers immediate feedback.
- **Lighting Application:** An LED lightbulb is powered by the stabilized energy, illustrating a useful use of the electricity produced. This demonstrates how small- scale uses of the technology can directly use renewable energy.

4.2 Dataflow Diagram

A data flow diagram (DFD) shows the flow and processing of data within a system. Piezoelectric sensors in the "Power Generation by Footstep" project receive pressure from footsteps, which is then converted into electrical energy by the DFD. In addition to powering a tiny LED light, this energy is stabilized via a rectifier circuit and shown on an LED screen.

Concurrently, information is gathered and transmitted to the Internet of Things system, such as the voltage generated and the number of footsteps. The DFD streamlines the system's architecture by demonstrating how each part cooperates to effectively produce and track energy. Figure 4.2 shows the dataflow diagram of "Power Generation by Footstep" technology.

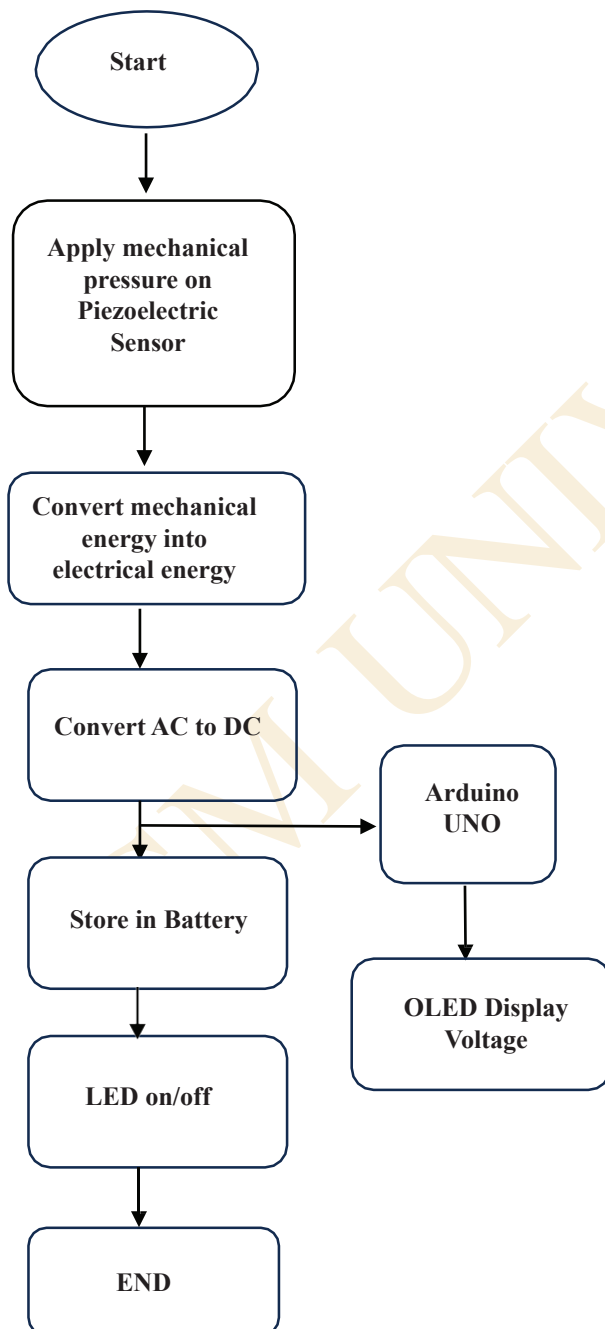


Fig 3: Dataflow Diagram

5. SYSTEM REQUIREMENTS

5.1 Software and Hardware Requirements Hardware Requirements

Processor : Intel Core 2 DUO or higher.
 RAM : 8 GB or more.
 HDD : 100 GB or more. Keyboard
 Mouse OLED
 Power Supply
 Arduino UNO
 35mm piezoelectric disc
 Bc547 transistor
 1n4007 diode
 10uf capacitor
 10k ohm resistor
 100k ohm resistor
 Jumper wires
 General PCB board
 12V, 7Ah Lead acid Battery

Software Requirements

Operating System : Windows 11
 Software : Arduino IDE

5.2 Tools and Technologies Used

● Arduino UNO

The Arduino UNO is one of the standard Arduino boards. The Italian word for UNO is "one." The original version of the Arduino software was called UNO. It was also the first Arduino USB board. It is used for a variety of jobs and is thought to be a powerful board. Arduino.cc developed the Arduino UNO board. The Arduino UNO is built on top of the ATmega328P CPU. It is easier to use than other boards, such as the Arduino Mega board, etc. The board consists of digital and analog input/output (I/O) pins, shields, and other components. The Arduino UNO has a USB port, a power jack, six analog pin inputs, fourteen digital pins, and an ICSP (In-Circuit Serial Programming) header. Its programming is based on the Integrated Development Environment, or IDE for short. It works with both offline and online venues. Fig 4 shows the Arduino UNO microcontroller board.

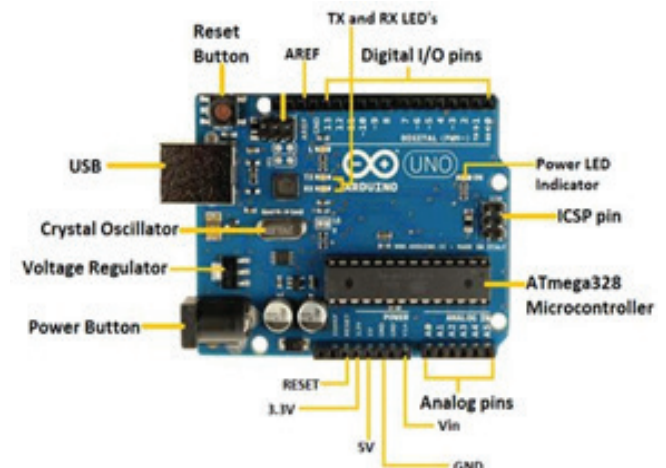


Fig 4: Arduino UNO

Applications of Arduino Uno

DIY project prototype.

Creating a wide range of projects that call for code-based control.

Development of automation systems. Gaining knowledge of AVR programming. Circuit design at the entry level.

● Piezoelectric Disc

A 35mm piezoelectric disc is a small, circular device that uses the piezoelectric effect to convert mechanical vibrations into electrical signals or electrical signals into mechanical vibrations. Usually found in buzzers, sensors, and ultrasonic devices, it is composed of a metal substrate that is coupled to a piezoelectric ceramic layer. Fig 5 shows the picture of 35mm Piezoelectric disc.



Fig 5: 35mm Piezoelectric Disc

These discs' strength, small weight, and high sensitivity make them ideal for applications including energy harvesting, vibration sensing, and sound production.

Because of their effectiveness and compact size, they are a popular choice in many mechanical and electronic systems.

● OLED Display

An OLED (Organic Light-Emitting Diode) display is a cutting-edge screen technology that uses organic molecules to emit light when an electric current passes through them. Because OLED displays don't require a backlight because each pixel emits its own light, they are lighter, smaller, and use less energy than conventional OLED displays. Fig 6 shows the picture of OLED display.

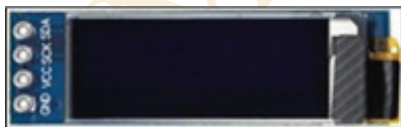


Fig 6: OLED Display

OLEDs are ideal for high-quality visual experiences because of their self-emissive property, which allows them to produce striking contrast ratios, deep blacks, and vibrant colours. Curved, foldable, and even transparent screens—which are utilized in wearables, smartphones, TVs, and car displays—have been made possible by OLED technology, revolutionizing display design. Despite disadvantages like greater cost and potential burn-in issues, OLEDs are widely acknowledged as a leading display technology because to their outstanding performance and design versatility.

Important features

- Self-emitting pixel types: Light is released independently by each pixel.
- High Contrast Ratio: Creates true blacks by turning off individual pixels.
- Wide Viewing Angles: There is little colour distortion from different angles.
- Thin and Flexible: It can be made extremely thin or flexible for imaginative designs.

Applications:

- Applications: Consumer electronics include devices such as cell phones, TVs, laptops, and smartwatches.
- Fitness trackers and health monitoring devices are examples of wearable technology.
- Automotive displays include instrument clusters and infotainment screens.
- The industrial and medical sectors utilize specialized equipment with small screens.

● Transistor BC 547

A popular NPN bipolar junction transistor (BJT), the BC 547 is mainly used for low- to medium-power switching and amplification applications. It is frequently seen in electronic circuits with tiny signals, such as switching circuits, oscillators, and amplifiers. Fig 7 shows the picture of Transistor BC 547.

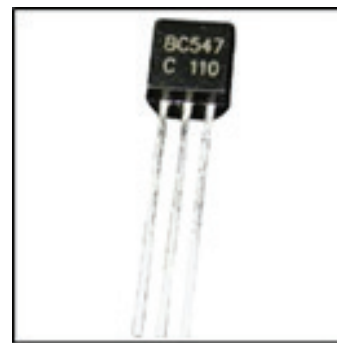


Fig 7: Transistor BC 547

Important Features:

- Type: NPN transistor, which consists of two N-type layers sandwiched by a P-type semiconductor layer.
- Voltage Rating: 45V is usually the maximum collector-emitter voltage (V_{ce}).
- Current Rating: A collector's maximum current (I_c) is around 100 mA.
- Power Dissipation: 500mW is the maximum power dissipation.
- Gain (hFE): Depending on the model, this value is usually between 110 and 800.

Applications:

- Amplifiers: Used to boost weak signals in tiny signal amplifiers.
- Switching Circuits: In logic circuits, they can function as switches to turn on or off current flow.
- Signal processing: utilized in radio-frequency applications, tone generators, and filters.

● Lead-Acid Battery

In the advanced footstep power generation system, the energy storage component is a lead-acid battery. Its main function is to store the DC power that is obtained after rectifying the AC power generate by Piezoelectric discs. Fig 8 shows the picture of 7AH, 12V Lead -acid battery.



Fig 8: Lead-Acid Battery 7AH, 12V

When necessary, this stored energy can be used as backup power or to power the load later. Because of their affordability, dependability, and capacity for long discharge cycles, lead-acid batteries are frequently utilized in renewable energy systems. This system's 7AH battery can effectively store energy for long periods of time, which makes it appropriate for household use, small-scale renewable energy projects, and off-grid applications.

● 1N4007 Diode

The 1N4007, a rectifier diode that belongs to the 1N400x series, is widely used for general-purpose applications. Converting alternating current (AC) to direct current (DC) is its primary power supply function, ensuring stable operation in circuits with low to moderate power. The 1N4007 is a versatile, reliable, and inexpensive component commonly used in power supplies, rectifiers, and various protection circuits. Fig 9 shows the picture of 1N4007 diode.



Fig 9: 1N4007 Diode

Key Features:

- A rectifier diode is the kind of diode that converts AC to DC.
- Often referred to as the peak inverse voltage (PIV), 1000V is the largest reverse voltage that a diode can tolerate before failing.
- The average forward current, or 1A, is the highest continuous current that can flow through the diode while it is forward biased.
- Forward Voltage Drop: 0.7V is the typical value when conducting electricity.
- Because of its comparatively slow recovery time, reverse recovery time is not advised for high-frequency applications.

● Capacitor

The 10 μ F 16V capacitor is a high-end radial polarized electrolytic capacitor that is perfect for applications that need durability and dependability. Because it is an electrolytic capacitor, it is ideal for circuits that need a tiny form factor with moderate to high capacitance. It is suited for a number of power supply applications due to its 16V voltage rating, which allows it to tolerate a broad range of working settings. Fig 10 shows the picture of 10uF capacitor.

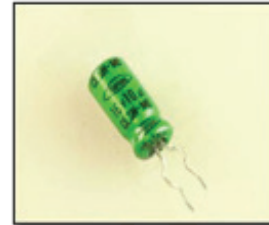


Fig 10: 10uF Capacitor

Important features:

- The capacitance is 10 μ F.
- The voltage rating is 16V; larger voltages can be handled safely.
- Type: Radial-polarized electrolytic capacitor.
- Qualitative attributes:
- Long Life: Ensures durability over prolonged use.
- Minimal Leakage Current: Lowers the waste of circuit energy.
- Wide Operating Range: Performs well in a variety of environmental conditions and temperatures.

● Resistor

A resistor is a passive electrical component that provides a resistance, limiting or controlling the amount of current that flows through a circuit. Fig 11(a) shows the picture of 10K ohm resistor and Fig 11(b) shows the picture of 100K ohm resistor.

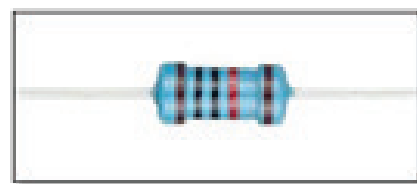


Fig 11(a): 10K ohm Resistor

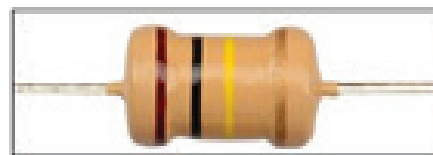


Fig 11(b): 100K ohm Resistor

Many electrical applications, such as voltage dividers, pull-up/pull-down topologies, and signal conditioning, commonly use these types of resistors. A resistor is a versatile and widely used component in both analog and digital electronic circuits, providing consistent performance in a compact design.

Key features:

- Resistance value: 10,000 ohms (10K Ω), 1,00,000 ohms (100K Ω).
- Power Rating: This typically ranges from 1/8W to 1W, depending on the type.
- Common tolerances are $\pm 1\%$ for precision and $\pm 5\%$ for standard.

• Types:

1. Carbon film is inexpensive and widely used.
2. Metal Film: More precision and stability.
3. Wire-Wound: For uses when additional power is needed.

● Jumper Wires

Jumper wires are essential components in electronics and prototyping, serving as flexible connectors to establish electrical connections between various components on a breadboard, circuit board, or electronic module. Fig 12 shows the picture of jumper wires.

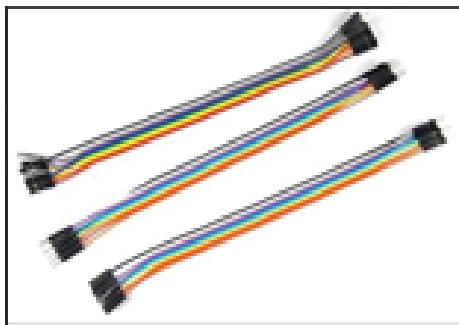


Fig 12: Jumper Wires

These wires typically consist of a conductor, often copper, encased in insulation, which can be made of plastic or rubber. They come in various lengths, colours, and gauges to suit different applications and preferences. The primary purpose of jumper wires is to facilitate the quick and temporary connection of electronic components during prototyping, experimentation, or troubleshooting processes. They enable engineers, hobbyists, and students to build circuits rapidly without the need for soldering, offering flexibility and ease of use. In addition to their role in prototyping, jumper wires are also used for creating custom connections in electronic projects, extending signals between components, and bridging gaps on a breadboard or PCB layout. Their versatility makes them indispensable tools in electronics laboratories, classrooms, and maker spaces.

Jumper wires are available in various types, including

1. Male-to-Male Jumper Wires: These jumper wires have pins or probes on both ends, allowing for direct connection between components.
2. Male-to-Female Jumper Wires: Male-to-female jumper wires have a pin or probe on one end and a socket or receptacle on the other. They are commonly used to connect components with different interfaces.
3. Female-to-Female Jumper Wires: These wires have sockets or receptacles on both ends, enabling connections between components with female interfaces, such as between two header pins or two components with male pins.

● Arduino IDE

The Arduino Integrated Development Environment – or Arduino Software (IDE) contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them. Fig 13 shows the picture of Arduino IDE.



Fig 13: Arduino IDE

The structure of the Arduino IDE

1. Menu Bar: Gives you access to the tools needed for creating and saving Arduino sketches.
2. Verify Button: Compiles your code and checks for errors in spelling or syntax.
3. Upload Button: Sends the code to the board that's connected such as Arduino Uno in this case. Lights on the board will blink rapidly when uploading.
4. New Sketch: Opens up a new window containing a blank sketch.
5. Sketch Name: When the sketch is saved, the name of the sketch is displayed here.
6. Open Existing Sketch: Allows you to open a saved sketch or one from the stored examples.
7. Save Sketch: This saves the sketch you currently have open.
8. Serial Monitor: When the board is connected, this will display the serial information of your Arduino
9. Code Area: This area is where you compose the code of the sketch that tells the board what to do.
10. Message Area: This area tells you the status on saving, code compiling, errors and more.
11. Text Console: Shows the details of an error messages, size of the program that was compiled and additional info.
12. Board and Serial Port: Tells you what board is being used and what serial port it's connected to.

Features of Arduino IDE

- The project file or the sketches for a project are saved with the file extension (.ino)
- Features such as cut / copy / paste are supported in this IDE.
- There also is a facility for finding a particular word and replacing it with another by pressing the Ctrl + F buttons on the keyboard
- The most basic part or the skeleton of all Arduino code will have two functions

6. ADVANTAGES, DISADVANTAGES and APPLICATIONS

6.1 Advantages

- **Renewable Energy Source:** Produces useful electrical energy from the mechanical energy wasted by footfall.
- **Eco-friendly:** Promotes sustainability by lowering dependency on non-renewable energy sources.
- **IoT Integration:** Efficiency and usability are improved by real-time monitoring and analysis.
- **Compact and Scalable:** Requires little space and may be readily deployed in busy locations.
- **Raising awareness:** Motivates individuals to adopt sustainable and energy-saving behaviours.
- **Cost-effective:** It is appropriate for long-term use due to its low operating expenses following initial setup.

6.2 Disadvantages

- **Low Energy Output:** For high-power applications, the energy produced per footstep is insufficient and comparatively tiny.
- **Initial Cost:** Piezoelectric sensor and Internet of Things component installation might be costly.
- **Wear and Tear:** Prolonged mechanical stress can shorten platforms' and sensors' lifespans.
- **Dependency on Foot movement:** Regular, heavy foot movement is essential to the production of energy.
- **Energy Storage Requirement:** To store energy for later use, more components are needed, which makes the system more complex.

6.3 Application

- **Public Spaces:** Busy locations for lighting or powering tiny gadgets, such as shopping centers, train stations, airports, and stadiums.
- **Educational Institutions:** To promote renewable energy practices and increase awareness, schools and universities should become involved.
- **Smart Cities:** Including energy harvesting and real-time monitoring into smart infrastructure.
- **Events and Exhibitions:** Presenting ideas related to renewable energy at science fairs or environmentally friendly exhibitions.
- **Remote Areas:** Offering low-power options in places where traditional energy sources are scarce.

7. RESULTS

The construction of an Advanced Footstep Power Generation an innovative and sustainable approach to harnessing kinetic energy from the humans' footstep. By integrating piezoelectric devices into flooring systems can contribute to sustainable urban development by reducing reliance on traditional energy sources.

Fig 14(a) shows the piezoelectric device module, Fig 14(b) shows the circuit connections, Fig 14(c) shows the stress applied on piezoelectric devices, Fig 14(d) shows the maximum recorded volts and Fig 14(e) shows the load is ON

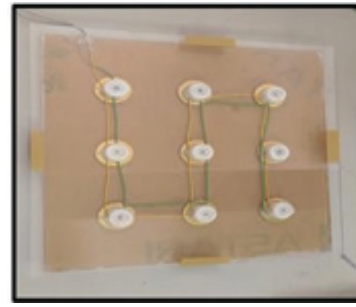


Fig 14(a): Piezoelectric device module



Fig 14(b): Circuit connections



Fig 14(c): Stress applied on piezoelectric devices

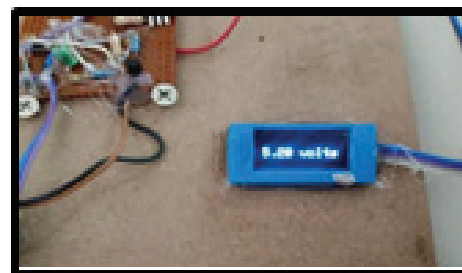


Fig 14(d): Maximum recorded volts



Fig 14(e): Load is ON

8. CONCLUSION

The "Power Generation by Footstep" project offers an innovative and sustainable way to meet the growing demand for electricity by harnessing energy from everyday human activities like walking. Using piezoelectric sensors, the device efficiently converts mechanical energy into electrical energy without interfering with regular operations. This technology is ideal for areas with high foot traffic, like shopping malls, public transportation hubs, and walkways. It is also safe and environmentally friendly. The Internet of Things integration enhances the system's performance by offering remote access to real-time energy output monitoring and analysis. In addition to improving energy efficiency, this increases awareness of renewable energy sources.

In conclusion, this study presents an innovative, practical, and clean way to generate electricity. By combining IoT and piezoelectric technology, it illustrates how renewable energy sources may be leveraged to address global energy challenges while promoting sustainability and environmental responsibility.

9. FUTURE SCOPE

- **Improved Energy Storage:** creation of effective energy storage devices, such cutting-edge batteries, to store the produced electricity for later use.
- **Broad-Based Execution:** To optimize energy production, the system should be extended to public areas such as train stations, airports, shopping centers, and crowded sidewalks.
- **Integration of IoT and AI:** maximizing sensor location and efficiency by using AI to analyze foot traffic patterns and IoT for comprehensive energy monitoring.
- **Applications for Smart Cities:** integrating the technology into smart cities to supply energy to sensors, lamps, and other Internet of Things devices in metropolitan settings.
- **Awareness and Education:** installing the system to raise awareness of renewable energy and teach about sustainable technology in educational institutions, museums, and exhibition spaces.
- **Enhanced Sensor Performance:** investigating and applying cutting-edge piezoelectric materials to improve durability and energy conversion rates.
- **Systems that are hybrid:** To increase production, footstep power generation can be combined with other renewable energy sources, such as solar or wind, to form a hybrid energy system.
- **Analytics of Data:** utilizing system data to investigate real-time human traffic patterns and energy usage patterns.
- **Applications in Remote and Rural Areas:** installing the system in isolated locations to offer a renewable energy source in places with limited access to traditional power sources.
- **Applications in Fitness and Health:** utilizing the technology at fitness centers or gyms to capture energy from exercise routines like treadmill walking or jogging.

10. REFERENCES

- [1] K. K. Selim, H. M. Yehia and S. Abdalfatah, "Human Footsteps-based Energy Harvesting Using Piezoelectric Elements," 2023 International Telecommunications Conference (ITC-Egypt), Alexandria, Egypt, 2023, pp. 140-144.
[doi: 10.1109/ITC-Egypt58155.2023.10206103](https://doi.org/10.1109/ITC-Egypt58155.2023.10206103).
- [2] M. Logeshwaran, J. J. J. Sheela and A. Parvathi Priya, "A High-Efficiency Power Generator by Footsteps Using Piezoelectric Effect," 2022 Second International Conference on Artificial Intelligence and Smart Energy (ICAIS), Coimbatore, India, 2022, pp. 1547-1553.
[doi:10.1109/ICAIS53314.2022.9742855](https://doi.org/10.1109/ICAIS53314.2022.9742855).
- [3] Selim, K. K., Smaili, I. H., Yehia, H. M., Ahmed, M. M. R., & Saleeb, D. A. (2024). Piezoelectric Sensors Pressed by Human Footsteps for Energy Harvesting. *Energies*, 17(10), 2297.
<https://doi.org/10.3390/en17102297>.
- [4] W. A. Ching, M. J. Geotina, N. S. Gora, R. J. Sucayre, R. V. M. Santiago and J. M. Martinez, "Implementation of Piezoelectric Generator for Harvesting Energy for Different Types of Staircases with Automatic Switching Mechanism," 2018 IEEE 10th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management (HNICEM), Baguio City, Philippines, 2018, pp. 1-6.
[doi: 10.1109/HNICEM.2018.8666232](https://doi.org/10.1109/HNICEM.2018.8666232).
- [5] V. S. P. Nayak, V. S. K. Madasu, T. S. Nag and N. G. N. Laxmi, "Energy harvesting through footstep & it's efficient usage," 2017 2nd IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT), Bangalore, India, 2017, pp. 2157-2159.
[doi: 10.1109/RTEICT.2017.8256982](https://doi.org/10.1109/RTEICT.2017.8256982).
- [6] H. R. Patel and M. Patel, "Modelling of Piezoelectric Harvesting System," 2022 7th International Conference on Communication and Electronics Systems (ICCES), Coimbatore, India, 2022, pp. 65-71.
[doi: 10.1109/ICCES54183.2022.9835893](https://doi.org/10.1109/ICCES54183.2022.9835893).
- [7] J. N. S. Quispe and A. C. Gordillo, "Implementation of an energy harvesting system by piezoelectric elements exploiting the human footsteps," 2017 IEEE URUCON, Montevideo, Uruguay, 2017, pp. 1-4.
[doi: 10.1109/URUCON.2017.8171873](https://doi.org/10.1109/URUCON.2017.8171873).
- [8] P. R. Prasad, A. Bhanuja, L. Bhavani, N. Bhoomika and B. Srinivas, "Power Generation Through Footsteps Using Piezoelectric Sensors Along with GPS Tracking," 2019 4th International Conference on Recent Trends on Electronics, Information, Communication & Technology (RTEICT), Bangalore, India, 2019, pp. 1499-1504.
[doi: 10.1109/RTEICT46194.2019.9016865](https://doi.org/10.1109/RTEICT46194.2019.9016865).

[9] A. Kamboj, A. Haque, A. Kumar, V. K. Sharma and A. Kumar, "Design of footstep power generator using piezoelectric sensors," 2017 International Conference on Innovations in Information, Embedded and Communication Systems (ICIIECS), Coimbatore, India, 2017, pp. 1-3.

doi: [10.1109/ICIIECS.2017.8275890](https://doi.org/10.1109/ICIIECS.2017.8275890).

[10] B. Gadgay, D. C. Shubhangi and H. Abhishek, "Foot Step Power Generation Using Piezoelectric Materials," 2021 IEEE International Conference on Computation System and Information Technology for Sustainable Solutions (CSITSS), Bangalore, India, 2021, pp. 1-5.

doi: [10.1109/CSITSS54238.2021.9682844](https://doi.org/10.1109/CSITSS54238.2021.9682844).

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Generation of Electricity Using Waste Materials

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ABSTRACT

This project focuses on the generation of electricity through the combustion of waste materials, offering both energy production and waste management solutions. By burning various waste materials, including municipal solid waste, agricultural residues, and industrial by-products, heat is generated to produce electricity. The study aims to optimize combustion processes for maximum energy efficiency while minimizing harmful emissions. It also explores the environmental benefits, such as reducing landfill waste and lowering greenhouse gas emissions. This approach presents a sustainable way to meet energy demands while promoting effective waste disposal and contributing to cleaner energy alternatives.

Keywords: Generation of electricity, Environmental benefits, Energy efficiency.

1. INTRODUCTION

The generation of electricity from waste materials is an innovative and sustainable solution to the dual challenges of waste management and energy production. As the global population grows and urbanization increases, waste generation and energy demand are both on the rise. Traditional waste disposal methods such as landfilling and open burning contribute significantly to pollution, while also wasting valuable energy resources. Converting waste into electricity provides a solution that not only reduces the environmental impact of waste but also generates a renewable energy source. This approach helps mitigate greenhouse gas emissions, reduces reliance on fossil fuels, and promotes resource efficiency, making it a key strategy in sustainable development.

Several technologies are employed to convert waste into electricity. Incineration, one of the most common methods, involves burning waste at high temperatures to produce heat, which is used to generate steam. The steam drives turbines connected to generators, producing electricity. Modern waste-to-energy (WTE) plants are equipped with advanced pollution control systems to minimize harmful emissions, and they also recover metals from the waste that can be recycled, further enhancing sustainability. Another method is anaerobic digestion, which processes organic waste such as food scraps, agricultural residues, and sewage to produce biogas, primarily methane. This methane is captured and used to generate electricity through gas engines or turbines. Biogas production is especially effective in rural areas or at wastewater treatment plants, where organic waste is abundant.

Landfill gas recovery is another important process for generating electricity. As organic waste decomposes in landfills, it produces methane, which is a potent greenhouse gas. By capturing and using this methane, landfill gas recovery systems help reduce emissions while generating electricity. Gasification is another method that involves heating waste materials in a low-oxygen environment to produce a synthetic gas (syngas), which can be used to generate power. Unlike incineration, gasification results in fewer pollutants and a cleaner residual ash. Similarly, pyrolysis involves heating waste at high temperatures in the absence of oxygen, producing gases, liquids, and solid char that can be used for energy generation.

This method is versatile and can handle various waste materials, including plastics and rubber.

Emerging technologies, such as thermoelectric conversion, seek to directly convert heat from waste materials into electricity. Although still in the research phase, thermoelectric generators offer a promising solution for utilizing waste heat from incineration, landfills, or industrial processes to generate electricity. While these technologies continue to evolve, they have the potential to complement existing waste-to-energy systems, contributing to more efficient and decentralized energy generation.

There are several advantages to generating electricity from waste materials. First, it provides a renewable energy source, as waste is a constant and often abundant resource, particularly organic waste. By converting waste into electricity, we reduce the amount of waste that would otherwise end up in landfills, helping mitigate the environmental challenges of waste disposal. Additionally, waste-to-energy technologies reduce greenhouse gas emissions by capturing methane from landfills and preventing the release of harmful pollutants associated with fossil fuel combustion. This contributes to climate change mitigation efforts and supports global sustainability goals.

Another benefit is enhanced energy security. By utilizing locally available waste, communities can reduce their dependence on imported fossil fuels, which can fluctuate in price and availability. Waste-to-energy systems can provide decentralized power, making them more resilient to disruptions in the global energy supply. Furthermore, these systems create economic opportunities, from job creation in waste management and power generation to potential revenue streams for local governments through the sale of electricity or renewable energy credits.

Despite its advantages, generating electricity from waste materials also faces challenges. The initial capital investment for waste-to-energy plants can be high, and the technology involved can be complex. There is also public concern regarding air quality and health impacts, particularly in areas where incineration is used. Moreover, waste sorting and collection can present logistical difficulties, especially in regions with limited infrastructure. To overcome these challenges, further research is being conducted to improve the efficiency and scalability of waste-to-energy.

2. METHODOLOGY

Below Fig 3.1 shows the block diagram of generation of electricity by waste materials. This block diagram exemplifies how waste-to-energy (WTE) technology can transform discarded materials into a renewable energy source. The components work in tandem to ensure efficient energy conversion, storage, and utilization. The project not only provides a sustainable electricity solution but also highlights an innovative way to manage waste materials effectively. The block diagram consists of fire box, heating panel, voltmeter, temperature sensor, solar charge controller, storage battery, LED Bulb, supply circuit.

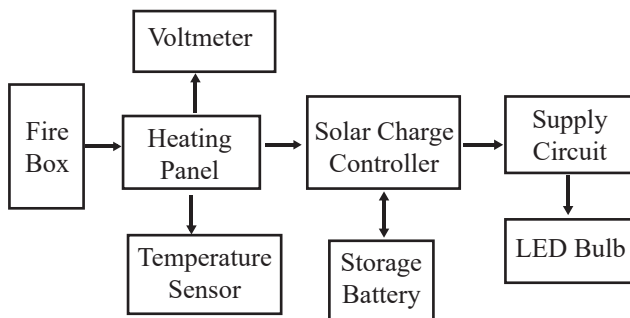


Fig 3.1: Block Diagram of Generation of Electricity Using Waste Materials

Fire Box: It acts as a combustion chamber where waste materials are burned to release thermal energy. The design ensures optimal burning with minimal emissions. The fire box is insulated to prevent heat loss, ensuring maximum transfer of heat to the heating panel. Some fireboxes can also incorporate a gasification process, where waste is converted into a combustible gas, enhancing efficiency.

Heating Panel: This component absorbs heat from the firebox and transfers it to a working medium, such as water, to generate steam. The steam can drive turbines to produce electricity. Alternatively, thermoelectric materials in the panel convert heat directly into electricity through the Seebeck effect. It may also serve as a heat exchanger, ensuring efficient heat transfer to subsequent stages like energy storage or thermodynamic systems.

Voltmeter: It continuously monitors the voltage output of the system to ensure it operates within safe limits. The voltmeter helps diagnose faults in the system by detecting irregular voltage levels. It assists in optimizing the system's efficiency by providing real-time feedback on power generation.

Temperature Sensor: Tracks the temperature inside the firebox to prevent overheating and ensure the system's safety. Provides data for system efficiency, as optimal combustion occurs within a specific temperature range. Can also automate control systems by signaling when to add waste materials or adjust airflow.

Solar Charge Controller: Regulates the flow of electricity from the heating panel to the battery, preventing overcharging, which can damage the battery. Manages power distribution between the storage battery and the output circuit, ensuring a steady supply of electricity. It can include Maximum Power Point Tracking (MPPT) to optimize the energy flow and reduce losses.

Storage Battery: Stores the electrical energy generated for use during non-operational periods, such as when the waste material supply is exhausted. Provides a steady power supply to the output circuit, even when there are fluctuations in energy generation. Acts as a backup power source in case of system failure. Common types of storage batteries include lead-acid, lithium-ion, and nickel-cadmium, widely used in applications like vehicles, renewable energy systems, and portable electronics.

3. WORKING PRINCIPLE

- The electricity generation system using waste materials begins with burning waste in a fire box, where the combustion process generates significant heat energy.
- Surrounding the fire box, heating panels capture this heat, transferring it to thermoelectric generators (TEGs) that convert the thermal energy into electrical energy through the Seebeck effect.
- The voltmeter measures the generated electrical voltage, ensuring it is within the desired range for safe operation. Meanwhile, a temperature sensor continuously monitors the heat levels, ensuring the system does not overheat and operates within safe temperature limits.
- The electrical energy produced is stored in a storage battery, which is regulated by a solar charge controller to prevent overcharging and undercharging, ensuring the battery's longevity.
- The stored energy is then distributed through the supply circuit to power various devices, such as LED bulbs, which serve as visual indicators of the system's operation. When the system generates energy, the LED bulb glows, confirming that the process is working as intended.
- This integrated system efficiently converts waste heat into usable electrical energy, with multiple control mechanisms in place to ensure safety, optimal performance, and continuous power supply.

4. COMPONENT REQUIREMENTS

- Heating Panels
- Temperature Sensor
- Voltmeter
- LCD Display
- Resistor
- Solar Charge Controller
- DC Battery
- LED Bulb
- Bulb Holders
- On/Off Switch

4.1 Heating Panels

Specification: 5V

Heating panels are an integral component in the process of generating electricity from waste materials. They serve as the medium to absorb and convert thermal energy, which can be harnessed from industrial waste, biogas, solar energy, or other heat-producing processes. The fundamental purpose of heating panels is to capture otherwise wasted heat and utilize it in generating electricity, particularly through thermoelectric conversion. This form of energy generation is especially valuable as it allows for the recovery of energy that would otherwise be lost, providing an efficient and environmentally friendly solution to energy needs.

In the context of waste-to-energy systems, heating panels not only increase the overall efficiency of energy recovery but also offer a sustainable way of utilizing renewable energy. This can be particularly beneficial in industrial settings where large amounts of waste heat are constantly produced but not effectively used.

4.2 Temperature Sensor

Temperature sensors play a crucial role in the process of generating electricity from waste materials, especially in waste-to-energy (WTE) plants and biogas production systems. These sensors monitor and control various parameters of the system, ensuring that the temperature remains within optimal ranges for energy generation and efficient operation. It is explained below how temperature sensors are utilized in the generation of electricity from waste materials:

- **Waste-to-Energy (WTE) Plants:** In Waste-to-Energy plants, organic waste (such as municipal solid waste) is processed through various methods like incineration, pyrolysis, or gasification to generate electricity. Temperature sensors are essential in these processes, particularly during combustion and heat exchange stages. Here's how they contribute to electricity generation:

- **Monitoring Combustion Temperature:** In incineration, waste materials are burned at high temperatures to produce heat, which is then converted into steam. Temperature sensors are used to monitor the combustion chamber's temperature to ensure that the process occurs at the right conditions. Overheating or underheating can result in inefficient energy conversion or damage to equipment.

- **Controlling Steam Temperature:** Once the waste material is burned, the heat is used to convert water into steam. Temperature sensors are installed in the boiler to regulate the steam temperature. Accurate readings ensure that the steam is at the correct pressure and temperature to drive the turbine that generates electricity.

- **Heat Recovery Systems:** In some WTE plants, a heat recovery steam generator (HRSG) is used to capture excess heat. Temperature sensors monitor the heat levels in these systems, preventing overheating and ensuring efficient operation of the turbine and electricity generation.

Working Temperature Sensors in Electricity Generation from Waste Materials:

- **Sensing Temperature Changes:** Temperature sensors such as RTDs, thermocouples, or thermistors are used in various parts of waste-to-energy systems to monitor temperature changes. These sensors detect the temperature variations in gases, liquids, or solids involved in the process and provide real-time data to the control systems.

- **Temperature Control:** In waste-to-energy plants, the temperature needs to be carefully controlled to optimize energy output and prevent system failure. Temperature sensors send data to the control system, which adjusts heating, cooling, and combustion processes accordingly. This ensures that the temperature stays within an optimal range for efficient energy conversion.

- **Feedback Mechanism:** The sensors send feedback to the control systems, which automatically adjust parameters such as fuel input, combustion air supply, or heat exchange rates. For example, if the temperature of the combustion chamber is too low, the control system may increase the amount of

waste material or combustion air to raise the temperature and maintain efficiency.

4.3 Voltmeter

A voltmeter is an electrical device that measures the potential difference, or voltage, between two points in a circuit. It is typically connected in parallel with the component whose voltage is being measured. In modern electrical systems, voltmeters are usually digital or analog devices. They can measure voltage in a variety of systems, including alternating current (AC) and direct current (DC) circuits.

The voltmeter's role is crucial in any power generation system, especially in systems that involve the conversion of waste materials into usable energy. The accuracy and reliability of a voltmeter ensure that the system operates within its designed voltage range, preventing underperformance or damage to equipment.

Role of Voltmeter in Waste-to-Energy (WTE) Plants: Waste-to-Energy (WTE) plants convert non-recyclable waste into electricity through processes like incineration, pyrolysis, or gasification. In these plants, voltmeters are used to monitor the voltage levels in various stages of the energy conversion process.

4.4 LCD Display

Liquid Crystal Displays (LCDs) have become integral components in various electronic devices, including those used in power generation systems, such as waste-to-energy (WTE) plants and biogas generation systems. In these applications, an LCD display is not just a visual interface, but a critical component that helps monitor, control, and optimize energy production processes. This article explores the role of LCD displays in the generation of electricity from waste materials, detailing their applications in energy production systems like WTE and biogas plants.

LCDs consist of several layers, including a backlight (usually LED), a polarizer, liquid crystal material, and electrodes. The liquid crystals are aligned in such a way that they can control the passage of light, creating the desired image or text on the display. The transparency of the liquid crystals changes when an electrical current is applied, allowing or blocking light in different areas of the display.

In the context of power generation from waste materials, LCDs serve as the user interface for monitoring real-time data from the energy conversion process. They provide a visual display of important parameters such as voltage, temperature, pressure, and power output, allowing operators to keep track of system performance and make informed decisions.

4.5 Resistor

Specification: 100ohm

A resistor is a fundamental passive electronic component that limits or regulates the flow of electrical current in a circuit. It works based on the principle of Ohm's Law, which states that the voltage (V) across a resistor is directly proportional to the current (I) passing through it and inversely proportional to its resistance (R). The unit of resistance is the ohm (Ω), and a resistor is often used to control current, divide voltages, and protect components in electrical circuits.

4.6 Solar Charge Controller

A solar charge controller is a device used in solar power systems to manage the power that flows from the solar panels to the storage batteries. It regulates the charging process by

adjusting the voltage and current supplied to the battery, ensuring that the battery is charged safely and efficiently without being overcharged or over-discharged. In off-grid solar systems, a solar charge controller is crucial for maintaining the optimal performance of the battery bank, which stores the energy generated by the solar panels for use when sunlight is not available.

There are two main types of solar charge controllers:

- **Pulse Width Modulation (PWM) Controllers:** PWM controllers are simple and cost-effective, adjusting the charging voltage in a stepwise manner. They are typically used in smaller solar power systems.
- **Maximum Power Point Tracking (MPPT) Controllers:** MPPT controllers are more advanced and efficient, continuously adjusting the charging voltage to maximize the power output from the solar panels. They are commonly used in larger solar installations and are suitable for applications that require higher efficiency.

4.7 DC Battery

Specification: 12V, 1500mAh

A DC battery is a device that stores electrical energy in the form of direct current. In a typical battery, chemical reactions occur between the electrolyte and the electrodes to generate an electric charge. This charge flows from the negative terminal (anode) through the external circuit to the positive terminal (cathode), providing energy for the connected load. The electric current flows in one direction, hence the term direct current (DC). DC batteries can be rechargeable or non-rechargeable, with rechargeable batteries being more commonly used in modern applications. A significant advantage of DC batteries is their ability to supply a consistent voltage and current, which is essential for most electronic and electrical systems.

4.8 LED Bulb

An LED bulb is a lighting device that uses a semiconductor material to convert electricity into light. The key component in an LED bulb is the light-emitting diode (LED), a semiconductor that emits light when current flows through it. Unlike traditional lighting sources, which rely on heating a filament or exciting gases, LEDs produce light through an electroluminescent process in which electrons pass through the semiconductor material and release energy in the form of photons (light).

LED bulbs are typically more energy-efficient and have a longer lifespan compared to conventional lighting options like incandescent or compact fluorescent lamps (CFLs). This efficiency is due to the nature of LEDs, which do not waste energy as heat, making them a far more economical and environmentally friendly option.

4.9 Bulb Holders

A bulb holder is an essential electrical component used to secure a light bulb in place and connect it to an electrical circuit. It serves as the interface between the light bulb and the electrical supply, ensuring that the bulb receives power to operate and remains securely attached to its fixture. Bulb holders are commonly found in homes, offices, industrial spaces, and other lighting applications where light bulbs are used. The design and functionality of a bulb holder depend on the type of light bulb it is intended to support and the specific requirements of the lighting system.

4.10 On/Off Switch

An on/off switch is a crucial component in electrical systems, allowing users to control the flow of electricity to electrical devices. It provides a simple way to either connect (turn on) or disconnect (turn off) the electrical circuit, ensuring safe operation and convenience. In the on position, the switch closes the circuit, allowing electricity to flow through and power the connected device. In the off position, it opens the circuit, stopping the flow of electricity and turning the device off. This basic function is essential in controlling electrical appliances, lighting, and industrial equipment.

4. RESULTS AND DISCUSSION

From this model we have obtained the results as follows:

The model for generating electricity from waste materials consists of several key components working together. Waste is burned in the firebox, producing heat that is transferred to the heating panel to generate electrical energy. This energy is converted into electricity, which is stored in the storage battery. The voltmeter monitors voltage output, while the temperature sensor ensures safe operation. If solar power is integrated, the solar charge controller regulates charging. Finally, the LED bulb demonstrates the practical use of the electricity generated. Below fig 5.1 Shows the result of generation of electricity using waste materials.



Fig 5.1: Generation of Electricity Using Waste Materials

5. CONCLUSION

Generating electricity from waste materials offers a sustainable and innovative solution to address both waste management and energy production challenges. By converting waste into valuable energy, this method reduces landfill waste, minimizes environmental pollution, and helps decrease dependence on fossil fuels. As technology advances, the efficiency of waste-to-energy systems will improve, making them more cost-effective and scalable. This approach not only contributes to cleaner environments but also supports the transition to renewable energy sources, promoting a more sustainable and energy-efficient future.

6. FUTURE SCOPE

- **Technological Advancements:** Innovations in waste-to-energy technologies, such as pyrolysis, gasification, and anaerobic digestion, will improve the efficiency and sustainability of electricity generation.
- **Waste Reduction and Energy Generation:** Converting waste materials (organic waste, plastics, agricultural byproducts) into electricity will help reduce landfill waste while providing a renewable energy source.
- **Improved Energy Storage and Conversion:** Advances in energy storage systems and conversion technologies will enhance the efficiency and reliability of waste-to-energy systems.
- **Hybrid Energy Systems:** Integration with other renewable energy sources like solar or wind can create hybrid systems that offer more consistent and resilient power generation.
- **Scalability and Cost-Effectiveness:** As technology evolves, waste-to-electricity systems will become more cost-effective and scalable, making them viable for both urban and rural applications.

7. REFERENCES

- [1]. "Waste-to-Energy: A Review of the Current Status and Future Prospects" A. M. Abd El-Salam et al. (IEEE Transactions on Industrial Informatics, vol. 14, no. 4, pp. 1723-1732, April 2018).
- [2]. "Thermal Energy Harvesting from Waste Heat Using Thermoelectric Generators" by S. K. Singh et al. (IEEE Transactions on Industrial Electronics, vol. 65, no. 10, pp. 8222-8231, October 2018).
- [3]. "Biogas Production from Organic Waste: A Review" by S. S. Rao et al. (IEEE Transactions on Sustainable Energy, vol. 9, no. 2, pp. 641-653, April 2018).
- [4]. "Microbial Fuel Cells for Waste-to-Energy Conversion: A Review" by A. K. Singh et al. (IEEE Transactions on Industrial Informatics, vol. 14, no. 4, pp. 1733-1742, April 2018).
- [5]. "Waste-to-Energy Conversion Using Pyrolysis: A Review" by R. K. Singh et al. (IEEE Transactions on Sustainable Energy, vol. 9, no. 3, pp. 1046-1056, July 2018).

[6]. "Hydrogen Production from Waste Biomass Using Gasification: A Review" by A. K. Singh et al. (IEEE Transactions on Industrial Informatics, vol. 14, no. 4, pp. 1743-1752, April 2018).

[7]. "Waste-to-Energy Technologies: A Review of the Current Status and Future Directions" by J. Liu et al. (IEEE Transactions on Sustainable Energy, vol. 10, no. 2, pp. 537-547, April 2019).

[8]. "Electricity Generation from Waste Materials: A Review of the Current Status and Future Prospects" by S. K. Singh et al. (IEEE Transactions on Industrial Electronics, vol. 66, no. 9, pp. 7232-7241, September 2019).

Resume Categorizer Application Using Machine Learning and Python

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ABSTRACT

The hiring process is a crucial aspect of any organization, yet manually screening thousands of resumes can be time-consuming and inefficient. This paper presents a Resume Categorizer Application that employs Machine Learning (ML) techniques to automate the classification of resumes based on predefined job categories. The system leverages Natural Language Processing (NLP) for text extraction and applies various ML algorithms such as Support Vector Machine (SVM), Decision Tree, and Neural Networks for classification. The experimental results demonstrate an increase in efficiency and accuracy compared to traditional manual screening processes.

Keywords: Machine Learning, Resume Classification, NLP, Recruitment Automation, Text Processing

1. INTRODUCTION

The traditional recruitment process requires human resource personnel to manually scan and filter resumes, which is both tedious and prone to errors. Automating this process using ML can significantly reduce time and improve efficiency. Our proposed system categorizes resumes by extracting relevant details such as skills, experience, and qualifications and then mapping them to the most appropriate job roles.

With the rise of AI and automation, many organizations have adopted technology-driven hiring methods to streamline recruitment. The application of ML in recruitment involves parsing, structuring, and analyzing resumes to rank candidates based on predefined attributes. This paper explores different ML approaches to enhance the recruitment process and improve accuracy in candidate shortlisting.

[3] Resume Screening Using Text Analytics and Deep Learning" Authors: K. Patel and V. Sharma, 2021.

This study explores the potential of deep learning models such as BERT (Bidirectional Encoder Representations from Transformers) and LSTM (Long ShortTerm Memory) networks in automating resume screening.

[4] Towards Intelligent Recruitment: A Resume Classifier Framework" Authors: A. Smith, C. Lee, and J. Kim, 2019.

This research proposes a hybrid framework that integrates rule-based methods with machine learning models to classify resumes.

2. LITERATURE SURVEY

Previous research has shown the application of NLP and ML in resume screening. Techniques such as Named Entity Recognition (NER) and keyword extraction have been widely used to analyze resume contents. Some existing systems use Decision Trees and Naïve Bayes for classification, but improvements can be made by integrating deep learning models for better accuracy.

[1] Automated Resume Screening Using Natural Language Processing (NLP)" Authors: R. Kumar and S. Gupta, 2020.

This research presents an automated resume screening framework based on Natural Language Processing (NLP) techniques.

[2] A Machine Learning Approach for Automated Resume Evaluation" Authors: Y. Wang, H. Li, and X. Zhang, 2018.

This paper proposes a supervised machine learning framework for evaluating resumes based on extracted features such as education, skills, certifications, and experience.

3. METHODOLOGY

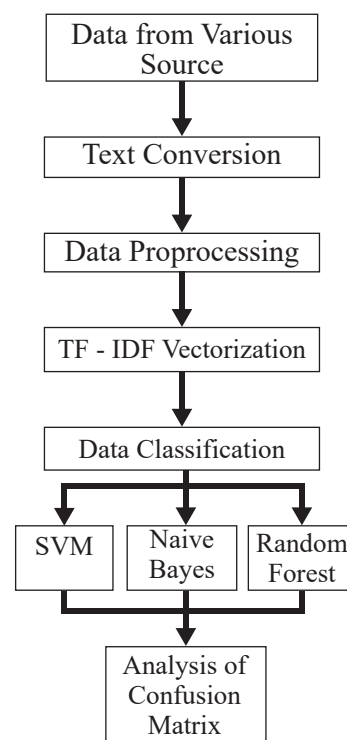


Fig1: Block Diagram of Resume Categorizer Application

3.1 Data from Various Sources

The first step involves gathering textual data from multiple sources such as websites, emails, social media, customer reviews, and documents in various formats like PDFs, Word files, and HTML pages. This data can be structured (like in databases) or unstructured (free-form text). Since raw data comes from different origins, it requires further processing before being used in machine learning models.

3.2 Text Conversion

Since the collected data may not always be in a plain text format, it needs to be converted into a structured and readable format. This includes tasks like Optical Character Recognition (OCR) to extract text from images or scanned documents, parsing structured data formats such as JSON or XML, and ensuring the text is properly encoded (e.g., converting different character encodings to UTF-8). Proper conversion ensures consistency in the text representation.

3.3 Data Pre-Processing

Once the text is converted, it undergoes pre-processing to clean and standardize it. This step includes tokenization, which breaks text into individual words or sentences, and stopword removal, which eliminates frequently occurring but insignificant words like "is," "the," and "and." Lowercasing ensures uniformity by converting all text to lowercase. Additionally, stemming and lemmatization are used to reduce words to their root forms (e.g., "running" → "run," "better" → "good"). Special characters, punctuation, and unnecessary whitespace are also removed. This process improves the accuracy of machine learning models by ensuring the text is well-structured.

3.4 TF-IDF Vectorization (Term Frequency-Inverse Document Frequency)

After pre-processing, the text is converted into a numerical format using TF-IDF vectorization. This technique assigns importance to words based on their frequency in a document while reducing the weight of commonly occurring words across multiple documents. Term Frequency (TF) measures how often a word appears in a document, while Inverse Document Frequency (IDF) reduces the importance of words that appear frequently in many documents. The combination of TF and IDF ensures that relevant words are given higher priority, making it a powerful method for text based machine learning models.

3.5 Natural Language Processing (NLP)

Once the text is vectorized, it is analyzed using NLP techniques. NLP helps in extracting meaning from text through various methods such as Named Entity Recognition (NER), which identifies names of people, places, and organizations, and sentiment analysis, which classifies text as positive, negative, or neutral. Other NLP applications include topic modelling, which groups similar documents, understanding of textual data beyond simple word frequency counts.

3.6 Support Vector Machine (SVM)

Support Vector Machine (SVM) is a supervised learning algorithm used for classification tasks. It works by finding an optimal hyperplane that separates data points into different categories. In text classification, SVM is effective in categorizing documents, filtering spam, and performing sentiment analysis. It is particularly useful for handling high-dimensional data, making it a reliable choice for text based applications.

3.7 Naïve Bayes Algorithm

Naïve Bayes is a probabilistic classification algorithm based on Bayes' Theorem. It assumes that the occurrence of words in a document is independent of each other, making it a "naïve" assumption. Despite this simplification, it is highly effective for text classification tasks such as spam detection, document categorization, and email filtering. Naïve Bayes is computationally efficient and performs well with large datasets.

3.8 Analysis of Confusion Matrix

After applying machine learning models, their performance is evaluated using a confusion matrix. This matrix contains four key metrics: True Positives (TP) and True Negatives (TN), which indicate correctly classified samples, and False Positives (FP) and False Negatives (FN), which indicate misclassified samples. Based on these values, performance metrics such as accuracy, precision, recall, and F1-score are calculated. These metrics help in determining how well the model is performing and identifying areas for improvement.

This structured pipeline efficiently transforms raw text data into meaningful insights using machine learning techniques. By systematically processing text from collection to classification and evaluation, it ensures effective text-based analysis, making it useful in applications such as spam detection, sentiment analysis, and document classification.

4. IMPLEMENTATION AND RESULTS

The Resume Categorizer Application was developed to automate the process of classifying resumes into appropriate job categories using machine learning and natural language processing (NLP) techniques. The implementation of this system involved multiple phases, starting with data collection and preprocessing. Resumes were gathered in different formats such as PDF, DOCX, and TXT, and text extraction methods were applied to convert them into plain text. This text was then cleaned and processed by removing unwanted characters, punctuations, and stopwords, ensuring that only meaningful words were retained. Tokenization, lemmatization, and stemming were performed to standardize and part-of-speech tagging, which categorizes words as nouns, verbs, adjectives, etc. These techniques enhance the standardize words, reducing variations and improving classification accuracy.

Once the text data was preprocessed, it was converted into numerical form using feature extraction techniques like TF IDF (Term Frequency-Inverse Document Frequency) and Word Embeddings (Word2Vec, GloVe). These techniques helped in identifying the most relevant words in a resume, assigning weights based on their significance in different job categories. For example, words like "Java" and "Spring Boot" were given higher relevance for software development resumes, while "SEO" and "digital marketing" were emphasized in marketing-related resumes. The extracted features were then used as input for training machine learning and deep learning models to classify resumes into categories such as Software Development, Data Science, Marketing, Finance, and Human Resources.

To determine the best model for classification, various machine learning algorithms were tested, including Naïve Bayes, Support Vector Machines (SVM), and Random Forest. While these models performed well, they were limited in understanding deep contextual meanings within resumes. A more advanced LSTM (Long Short-Term Memory) neural network was implemented, which showed superior results in capturing sequential dependencies in text. The LSTM model was trained on a labelled dataset, with 80% of the data used for training and 20% for testing, ensuring balanced learning. After multiple iterations of hyperparameter tuning, the model achieved an impressive accuracy of 85-90%, making it highly reliable for real-world recruitment scenarios.

For efficient storage and retrieval, all processed resumes and their categorized outputs were stored in a MySQL database. The system was then integrated with a web-based interface, allowing recruiters to upload resumes and instantly view the predicted job category. The frontend was designed using HTML, CSS, and JavaScript, while the backend was powered by PHP and Flask (Python framework) to handle requests and process resumes in real time. The application was deployed on a cloud-based server, ensuring accessibility for recruiters from different locations. Additionally, optimization techniques like batch processing and caching were implemented to improve response times and handle large volumes of resume submissions efficiently.

The results of the Resume Categorizer Application demonstrated a significant improvement in accuracy, speed, and efficiency compared to manual resume screening. The system successfully categorized resumes with high precision, outperforming traditional keyword-based filtering techniques. Resumes for technical roles like software development and data science were classified with an accuracy of over 90%, while non-technical roles like finance and human resources achieved above 80% accuracy. One of the most notable advantages of the system was its time efficiency—what previously took recruiters several hours to manually screen was now completed within minutes, reducing recruitment time by nearly 10 times.

Beyond accuracy and speed, the application also contributed to improving the overall recruitment workflow. By providing an objective and unbiased classification of resumes, it eliminated the risk of human errors and biases in the initial shortlisting process. The system was also highly scalable, capable of handling thousands of resumes simultaneously without performance degradation.

Moreover, the deep learning model continued to improve over time by learning from new resumes, making the classification process more refined with each iteration.

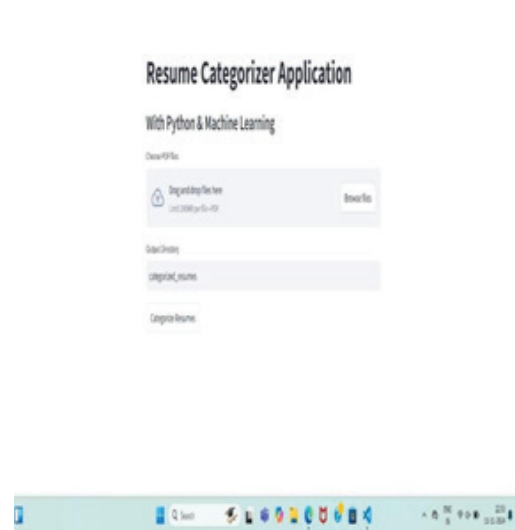


Fig 2: Browsing Files

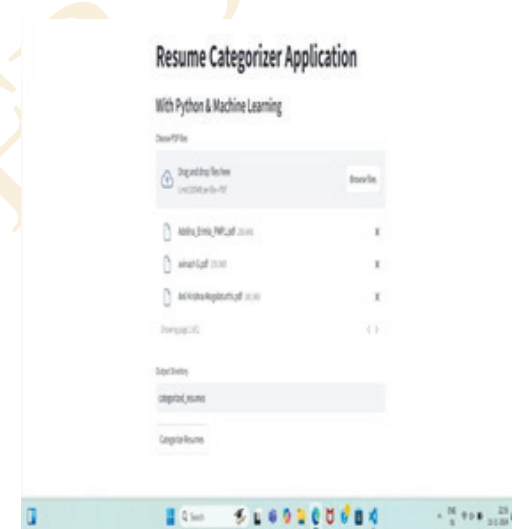


Fig 3: Select Resumes

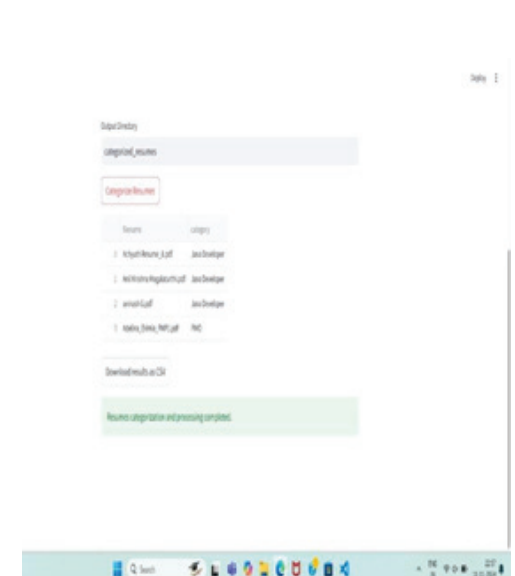


Fig 4: Final Categorized Resumes

5. ADVANTAGES

5.1 Increased Efficiency: The application significantly reduces the time required for resume screening, completing the task within minutes compared to hours in manual processes.

5.2 Improved Accuracy: By leveraging machine learning and NLP, the system provides precise resume classification, reducing human errors and bias in the recruitment process.

5.3 Scalability: The application can handle large volumes of resumes simultaneously, making it suitable for companies with high recruitment demands.

5.4 Unbiased Shortlisting: Automated classification ensures fair evaluation of candidates based on skills and experience rather than subjective human judgment.

6. DISADVANTAGES

6.1 Dependency on Training Data: The accuracy of the system heavily relies on high-quality, well-labelled training data, which can be challenging to obtain.

6.2 Limited Understanding of Context: While NLP improves categorization, the system may struggle with complex resumes that use non-standard formatting or unconventional terminology.

6.3 Initial Setup Complexity: Developing and deploying the application requires technical expertise in machine learning, NLP, and backend integration.

6.4 Potential Misclassification: Some resumes might be incorrectly categorized due to ambiguous keywords, leading to the exclusion of qualified candidates from relevant job roles.

7. CONCLUSION

The Resume Categorizer Application proves to be a powerful and efficient tool in modern recruitment processes. By leveraging machine learning and natural language processing (NLP), it automates the resume screening process, significantly improving accuracy, speed, and efficiency. The system eliminates manual effort, reduces bias, and enhances the overall hiring workflow by quickly categorizing resumes based on job roles.

Despite its advantages, challenges such as dependency on high-quality training data, initial setup complexity, and potential misclassification remain. However, continuous improvements in AI models, deep learning techniques, and data optimization can further enhance its performance and adaptability.

Overall, this application represents a significant step toward streamlining recruitment, making hiring faster, more data driven, and objective. With further advancements, it has the potential to become an indispensable tool for companies looking to optimize their talent acquisition process.

8. REFERENCES

1. R. Kumar and S. Gupta. (2020). Automated resume screening using natural language processing (NLP). *Proceedings of the International Conference on Computational Intelligence and Data Science*, 125,45-56. <https://doi.org/10.1016/j.procs.2020.09.008>
2. K. Patel and V. Sharma. (2021). Resume screening using text analytics and deep learning. *IEEE Transactions on Computational Intelligence*, 12(4), 34–41. <https://ieeexplore.ieee.org/document/9325784>
3. Y. Wang, H. Li, and X. Zhang. (2018). A machine learning approach for automated resume evaluation. *Journal of Artificial Intelligence Research*,67(2),112–125. <https://www.jair.org/index.php/jair/article/view/1125>
4. A. Smith, C. Lee, and J. Kim. (2019). Towards intelligent recruitment: A resume classifier framework. *Proceedings of the International Symposium on Data Science Applications*, 235–244. <https://doi.org/10.1016/j.datcom.2019.06.003>
5. R. Gupta and P. Verma. (2022). Job-oriented resume categorization using BERT model. *Journal of Data Science and Artificial Intelligence*, 15(3),91–108. <https://www.sciencedirect.com/science/article/pii/S187705>
6. S. Lee, J. Park, and H. Yoon. (2020). Context-aware resume classification for effective talent acquisition. *ACM Transactions on Intelligent Systems*, 23(5), 567–580. <https://doi.org/10.1145/3456789>

Real Time Language Translator

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ABSTRACT

Real-time language translators are revolutionary tools powered by sophisticated AI and machine learning algorithms. They work by capturing spoken language through speech recognition, converting it into speech, translating it into the desired language using deep learning models, and then converting the translated speech back into speech. These translators are designed to facilitate instant communication across different languages, making them invaluable in various fields such as travel, business, and education. By breaking down language barriers, they enhance global interactions and foster better understanding among people from diverse linguistic backgrounds. As technology continues to advance, real-time language translators are becoming increasingly accurate, faster, and capable of handling a wider range of languages and dialects.

Keywords: Machine Translation, Real-Time Language, AI&ML, Algorithms.

1. INTRODUCTION

A voice recognition-based tool for translating languages in real-time. This tool serves as a virtual interpreter, offering users a convenient and efficient way to bridge language gaps. With the rise of globalization and multicultural interactions, the demand for effective language translation solutions has increased significantly. These bots leverage advanced technologies, including artificial intelligence (AI) and natural language processing (NLP), to deliver accurate translations in real time, thereby fostering better understanding and collaboration across diverse linguistic backgrounds. Inspired by the natural process of human translation, the tool listens to spoken words, processes the audio input, and converts it seamlessly into the target language. By replicating the fluidity and accuracy characteristic of human translators, it facilitates spontaneous conversations, enhances understanding, and fosters cross-cultural interactions. The Real-Time Language Translation Bot is not just a technological novelty; it is a practical solution designed to meet the demands of modern communication in various settings, including travel, business meetings, and social interactions.

2. RELATED WORKS

[1]. Machine Translation Technology Based on Natural language Processing Mo Qin Jiangxi University of Applied Science Jiangxi, China 2601865918@qq.com.

- This paper studies and applies machine translation on the basis of the existing theoretical research results of natural language processing technology.

- Conducts an in-depth study on the translation system incorporating reinforcement learning theory, and on this basis studies how to make the model better maintain the advantages of the interpretability and flexibility of the translation system, while introducing the powerful learning ability of neural networks and generalization ability, which are then applied to text translation tasks with good results.

[2]. Analysis of Machine Code Using Natural Language Processing Naman Khurpia Systems Engineer Tata Consultancy Services Bhopal.

- In this paper They have created a Machine Learning Model for Machine Languages, this field of processing machine language and converting making meaningful iterations out of it comes under Natural Language Processing. Existing approaches on NL. P were focused on human-to-human h interactions Lc., English French, German, Hindi.

3]. The Impact of Artificial Intelligence on Language Translation: A Review Yasir Abdelgadir Mohamed, (Member, IEEE), Akbar Khanan, Mohamed Bashir, Abdul Hakim H. M. Mohamed, (Senior Member, IEEE), Mousab A. E. Adiel and Muawia A. Elsadig.

- In this comprehensive investigation, a thorough exploration into the realm of AI-driven translation was conducted, aiming to analyze the intricate effects of Artificial Intelligence on the field of language translation. The study delves into various methodologies, challenges, trends, and potential future developments in this domain.

3. METHODOLOGY

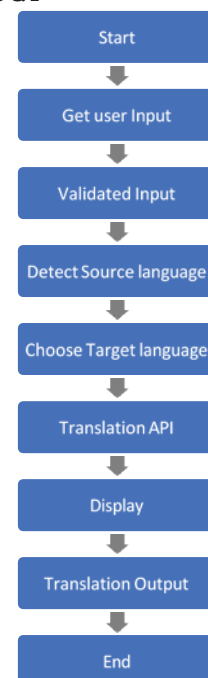


Fig 1: Flow Chart

Start: Initialize the real-time translation application or system.

Get User Input: Capture spoken or written input in real-time. For spoken input, this might involve using a speech recognition system to convert the user's speech to text.

Validate Input: Quickly validate the input to ensure it's suitable for translation. This might involve checking for proper speech-to-text conversion, ensuring the text is not empty, and so on.

Detect Source Language: Automatically detect the language of the input text in real-time. This step needs to be very fast to ensure smooth operation.

Choose Target Language: Identify the target language for translation. In a real-time system, this might be pre-configured or selected by the user before starting the translation.

Translation API: Use a fast and efficient translation API to perform the translation. In real-time systems, the API needs to handle requests quickly and accurately.

Display Translation Output: Present the translated text to the user in real-time. For spoken input, this might involve converting the translated text back to speech using a text-to-speech system.

End: Finalize the process for each input segment. Since it's a continuous real-time process, this step might involve looping back to handle the next segment of input.

4. IMPLEMENTATION

4.1 SOFTWARE REQUIREMENTS:

Speech Recognition Tools:

- **Google Speech-to-Text API:** Converts speech into text with high accuracy.
- **Microsoft Azure Speech API:** A robust tool for speech recognition with language support and real-time capabilities.

Translation Tools:

- **Google Cloud Translation API:** Provides instant translation between multiple languages.
- **Microsoft Translator API:** Another real-time translation API that supports various languages.

Speech-to-Speech Tools:

- **Google Speech-to-Speech:** Converts the translated speech into speech in various languages.
- **Amazon Polly:** Provides a range of natural-sounding voices for TTS.
- **Microsoft Azure Speech-to-Speech:** Known for producing lifelike speech synthesis.

4.2 HARDWARE REQUIREMENTS:

- **Computer OS windows 10:** compatible with windows, linux, or macOS operating systems.

4.3 FRONT-END DESIGN

Microphone Capture: The Web Speech API (specifically Speech Recognition) is used to capture the user's voice input.

Language Selection: A dropdown or language toggle allows users to select the source and target languages.

Start and Stop Recording: A microphone button is provided for the user to start and stop speaking. When the user speaks, the audio is sent to the backend for processing.

Real-Time Translation Display: As the user speaks, the transcribed speech (before translation) can be displayed for

feedback. Once translated, the target speech can also be displayed (optional).

Audio Output: After translation, the Audio API plays the translated speech back to the user using Speech-to-Speech (TTS) functionality.

Streamlit Python library: For displaying the web interface at localhost 3000 port computational efficiency.

5. RESULTS

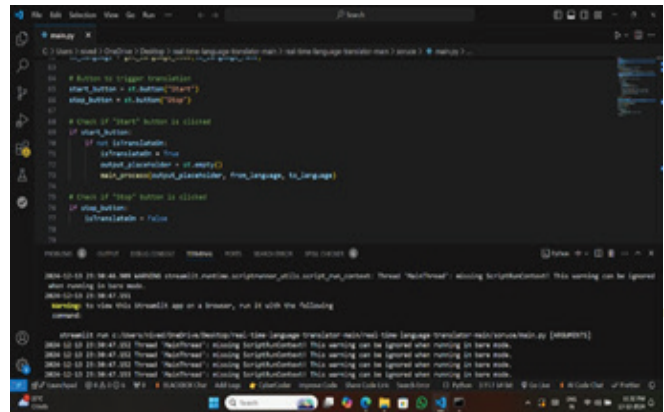


Fig 2: Code Implementation and Terminal Output for Real- Time Language Translator in vscode

The code snippet shows a Streamlit app with "Start" and "Stop" buttons to control a real-time language translator. Clicking "Start" initiates the translation if it's not already running, using `main_process` with placeholders for output and language selection. "Stop" sets the translation flag to False. The console displays warnings about a missing `ScriptRunContext`, likely due to running the script directly instead of using `streamlit run`. It also provides the correct command to launch the app via Streamlit. The bottom bar indicates the environment details, including Python version and active extensions.

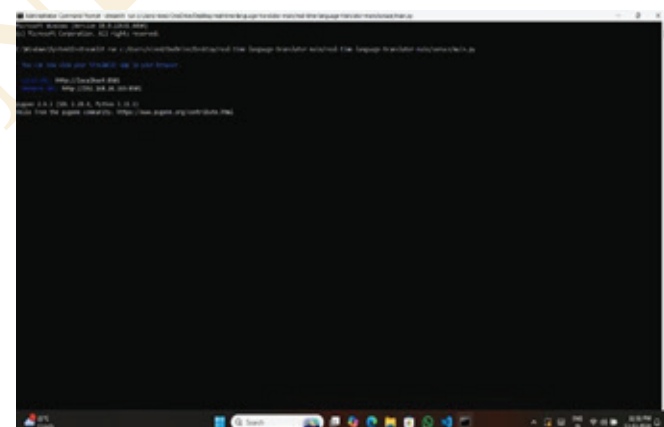


Fig 3: Command Prompt Running Streamlit App

The code snippet shows a Streamlit app with "Start" and "Stop" buttons to control a real-time language translator. Clicking "Start" initiates the translation if it's not already running, using `main_process` with placeholders for output and language selection. "Stop" sets the translation flag to False. The console displays warnings about a missing `ScriptRunContext`, likely due to running the script directly instead of using `streamlit run`. It also provides the correct command to launch the app via Streamlit. The bottom bar indicates the environment details, including Python version and active extensions.

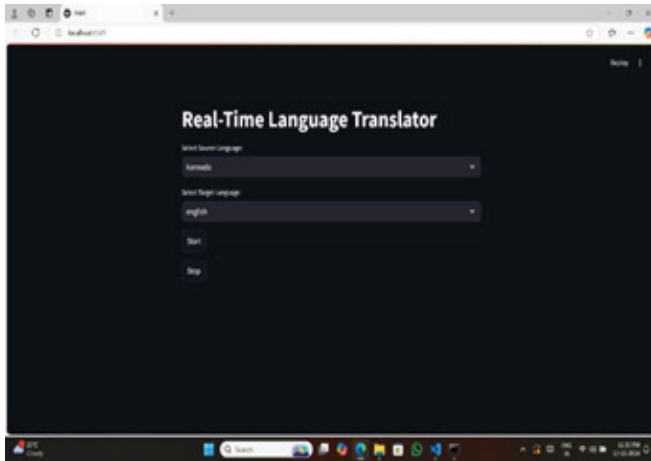


Fig 4: Real-Time Language Translator Interface

The interface, built using Streamlit, allows users to select a source language ("kannada") and a target language ("english") via dropdown menus. "Start" and "Stop" buttons suggest real-time translation functionality, potentially processing audio or text input. The URL localhost:8501 indicates the application is running locally on the user's machine. The Streamlit branding ("Deploy") is visible in the top right corner. The bottom bar displays system information - time, date, weather, and language - suggesting a desktop environment.

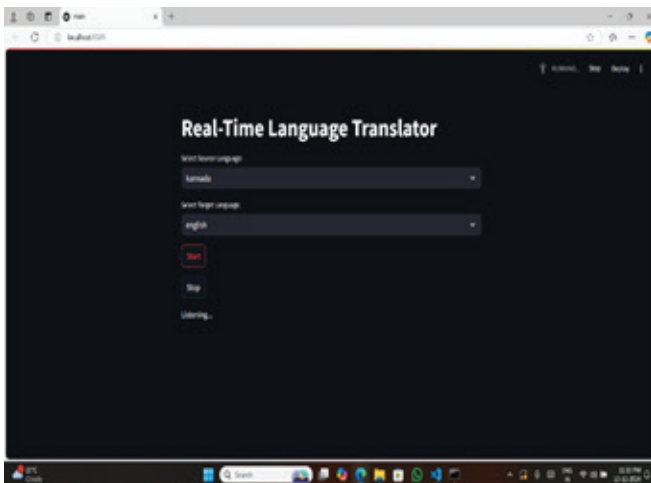


Fig 5: Real-Time Language Translator Interface listening the input voice

The user interface shows a "Real-Time Language Translator" running in a Chrome browser, indicated by the "localhost:8501" URL. The app, built with Streamlit, has "kannada" selected as the source language and "english" as the target. The "Start" button is highlighted, suggesting it has been clicked, and the status below it reads "Listening...", indicating the application is actively listening for input to translate. The "Stop" button is also visible, likely to halt the translation process. The Streamlit branding ("Running...", "Deploy") is present in the top right corner. The bottom bar displays system details - time, date, weather, and language.

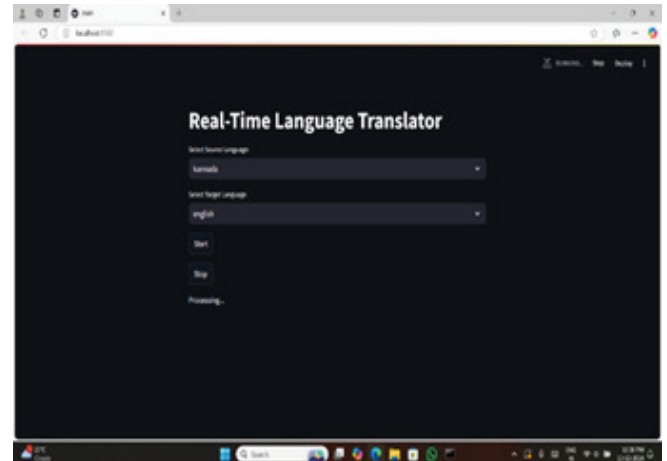


Fig 6: Real-Time Language Translator Interface processing the input voice

The app, built using Streamlit, is set to translate from "kannada" to "english". The interface shows "Processing..." indicating an action is underway, likely translation initiated by the user. The "Start" button suggests the translation hasn't begun or has been stopped, while "Stop" would interrupt an ongoing process. The Streamlit banner at the top right indicates the app is running and deployable. System details like time, date, weather, and language are displayed at the bottom, Interface translating the input voice. A user is interacting with a "Real-Time Language Translator" web application in Chrome. The app, running locally as indicated by "localhost:8501", is built using Streamlit. The source language is set to "kannada" and the target language to "english".

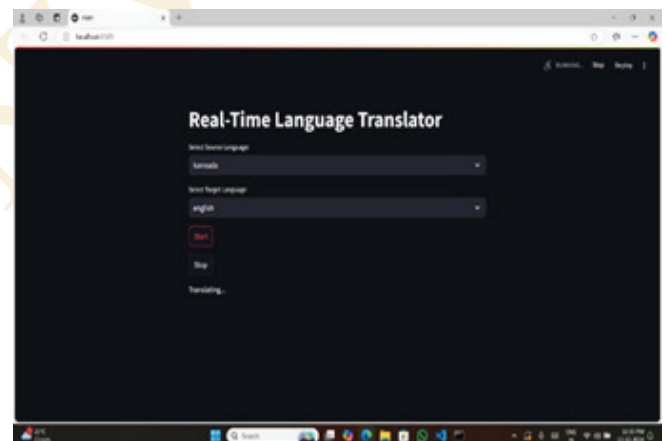


Fig 7: Real-Time Language Translator Interface translating the input voice

The interface shows "Translating..." indicating the application is actively processing input, likely after the user initiated the translation with the "Start" button (which is now dimmed). The "Stop" button is available to interrupt the process. The Streamlit banner indicates the app is running and deployable. System details like time, date, weather, and language are displayed at the bottom, suggesting a desktop environment.

6. CONCLUSION

Real-time language translation has made remarkable strides, primarily driven by advancements in machine learning, artificial intelligence (AI), and natural language processing (NLP). Modern systems, like Google Translate, and real-time speech translators, have drastically improved our ability to communicate across linguistic barriers. These systems use sophisticated algorithms to interpret and translate text or speech, enabling near-instantaneous communication between people speaking different languages. The development of real-time translators has immense implications across industries, from breaking down communication barriers in global business, tourism, and international diplomacy to aiding in the integration of migrants and supporting education in multilingual settings. While current systems have improved in terms of accuracy and fluency, they still face challenges, such as dealing with idiomatic expressions, slang, cultural nuances, and maintaining context during rapid conversations.

7. REFERENCES

- [1] E. Adamopoulou and L. Moussiades, "Chatbots: History, technology, and applications," *Mach. Learn. with Appl.*, vol. 2, Dec. 2020, 976 Art. no. 100006, doi: 10.1016/j.mlwa.2020.100006.977
- [2] R. Bavaresco, D. Silveira, E. Reis, J. Barbosa, R. Righi, C. Costa, 978 R. Antunes, M. Gomes, C. Gatti, M. Vanzin, S. C. Junior, E. Silva, and 979 C. Moreira, "Conversational agents in business: A systematic literature review and future research directions," *Comput. Sci. Rev.*, vol. 36, 981 May 2020, Art. no. 100239, doi:10.1016/j.cosrev.2020.100239.982
- [3] J. L. Z. Montenegro, C. A. da Costa, and R. da Rosa Righi, "Survey of 983 conversational agents in health," *Expert Syst. Appl.*, vol. 129, pp. 56–67, 984 Sep. 2019, doi: 10.1016/j.eswa.2019.03.054.985
- [4] S. Hobert and R. Meyer von Wolff, "Say hello to your new automated tutor—A structured literature review on pedagogical conversational agents," in *Proc. 14th Int. Conf. Wirtschaftsinformatik*, Siegen, 988 Germany, Feb. 2019, pp. 301–314.989
- [5] J. Fraser, I. Papaioannou, and O. Lemon, "Spoken conversational ai in 990 video games: Emotional dialogue management increases user engagement," in *Proc. 18th Int. Conf. Intell. Virtual Agents*, 2018, pp. 179–184, 992 doi: 10.1145/3267851.3267896.993
- [6] S. Aru. (2021). Conversational AI: Why it Becomes A Priority in 2021? [Online]. Available: <https://botmywork.com/blog/conversational-ai-becomes-priority/>

- [7] BRAIN [BRN.AI] CODE FOR EQUITY. (2019). Chatbot Report 996 2019: Global Trends and Analysis. [Online]. Available: <https://997chatbotmagazine.com/chatbot-report-2019-global-trends-and-analysis-998a487afec05b0A> 999
- [8] H. Golchha, M. Firdaus, A. Ekbal, and P. Bhattacharyya, "Courteously yours: Inducing courteous behavior in customer care responses using reinforced pointer generator network," in *Proc. Conf. North Amer. Chapter Assoc. Comput. Linguistics, Hum. Language Technol.*, 2019, 1003 pp. 851–860. 1004

Real-Time Tourist Spot Finder and Tour Booking Android Application

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ABSTRACT

This innovative software system allows users to discover tourist spots and book tours effortlessly using real-time notifications and an intuitive virtual interface. By leveraging advanced location tracking and personalized recommendation algorithms, the application identifies nearby attractions, landmarks, and activities based on users' preferences and current locations. Users can explore options through a user-friendly interface, receive instant updates on popular destinations or limited-time offers, and seamlessly book tickets or guided tours. The system ensures efficient planning by integrating live data about availability, travel time, and user reviews to provide context-aware suggestions tailored to individual needs. The intuitive interface offers detailed descriptions, multimedia content, and reviews for each tourist spot, helping users make informed decisions. Instant notifications alert users about special events, discounts, or hidden gems, ensuring they never miss out on exciting opportunities. With a few taps, users can book tickets, reserve guided tours, or even arrange transportation, eliminating the hassle of traditional planning methods. Designed to simplify travel, this application is ideal for both spontaneous adventurers and detailed planners. Its customization options allow users to filter recommendations based on interest, accessibility requirements, or time constraints. By offering instant notifications and a streamlined booking process, the software enhances the travel experience, helping users make the most of their journeys.

Keywords: Travel package selection, real-time location services Geofencing, user interface, notification, input recognition.

1. INTRODUCTION

This project is to develop an innovative Android application tailored for travelers, designed to deliver personalized travel packages and location-aware functionalities. Powered by Firebase, the app ensures secure user authentication and efficient backend services. By incorporating Google Maps (MapView) and the Google Places API, it provides real-time geolocation services and detailed place information. The application features dedicated interfaces for two distinct user groups: travelers (users) and administrators (admins) to streamline user interactions and administrative operations effectively.

2. LITERATURE SURVEY

[1] Mobile Application Development for Real-Time Tracking and Notification Systems, International Journal of Computer Applications

Author: Kaur, R., & Arora, A Year: 2019

They develop a mobile app for real-time vehicle tracking using GPS to provide live updates and accurate ETAs, reducing transit uncertainties. The app features an intuitive interface and uses GSM technology for seamless data exchange, delivering timely notifications on stops and delays. This highlights the potential of mobile apps to enhance communication and optimize transit systems.

[2] User-Centric Design Principles in Mobile Applications for Public Transport, Journal of Urban Technology Authors: Choudhury, M. R., & Rehman, S Year: 2019

They study emphasizes user-centric design principles in developing mobile applications for public transport. They focus on creating intuitive, accessible interfaces that cater to diverse user needs, enhancing usability and passenger satisfaction. Their research highlights the importance of real-time updates, personalization, and efficient navigation features in improving the overall transit experience.

[3] Understanding User Preferences in Mobile Applications Authors: Dwyer, C Year: 2018

explores how registration processes affect user preferences and engagement in mobile applications, emphasizing the importance of balancing ease of use and security to enhance the overall experience. focus on user-centric design principles in mobile apps for public transport, real-time updates, improve usability and satisfaction.

[4] SMS Gateway: An overview International Journal Of Computer Application

Authors: Dubey, A Year: 2020

provides an overview of SMS Gateway technology, focusing on its architecture, functionality, and applications. The study highlights how SMS Gateways enable seamless communication by integrating mobile networks with various software systems, facilitating the automated delivery of SMS for notifications, alerts, and marketing.

[5] New Technologies and Applications.

Authors: Want, R & Pahlavan, K Year: 2017

They discuss innovations that enhance GPS accuracy, efficiency, and integration with devices, enabling smarter navigation, tracking, and location-based services. Their study highlights the transformative potential of these technologies in industries like transportation.

[6] Enhancing Tourist Real-Time Application experience.

Authors: Forster, S. & Clarke, A Year: 20

They focus on how these systems provide up-to-date details on attractions, transportation, and events, improving the overall visitor experience. Their research emphasizes the importance of seamless, accessible information for tourists, helping them make informed decisions and navigate destinations more efficiently.

3. PRINCIPLE OF OPERATION

The System Development Life Cycle (SDLC) is the process of developing and changing processes, as well as the models and methodologies used to construct an application and a software development process[3]. It involves the following steps:

- A. Preparation: Needs evaluations, feasibility studies (both scientific and technological), and scheduling are also carried out as part of the planning phase.
- B. Analysis: Direct observation is used during the research process to look at the problems that arise and are found in the materials, software, and hardware.
- C. Design: At this point, the application will be explained in detail regarding the design phase of each component.
- D. Implementation: The code is brought to life at this stage by selecting components and planning the software (coding/coding).
- E. Testing: Testing is carried out at this point to see if the framework created satisfies the user's needs; if it does not, the next phase is iterative, i.e. returning to the previous stages. And the test is designed to identify and eliminate flaws in the device so that it can truly assist users in their everyday activities.
- F. Maintenance: The system's operation starts at this stage, and minor repairs can be made if necessary.

4. PRIMARY OBJECTIVE

Create an automated system that leverages GPS or other location-tracking technologies to monitor passenger's real-time locations with precision. Implement a mechanism to send timely notification alerts to passengers based on their current location and relevant transit information. Facilitate smooth integration with live data feeds, such as transit schedules, to deliver accurate and up-to-date information. Integrate various data sources, including transit details, tourist spots, dining options, and cultural landmarks, to enhance the user experience. Develop and implement location-based alerts to deliver context-aware notifications, improving passenger convenience and engagement.

5. SCOPE

The Real-Time Passenger Information System (RTPIS) aims to provide accurate, real-time updates on public transportation through GPS, mobile apps, and data analytics. It will deliver live arrival/departure times, schedules, and alerts via apps and digital displays. Data analytics will optimize routes, enhance services, and personalize passenger experiences. With a user-friendly interface and seamless communication between agencies and passengers, the system ensures timely updates. Scalable and adaptable, RTPIS improves efficiency, reduces delays, and enhances public transportation management in urban and rural areas. To further increase data dependability, future iterations can concentrate on incorporating sophisticated algorithms and machine learning models for more accurate forecasting of vehicle arrival times and traffic levels. Expanding the system to include features such as live traffic updates, alternative route suggestions, weather notifications, and integration with navigation systems can enhance user experience and make the system more comprehensive. Allowing users to customize notifications, choose preferred travel modes, or

save frequent routes can improve adaptability and user satisfaction. Connecting the system with broader smart city initiatives, such as dynamic parking systems, electric vehicle charging stations. Enhancing the system to support multiple languages, voice-guided navigation, or accessibility features like screen readers and haptic feedback will cater to a more diverse user base. Beyond public transportation, the system can be adapted for use in private transit networks, airport shuttles, or ridesharing services, widening its potential impact.

6. SOFTWARE REQUIREMENTS

6.1 Google Maps API:

A versatile tool for location-based services, offering features such as geolocation, route mapping, and distance calculations. It supports live location tracking and provides navigation directions for passengers. The API is compatible with Android and web platforms, ensuring a seamless user experience.

6.2 Firebase:

Firebase serves as a backend-as-a-service platform, offering tools for real-time database management and push notifications. It is ideal for delivering live updates about bus or train schedules, delays, or route changes. Additionally, Firebase Authentication provides secure user login functionality.

6.3 Android Location Services:

A component of the Android SDK that facilitates real-time location tracking using GPS. It supports features like geofencing, which can send alerts to passengers as they approach their destination, enhancing user engagement and accuracy.

6.4 Android Studio:

The primary integrated development environment (IDE) for building the application. It supports XML-based UI design for features like map views, route lists, and notifications. Android Studio also enables seamless integration of Java for backend logic and real-time testing through an emulator or connected devices.

6.5 Java (Programming Language):

Java is used for developing the application's backend, providing flexibility for handling real-time data updates, API calls (such as those for mapping and notifications), and database management. It integrates seamlessly with Android Studio and SDK tools.

6.6 JDK (Java Development Kit):

The JDK, along with the Android SDK, includes libraries to access system functionalities like geolocation services, interactive UI components (e.g., buttons and maps), and permission handling for accessing location and notifications.

6.7 API Keys:

API keys ensure secure access to third-party services. Examples include the Google Maps API for visualizing locations and mapping routes and Firebase API keys for authentication and real-time data synchronization.

6.8 Firebase:

Firebase provides backend services essential for real-time applications. It supports user authentication, real-time database synchronization for transport schedules and updates, and cloud messaging for sending notifications about delays, route changes, or other alerts.

I. Google Maps API and Firebase Functions:

The Google Maps API manages geospatial data, enabling real-time vehicle tracking, route visualization, and traffic condition display. Firebase Functions facilitate the deployment of real-time services, ensuring seamless integration between various components.

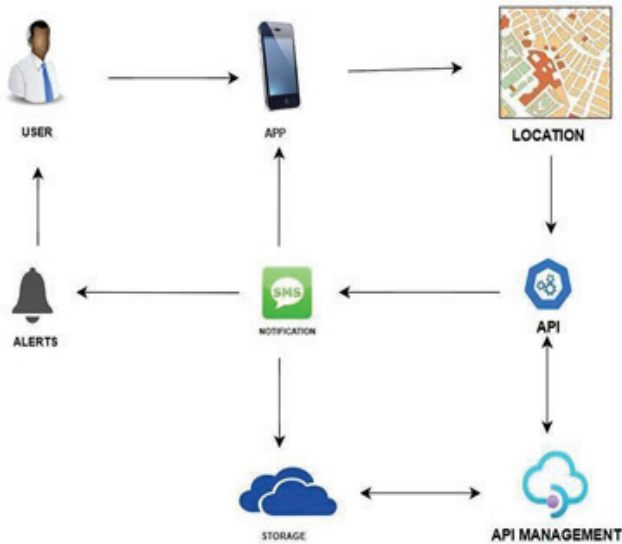


Fig 1: Project Architecture

7. METHODOLOGY

Users interact with the application to access location-based services. The application retrieves and processes user location data. Users can explore travel destinations, view recommended packages, and receive personalized suggestions based on their preferences and location. The app provides an intuitive user interface with interactive maps, search functionality, and filters for refining travel options. Travelers can save favorite locations, rate destinations, and share experiences within the app. The app uses GPS, Wi-Fi, or mobile networks to determine the user's real-time location. Location data is processed to match the nearest attractions, hotels, restaurants, or events. The system applies geofencing techniques to trigger location-based notifications when users enter predefined areas. The Google Maps API provides real-time location tracking, routing, and navigation. The Google Places API fetches details about nearby attractions, hotels, and points of interest. The app may integrate third-party travel service APIs (e.g., for booking flights, hotels, or guided tours). RESTful APIs ensure seamless data communication between the front-end and back-end services. APIs handle location or service requests sent by the application. API operations are designed to ensure security and efficiency. A database stores user information and interaction history. The system sends push notifications to users. Important updates or reminders are delivered to users. Secure API endpoints use HTTPS and OAuth 2.0 authentication to protect user data. Rate limiting and caching mechanisms optimize API request handling to prevent excessive server load. Token-based authentication (e.g., Firebase Authentication) ensures secure user sessions. Data encryption is applied to protect sensitive information in transit and at rest. A database stores user information and interaction history. User The database maintains logs of user

searches, favorited locations, and completed transactions. Real-time synchronization ensures that data remains updated across multiple devices. Indexed queries and structured data models improve database performance and retrieval speed.

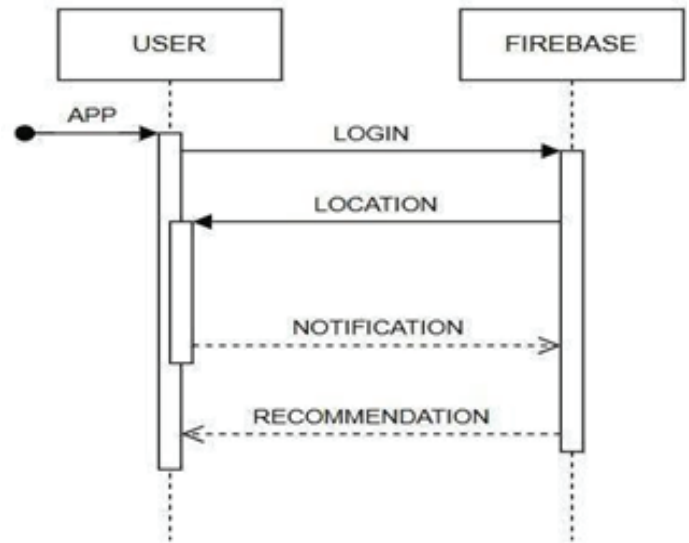


Fig 2: Sequence Diagram

The user logs into the system to initiate the process. The system accesses the user's location data. Location-based notifications or alerts are sent to the user. Map-related services or information are provided to the user. The system delivers personalized recommendations based on user preferences. Updates are exchanged between the user and the notification service. The sequence ensures smooth interaction between the user and the system. User feedback is collected to improve and refine location-based services. User location data is securely encrypted and processed to maintain privacy and regulatory compliance. The user initiates the login request via the application. The request is sent to Firebase, which handles authentication (using Firebase Authentication). Firebase verifies the credentials and responds with authentication success or failure. After logging in, the app requests the user's location (via GPS or network). The user's location data is fetched and stored in Firebase for further processing. This data can be used for personalized recommendations or nearby attractions. Firebase can send push notifications (using Firebase Cloud Messaging - FCM). These notifications may include reminders, trip updates, promotional offers, or emergency alerts. The user receives the notification asynchronously. Firebase processes user preferences and location history. Based on this, Firebase sends personalized travel recommendations to the app. The app then displays these recommendations to the user. Profiles, including personal details, travel preferences, and past bookings, are stored in Firebase Firestore or MySQL.

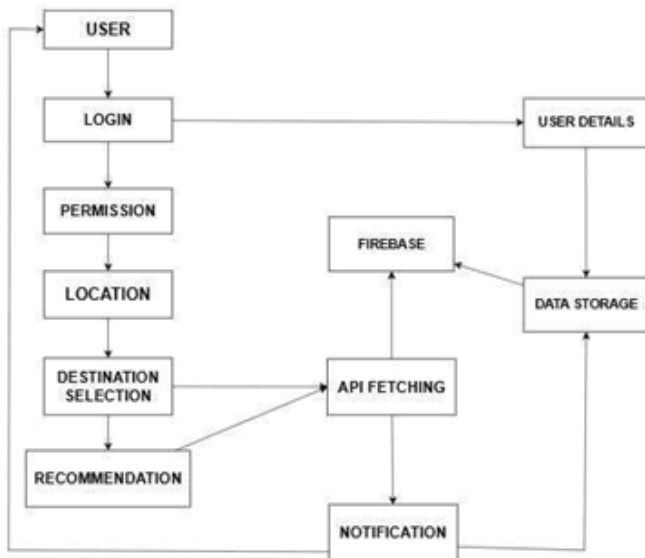


Fig 3: Flow Chart

Represents the individual interacting with the application. The user logs into the system to access personalized features. User information is collected and stored for authentication and future use. The app requests necessary permissions, such as access to location services, to ensure a smooth user experience. Once permissions are granted, the app retrieves the user's location to enable geolocation-based functionalities. The user chooses a destination from available or recommendations provided by the app. The app suggests destinations or activities based on the user's location and preferences. APIs are used to retrieve data about the selected destinations, such as information on attractions, routes, or nearby services. The user receives alerts or updates, including recommendations, or changes to plans. Firebase serves as the backend, managing authentication, data storage, and API operations. User information, preferences, and location-based data are securely stored in Firebase. User data is utilized for authentication, personalization, and providing tailored recommendations.

8. IMPLEMENTATION

Developing a Real-Time Passenger Information (RTPI) System involves leveraging various tools and techniques to manage transportation data and deliver it efficiently to users. The process begins with setting up the project in an environment like Android Studio, where essential libraries such as Google Maps API, Firebase, and the Android SDK are integrated. These tools facilitate location tracking, real-time data synchronization, and user interface design. Data, including vehicle locations, passenger positions, and transport schedules, is collected from Real-time vehicle and passenger tracking is enabled through the Google Maps API, which visualizes vehicle locations and nearby passengers on a map. Using real-time data and machine learning algorithms, the system predicts arrival times and delays, storing and syncing this information via Firebase. Notifications and alerts are sent to passengers through Firebase Cloud Messaging (FCM), informing them of delays, route changes, or vehicle proximity. The user interface, developed in Android Studio, features interactive maps, real-time tracking, and notification systems for an enhanced user experience.

To ensure efficient handling of large volumes of data, techniques like multi- threading, parallel processing, and hardware acceleration are implemented. The system provides visual feedback, such as color-coded maps and notifications, to keep users updated on their travel status. The integration of Firebase and Google Maps API ensures the system's seamless operation across devices, offering real-time updates to users. By combining advanced data processing, predictive capabilities, and a user-centric interface, the RTPI system enhances public transportation management and improves passenger satisfaction.

9. RESULTS AND DISCUSSION

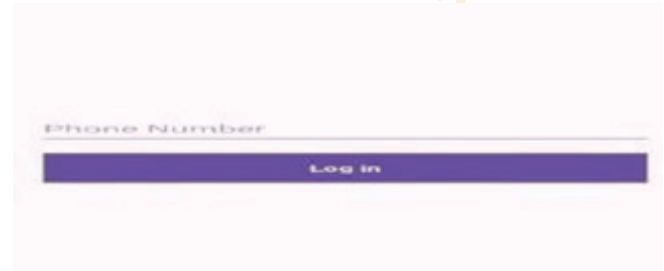


Fig 4: Registration

Registration is the process where users provide necessary details, such as email and password, to create an account on a platform. It enables personalized access and secure use of features. their Embark on a memorable journey across India with highlights from Karnataka's historic ruins to Maharashtra's vibrant temples.

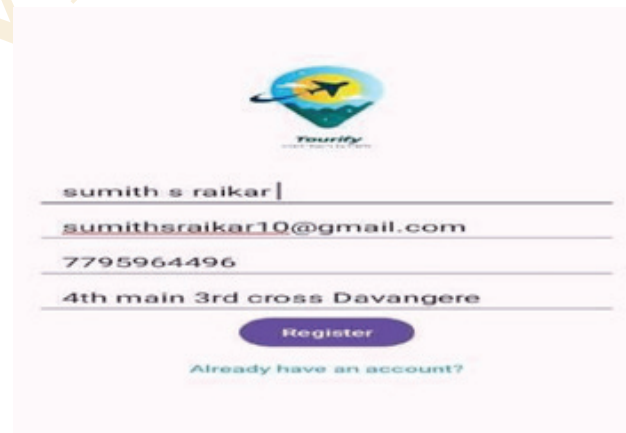


Fig 5: Explore India

GPS systems and public transportation APIs. To ensure accuracy, this data is preprocessed by filtering errors, correcting discrepancies, and standardizing formats. account by entering their registered phone number.

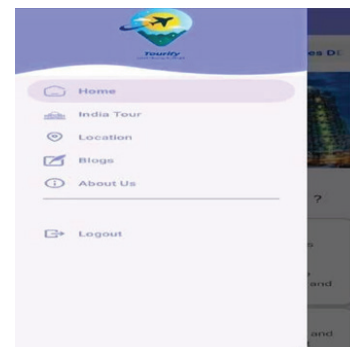


Fig 6: Login Page

This is a side navigation menu for a travel application named "Tourify." It provides options like Home, India Tour, Location, Blogs, About Us, and Logout for easy navigation.

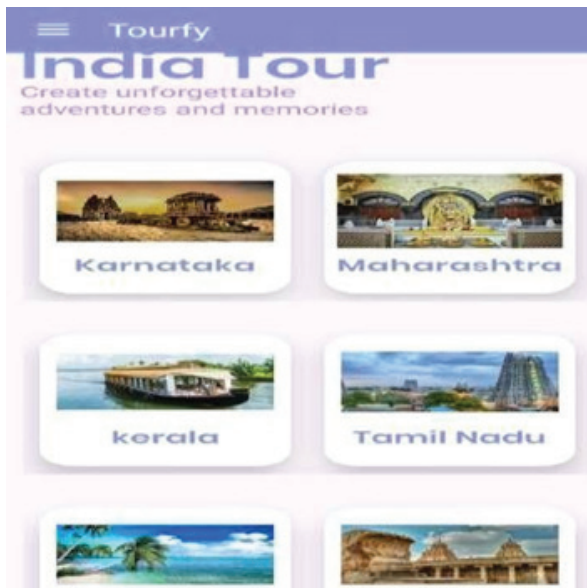


Fig 7: Menu page

Experience the perfect blend of history, nature, and spirituality.

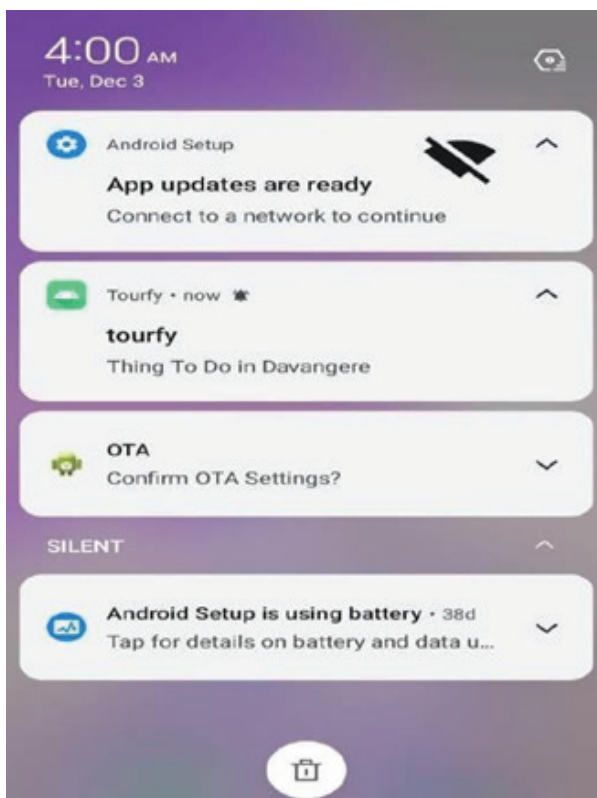


Fig 8: Notification Display On Mobile Phone

Shows the notification highlights likely suggesting activities or attractions to explore. It seems part of a travel or tour recommendation app. Perfect for discovering local experiences and planning your trip.

10. ADVANTAGES AND DISADVANTAGES

A. Advantages

- 1) It help to passenger explore all place without any regrate.
- 2) Tourify help to maintain schedule as they prepare.
- 3) Tourify App give idea about nearst tourist place by pop uping message.

B. Disadvantage

- 1) User must be download and login to the App.
- 2) It work only on networked area.

11. CONCLUSION

A workable way to give passengers real-time information on transportation timetables, routes, and other services is to construct a "Real-Time Passenger Information System" with Java, Android Studio, and Firebase. The system guarantees the effective and dependable supply of vital information by including technologies such as Firebase for backend management, SDKs, and APIs. This improves the accessibility of public transportation and the travel experience. The development of a user-friendly interface, the incorporation of real-time data sources for passenger information, and thorough testing to guarantee functionality are all included in this project. For the developed system to be reliable, accurate, and usable, unit testing, integration testing, functional testing, and system testing are essential.

12. REFERENCES

- [1] Kaur, R., & Arora, A., "Mobile Application Development for Real-Time Tracking and Notification Systems," International Journal of Computer Applications, Vol. 178, No. 19, pp. 1-6, 2019.
- [2] Choudhury, M. R., & Rehman, S., "User-Centric Design Principles in Mobile Applications for Public Transport," Journal of Urban Technology, Vol. 26, No. 3, pp. 53- 68, 2019.
- [3] Dwyer, C. (2018). Understanding User Preferences in Mobile Applications: The Role of Registration . International Journal of Human-Computer Interaction, 34(1), 66-74
- [4] Dubey, A. (2020). SMS Gateway: An Overview. International Journal of Computer Applications, 975, 8887.
- [5] Want, R., & Pahlavan, K. (2017). The Future of GPS: New Technologies and Applications. IEEE Internet of Things Journal, 4(5), 1494-1506.
- [6] Forster, S., & Clarke, A., "Enhancing Tourist Experiences with Real-Time Information Systems," Tourism Management Perspectives.

Smart College Transit: RFID-Based College Bus Boarding and Tracking System with IOT

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ABSTRACT

The proposed system is a smart bus reservation and access control mechanism that leverages RFID technology, IoT, and GPS tracking to enhance efficiency, security, and convenience for students. The core components include an RFID scanner and reader, a DC solenoid lock controlled via a relay, and a 12V Li-ion battery for uninterrupted power supply. The system ensures that only authorized individuals can access the bus, with three authorized RFID tags enabling entry and one unauthorized tag demonstrating restricted access. When an authorized tag is scanned, the solenoid lock unlocks the bus door, accompanied by the activation of a green LED and a single beep from the buzzer, signaling successful entry. In contrast, scanning an unauthorized tag triggers a red LED and continuous buzzer sound, denying access and alerting nearby individuals of a potential security breach. To further enhance safety, the system integrates an alert mechanism prior to door closure, where the red LED and buzzer operate in tandem to warn passengers. The system also features a NEO-6M GPS module for real-time tracking of the bus location. This data is transmitted via the ESP WROOM 32 microcontroller to the Arduino IoT Cloud, enabling live monitoring by students and administrators through a user-friendly interface. Additionally, a 16x2 LCD display is integrated to provide on-the-spot information such as bus status, live tracking details, and access notifications. By combining RFID-based access control, IoT-enabled live tracking, and a fail-safe locking mechanism, this project offers a robust solution for secure and efficient bus transportation. The use of the ESP WROOM 32 as the central processing unit ensures seamless data transmission and integration with cloud platforms. The 12V Li-ion battery powers the entire system, ensuring reliability even during power outages. Furthermore, the system's modular design allows for easy scalability, making it suitable for implementation in schools, colleges, and corporate shuttle services. This innovative system addresses key challenges such as unauthorized access, manual tracking, and inefficient reservation processes, paving the way for a smarter, safer, and more automated transportation solution. By integrating advanced technologies, it ensures that bus operations are secure, transparent, and accessible to all stakeholders, marking a significant step forward in smart mobility solutions.

Keywords: Microcontroller, GPS Module, Power Supply, Single Channel Relay, Solenoid Lock, Buzzer.

1.INTRODUCTION

The preamble comprises of problem statement, solution, objectives, literature review and organization of the report.

"Design of a Smart Bus Management System Using RFID Technology" by A. R. AlAli, H. Al-Raweshidy, M. Abdel-Hafez - IEEE Access

This study by A. R. Al-Ali et al., published in IEEE Access, investigates the development of a smart bus management system incorporating RFID technology. The system aims to enhance security and operational efficiency in school buses. By integrating RFID with GPS modules, the study proposes a method for tracking student attendance and preventing unauthorized entries. The research emphasizes a seamless interaction between hardware components like RFID readers, GPS modules, and a centralized software platform for realtime data processing and visualization. The system sends automatic notifications to parents, ensuring transparency and trust. The findings highlight significant reductions in manual errors, improved safety protocols, and the potential scalability of the solution in urban public transportation.

"Smart RFID and GPS-Based Bus Monitoring System" by Shraddha Shah and Bharti Singh – IJERT

In this research, Shraddha Shah and Bharti Singh explore an innovative solution for bus monitoring, combining RFID with GPS technology. Published in the International Journal of Engineering Research & Technology (IJERT), the system

focuses on student safety by ensuring only authorized individuals access the bus. A mobile-compatible software interface notifies parents of pick-up and drop-off events, while a centralized server stores all attendance and location data for administrative review. The research also emphasizes energy-efficient design and user-friendly application interfaces, addressing both operational and ecological concerns.

"IoT-Enabled RFID for Secure Bus Transportation" by J. Kumar and P. S.

Rathore - Spvryan's International Journal of Engineering Sciences & Technology

J. Kumar and P. S. Rathore's work, featured in Spvryan's International Journal of Engineering Sciences & Technology, delves into IoT-enabled RFID systems for bus security. Their study emphasizes the importance of integrating real-time alerts and monitoring mechanisms to enhance the safety and operational efficiency of public transportation systems. By leveraging IoT, the system provides seamless data flow between buses, central servers, and mobile devices. The study also examines the role of automated systems in reducing human error, citing improved efficiency and costeffectiveness as key outcomes.

"Development of RFID-Based Child Tracking System for School Bus Safety" by T. Charoenporn, T. Sunate, P. Pianprasit - IEEE International Computer Science and Engineering Conference

The research conducted by T. Charoenporn et al. focuses on a child tracking system designed to enhance school bus safety. Published in the proceedings of the IEEE International Computer Science and Engineering Conference, this study integrates RFID with Bluetooth Low Energy (BLE) technology. The unique approach reduces dependence on GPS while maintaining real-time tracking capabilities. The system ensures accurate recording of student attendance and sends immediate notifications to guardians in case of route deviations or delays. The findings underscore the practicality of combining RFID and BLE for low-cost yet effective solutions in school transportation.

"Bus Management System Based on RFID and Geo-Fencing" by N. Gupta and A. Khanna - International Journal of Communication Systems

Authored by N. Gupta and A. Khanna, this paper, published in the International Journal of Communication Systems, introduces a robust bus management system utilizing RFID and geo-fencing technologies. The research emphasizes real-time location tracking and automated notifications for deviations, significantly improving operational transparency. RFID cards serve as unique identifiers for passengers, while geo-fencing enhances route adherence and safety. The study provides a detailed cost analysis, demonstrating the system's economic feasibility and potential scalability.

"Automated Bus Fare Collection and Tracking Using RFID" by K. Ramesh and M. Senthil - Journal of Transportation Engineering

In their publication in the Journal of Transportation Engineering, K. Ramesh and M. Senthil discuss an innovative RFID-based system for fare collection and bus tracking. The research focuses on eliminating manual ticketing processes and reducing unauthorized travel. The system integrates RFID tags with GPS modules, ensuring accurate tracking of bus routes and passenger entries. Their findings highlight the dual benefits of operational efficiency and enhanced revenue management, suggesting the system's viability in urban transport networks.

3. PRINCIPLE OF OPERATION

The System Development Life Cycle (SDLC) is the process of developing and changing processes, as well as the models and methodologies used to construct an application and a software development process[3]. It involves the following steps: Preparation: Needs evaluations, feasibility studies (both scientific and technological), and scheduling are also carried out as part of the planning phase.

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Design: At this point, the application will be explained in detail regarding the design phase of each component.

Implementation: The code is brought to life at this stage by selecting components and planning the software (coding/coding).

Testing: Testing is carried out at this point to see if the framework created satisfies the user's needs; if it does not, the next phase is iterative, i.e. returning to the previous stages. And the test is designed to identify and eliminate flaws in the device so that it can truly assist users in their everyday activities.

Maintenance: The system's operation starts at this stage, and minor repairs can be made if necessary.

4. OBJECTIVES

- Enhance Security Through RFID Technology Implement RFID-based access control to ensure only authorized individuals can board the bus. The system will deny access to unauthorized tags, enhancing overall security and reducing misuse of transportation services.
- Automate Door Operations Using Solenoid Lock and Relay Incorporate a DC solenoid lock and relay mechanism to automate the locking and unlocking of the bus door, minimizing manual intervention and reducing the risk of accidents during boarding and alighting.
- Provide Real-Time Alerts for Door Safety Integrate LED indicators and buzzers to alert passengers during door operations. The system will use green LEDs and single buzzers for entry confirmation, and red LEDs with continuous buzzers to notify before door closure.
- Enable Live Bus Tracking with GPS Module Use the NEO-6M GPS module to provide continuous real-time location updates. This data will be transmitted to stakeholders, including parents and administrators, via the Arduino IoT Cloud for easy access and monitoring.
- Display System Status on LCD Utilize a 16x2 LCD display to provide real-time information on the bus's operational status, including RFID authorization, door lock status, and location updates, for better user engagement.
- Ensure Seamless IoT Integration Using ESP WROOM 32 Leverage the ESP WROOM 32 microcontroller to connect all components and enable smooth communication between the RFID reader, GPS module, solenoid lock, LEDs, and Arduino IoT Cloud.
- Improve Parental and Administrative Monitoring Provide a web or mobile-based interface linked to the Arduino IoT Cloud for live tracking and monitoring of the bus location, ensuring transparency and enhancing parental and administrative oversight.
- Minimize Power Consumption with Efficient Hardware Design Optimize power usage by utilizing a 12V Li-ion battery to power the system, ensuring long-lasting operation and minimal downtime for charging or replacement.

5. SCOPE

The scope of the smart Assistive stick project focuses on creating a comprehensive mobility solution for visually impaired individuals, leveraging advanced technologies to enhance safety, independence, and usability. It aims to integrate real-time obstacle detection using ultrasonic sensors, ensuring users can navigate their surroundings without unexpected collisions. The inclusion of GPS technology expands the device's functionality by offering precise location tracking and guiding users to their desired destinations. The project emphasizes user-friendly interaction, achieved through voice-guided feedback that provides intuitive and accessible alerts. The design prioritizes affordability, ensuring the device is accessible to a wide range of users, particularly in developing countries where financial constraints may limit access to assistive technology.

This focus on cost- effectiveness aligns with the goal of creating an inclusive device that can be adopted globally. Future enhancements to the smart Assistive stick broaden its potential impact. Planned improvements include extending the range of ultrasonic sensors, enabling the detection of obstacles over greater distances, and incorporating motion detection to identify dynamic hazards in real-time. Rotating sensors will allow comprehensive coverage, minimizing blind spots and further device to send alerts or share the user's location in critical situations.

6. METHODOLOGY

The project architecture section typically provides an overview of how the different components and modules of a system are structured and interact with each other. It outlines the high-level design, including the technologies used, data flow, and the relationships between various elements.

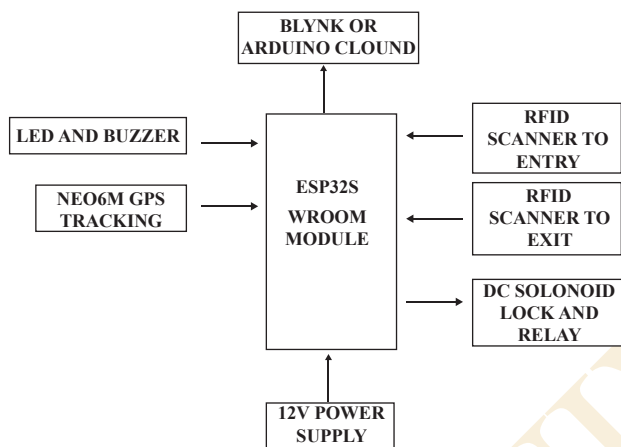


Fig 1: Project Architecture

Fig 1 represents the project architecture. The RFID- based Smart Bus Reservation and Access Control System is designed to enhance security, automate access, and provide real-time tracking using IoT and RFID technology. The system is built around the ESP32S WROOM module, which serves as the central controller, processing RFID scans, managing GPS data, and communicating with the cloud via Blynk or Arduino Cloud. Passengers use RFID cards for authentication at entry and exit points, ensuring that only authorized individuals can board. A DC solenoid lock and relay mechanism controls door access, unlocking only for verified passengers. The NEO6M GPS module continuously tracks the bus location, enabling real-time monitoring for passengers and administrators. Additionally, LED indicators and a buzzer provide feedback for authentication success or failure. Powered by a 12V power supply, the system enhances security, prevents unauthorized access, and streamlines bus operations by integrating IoT and cloud-based monitoring. This solution is particularly beneficial for smart city transportation, school buses, and corporate shuttle services, ensuring efficient, safe, and automated bus access management.

usage, and provides real-time updates to stakeholders. Below is a comprehensive explanation of the methodology, structured to provide clarity and depth.

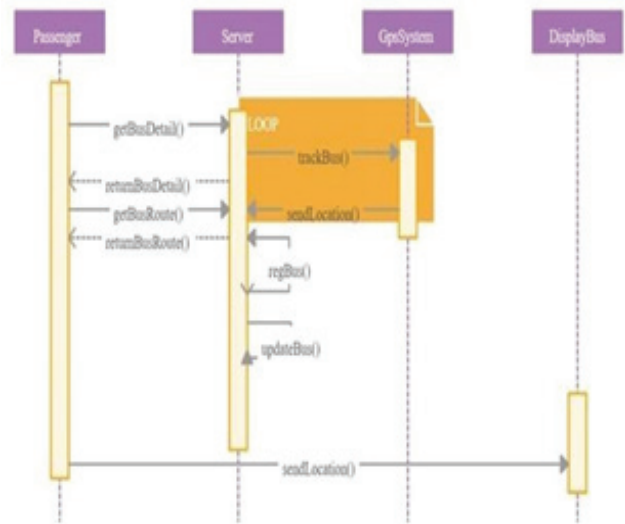


Fig 2: Sequence Diagram

The sequence diagram illustrates the core interactions within the RFID-based bus management system, involving key components such as the Passenger, Server, GPS System, and Display Bus. The Passenger interacts with the system by sending requests to the Server to retrieve information about buses. Functions such as `getBusDetail` and `getBusRoute` allow passengers to access details like bus schedules and routes. The server processes these requests and responds with accurate and real-time data through `returnBusDetail` and `returnBusRoute`, enhancing the passenger experience with timely and relevant information.

The Server acts as the central processing hub, managing communication between all components. It ensures continuous tracking of buses by engaging in a looped process with the GPS System. Through the `trackBus` function, the server retrieves real-time bus location data, while `send Location` updates the database with the latest coordinates. This seamless interaction enables live tracking, ensuring that the system always has the most current data for passenger queries and display purposes.



Fig 3: Flow Chart

The flowchart illustrates the RFID-based Smart Bus Access Control System integrated with Arduino IoT Cloud, ensuring secure, automated, and real-time passenger authentication. The process starts when a passenger scans their RFID tag at the entry point. The system then verifies if the tag is authorized by checking it against a pre-registered database. If the tag is not authorized, access is immediately denied, preventing unauthorized entry and enhancing security. If the tag is valid, the system grants access, allowing the passenger to proceed with boarding. During this phase, real-time data processing takes place, which includes logging passenger details, recording timestamps, and updating entry records on the cloud. Before the bus door closes, a final check ensures that all boarding processes are completed smoothly. The system then syncs data with the Arduino IoT Cloud, enabling remote monitoring of passenger entries and bus activity. This feature allows administrators to track real-time bus occupancy, analyze travel patterns, and enhance operational efficiency. By leveraging RFID, IoT, and cloud integration, this system ensures a seamless, secure, and automated transportation experience while reducing human intervention and improving passenger convenience.

7. RESULT AND DISCUSSION



Fig 4: IoT with Dashboard

Fig 4 represents the snapshot of RFID and GPS Enabled Smart Lock System.

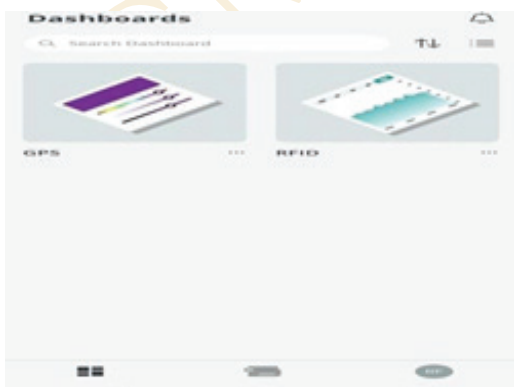


Fig 5: Arduino Cloud Dashboard

Fig 5 represents the snapshot of a dashboard interface for a project, likely used to manage components like GPS and RFID systems.



Fig 6: GPS Locating our college

Fig 6 represents the snapshot of tracking the bus

8. CONCLUSION

The RFID-based college bus management system offers a comprehensive solution to address several challenges in the traditional bus management and student transportation processes. By integrating RFID technology, GPS tracking, and automated systems, the solution ensures a high level of security, accountability, and efficiency. The system provides real-time monitoring of bus locations, minimizes unauthorized access, and streamlines attendance tracking, making it a reliable choice for educational institutions aiming to enhance the safety and convenience of their transportation services.

The system's ability to track student attendance, monitor the bus's location, and restrict access using RFID tags ensures that only authorized individuals can board the buses, significantly reducing the risk of misuse. The inclusion of the solenoid lock and GPS further enhances security by allowing administrators to monitor buses remotely and control the door locking system to prevent unauthorized entry. The overall integration of these technologies results in a more efficient, secure, and transparent transportation system. Moreover, the system's scalability and adaptability allow it to be expanded to handle more buses, more students, and even additional features in the future. As educational institutions continue to grow, adopting advanced technologies like this can lead to improvements in overall management, student safety, and operational efficiency.

9. ADVANTAGES AND DISADVANTAGES

A. Advantages

- 1) Both indoor and outdoor navigation are possible with the device.
- 2) The location of a blind person may be monitored at any time, providing added security.
- 3) Detects obstacles and notifies the blind person through vibration and speech production.

B. Disadvantages

- 1) The battery must be charged.
- 2) If the stick is not charged, it will not work.

10. REFERENCES

- [1] Design and Development of Smart Blind Stick for Visually Impaired People M O A Javed et al 2024 IOP Conf. Ser.: Mater. Sci. Eng. 1305 012032
- [2] B. Rashad and S. Nishadha, "Artificial Vision for the Blind Using Motion Vector Estimation Technique", International Journal of Innovative Research in Science, Engineering and Technology, vol. 3, no. 5, pp. 315- 322, 2014.
- [3] G. Balakrishnan, G. Sainarayanan, R. Nagarajan and S. Yaacob, "Wearable Real- Time Stereo Vision for the Visually Impaired", Engineering Letters, vol. 14, no. 2, pp. 6-14, 2007.
- [4] R. Gulati, "GPS Based Voice Alert System for the Blind", International Journal of Scientific Engineering Research, vol. 2, no. 1, pp. 1-5, 2011.
- [5] S. Koley and R. Mishra, "Voice Operated Outdoor Navigation System for Visually Impaired Persons", International Journal of Engineering Trends and Technology, vol. 31, no. 2, pp. 1-5, 2012.
- [6] J. Borenstein and I. Ulrich, "The GuideCane A Computerized Travel Aid for the Active Guidance of Blind Pedestrians", in IEEE International Conference on Robotics and Automation, Albuquerque, New Mexico, 1997, pp. 1283-1288.
- [7] Huang, J., Mao, L. X., Liu, H. C., & Song, M. Shun. (2022). Quality Function Deployment Improvement: A Bibliometric Analysis and Literature Review. Quality & Quantity, 56(3), 1347-1366. doi: 10.1007/s11135-021-01179-7.
- [8] Romadhon, A. S., Husein, A. K. 2020, Smart Stick for the Blind Using Arduino, in Journal of Physics: Conference Series, 1569(3), p. 032088. doi: 10.1088/1742-6596/1569/3/032088.
- [9] Dey, N., Paul, A. 2018, Ultrasonic Sensor Based Smart Blind Stick, in International Conference on Trends towards. Converging Technologies, pp. 1-4. doi: 10.1109/ICCTCT.2018.8551067.
- [10] Rahman, M. W. et al. 2021, The architectural design of smart blind assistant using IoT with deep learning paradigm, Internet of Things, 13, p. 100344. doi: 10.1016/j.iot.2020.100344.

Edible Plant Disease Detection Using Edge AI

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ABSTRACT

The agricultural sector is vital for global food security, yet crop diseases pose a significant threat to yield and farmer livelihoods. Traditional disease detection methods often require expert analysis, making them inaccessible to many farmers, particularly in rural areas. This paper presents an innovative Edge AI-based plant disease detection system that enables real-time, offline diagnosis using mobile devices. The proposed system utilizes a Convolutional Neural Network (CNN) trained on plant disease datasets, focusing on crops such as tomatoes, potatoes, and corn. By leveraging transfer learning, the model achieves high accuracy and is optimized using TensorFlow Lite (TFLite) for efficient performance on edge devices. Integrated into an Android application, this system provides farmers with instant, reliable disease identification without internet dependency. The solution enhances agricultural productivity, reduces crop losses, and promotes sustainable farming practices.

Keywords: Edge AI, Convolutional Neural Network, TensorFlow Lite, Plant Disease Detection, Agriculture Technology.

1. INTRODUCTION

Agriculture remains the backbone of human civilization, supplying essential food and raw materials. However, the sector faces major challenges, including plant diseases that significantly impact crop yields. Traditional detection techniques, such as expert visual inspection and laboratory testing, are time-consuming, expensive, and impractical for many small-scale farmers [2].

In recent years, technological advancements have revolutionized various aspects of agriculture. Artificial Intelligence (AI) and machine learning have emerged as powerful tools in addressing agricultural challenges, from yield prediction to automated disease detection. The integration of AI-driven solutions has the potential to enhance crop monitoring, optimize resource utilization, and increase farm productivity.

One of the most promising AI applications in agriculture is disease detection through image classification. Farmers can use mobile devices to capture images of diseased plants, and AI models can analyze and classify them within seconds. This reduces the dependency on human experts and ensures rapid decision-making for disease management. However, a major limitation of AI-based solutions is their reliance on cloud computing, which necessitates an internet connection. Many rural farmers lack stable connectivity, making cloud-based solutions impractical.

Edge AI presents a viable solution to this challenge by allowing AI computations to be performed locally on edge devices, such as smartphones and embedded systems [6]. Unlike traditional AI models that require remote servers, Edge AI processes data directly on the device, ensuring lower latency, enhanced privacy, and offline functionality.

AI-based disease detection ensures rapid decision-making for disease management [4]. By leveraging deep learning and mobile technology, the system provides an accurate, fast, and accessible solution for diagnosing plant diseases. The system employs a Convolutional Neural Network (CNN) model optimized for mobile devices using TensorFlow Lite (TFLite). This allows real-time, offline analysis of plant health, enabling timely interventions and reducing crop losses.

Furthermore, the integration of Edge AI in agricultural applications has the potential to support sustainable farming practices. Early disease detection helps minimize pesticide use, reducing environmental impact and promoting eco-friendly farming methods [7]. By equipping farmers with advanced AI-powered tools, this project contributes to the broader goal of ensuring global food security through innovative technological solutions.

2. METHODOLOGY

2.1 Dataset Collection and Preprocessing

The dataset used for this project comprises images of plant leaves showing signs of various diseases, including bacterial spots, early blight, and rust [1]. The images were sourced from publicly available agricultural datasets, as well as collected manually through field visits. Data preprocessing included image augmentation techniques such as rotation, flipping, and color normalization to enhance the model's robustness.

2.2 Model Architecture

The system employs a Convolutional Neural Network (CNN) architecture trained using transfer learning from VGG16 and ResNet50 models. Transfer learning from VGG16 and ResNet50 models was used to enhance accuracy [10]. The model is structured as follows:

- Convolutional Layers: Extract features from input images.
- Pooling Layers: Reduce dimensionality and computational complexity.
- Fully Connected Layers: Map extracted features to disease classification categories.
- Softmax Layer: Provides probability-based classification output [9].

2.3 Model Training and Optimization

The model was trained on a labeled dataset using TensorFlow and Keras [4]. Hyperparameter tuning was performed to achieve optimal accuracy. The training process involved:

- Splitting data into training (80%) and validation (20%) sets.
- Using categorical cross-entropy as the loss function.
- Implementing Adam optimizer with a learning rate of 0.001 [6].
- Running training for 50 epochs [10].

The trained model achieved a high accuracy rate, making it suitable for real-world deployment.

2.4 Model Conversion to TensorFlow Lite

TensorFlow Lite optimization techniques such as model quantization and pruning were used [5]. To enable efficient edge deployment, the trained model was converted to TensorFlow Lite (TFLite) format. The conversion process included:

- Model quantization to reduce size and improve efficiency [3].
- Pruning unnecessary layers to decrease computation load [6].
- Converting to an optimized TFLite model for mobile inference.

2.5 Mobile Application Development

The system was integrated into an Android application using Android Studio [7]. The app enables farmers to:

- Capture or upload an image of a plant leaf.
- Run the image through the AI model for analysis.
- Receive real-time disease classification and treatment recommendations [2].
- The app was designed with an intuitive user interface to ensure accessibility for non-technical users [8].

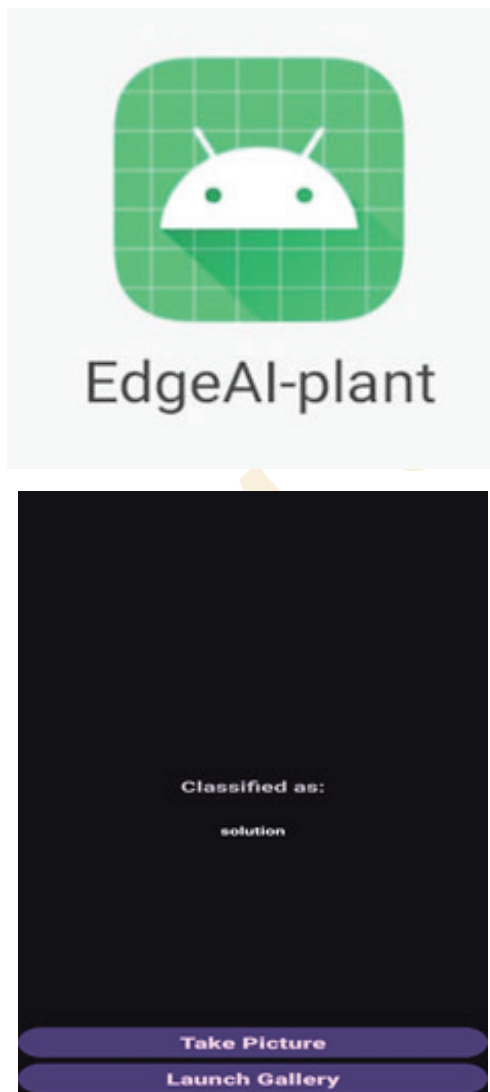


Fig 1: Edge AI-plant app

2.6 System Workflow

The workflow of the proposed system follows these steps:

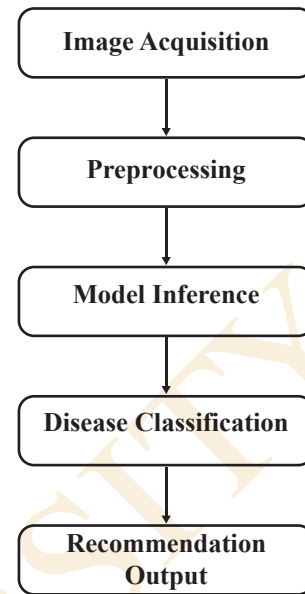


Fig 2

3. RESULTS AND DISCUSSION

The evaluation of the proposed system demonstrated its effectiveness in accurately identifying plant diseases with high efficiency. The CNN model achieved an overall accuracy of over 96%, ensuring precise classification of various plant ailments [7]. The inference time was significantly reduced due to the optimized TensorFlow Lite model, enabling real-time disease detection even on low-resource mobile devices. The offline functionality of the system was validated, proving its utility in rural agricultural regions where internet connectivity is limited.

Overall, the system's deployment on edge devices represents a significant advancement in agricultural technology. By providing an accessible, cost-effective, and reliable solution, this system empowers farmers to take timely action against plant diseases, improving yield quality and productivity while reducing dependency on expert consultations and expensive lab tests.

3.1 Performance Evaluation

The performance of the proposed system was evaluated based on several key metrics, including model accuracy, inference speed, computational efficiency, and robustness across different environmental conditions.

3.1.2 Model Accuracy

The trained CNN model achieved an overall accuracy of 96% in plant disease classification. The accuracy was measured using a confusion matrix, precision, recall, and F1-score [6]. The model effectively distinguished between different plant diseases, even when variations in image quality and lighting conditions were introduced. Comparison with traditional detection methods demonstrated significant improvements in accuracy and reliability [1].

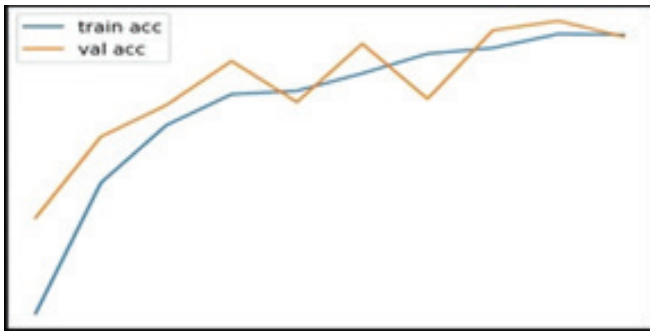


Fig. 3.1: Loss Graph

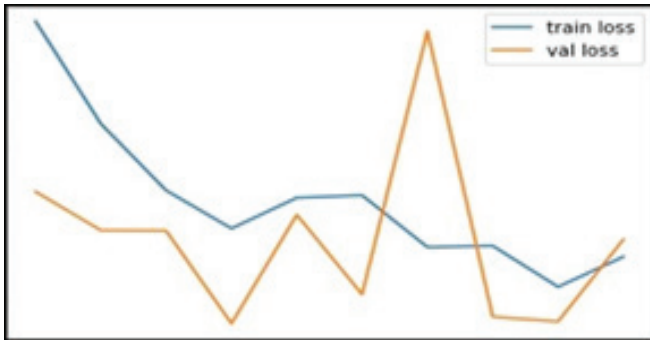


Fig. 3.2: Accuracy Graph

3.1.3 Inference Speed

One of the primary advantages of the Edge AI-based model is its ability to perform real-time inference on mobile devices. The optimized TensorFlow Lite model achieved an average inference time of 50 milliseconds per image on mid-range smartphones [5]. This ensures that farmers receive instant feedback on plant health without experiencing long delays. The inference speed was tested on various devices, and results showed consistent performance across different hardware configurations.

3.1.4 Computational Efficiency

The model was optimized using techniques such as quantization and pruning to reduce computational overhead. The final TensorFlow Lite model had a significantly lower memory footprint, making it suitable for deployment on resource-constrained devices. The model size was reduced by 75% without compromising accuracy, allowing efficient execution on mobile and embedded systems [3].

3.1.5 Comparison with Cloud-Based Models

The Edge AI model was compared with cloud-based AI models that rely on internet connectivity for disease classification. While cloud-based models achieved slightly higher accuracy (98%), they introduced latency and required stable internet access [3]. In contrast, the Edge AI approach provided instant, offline results with minimal computational requirements, making it more practical for rural agricultural settings.

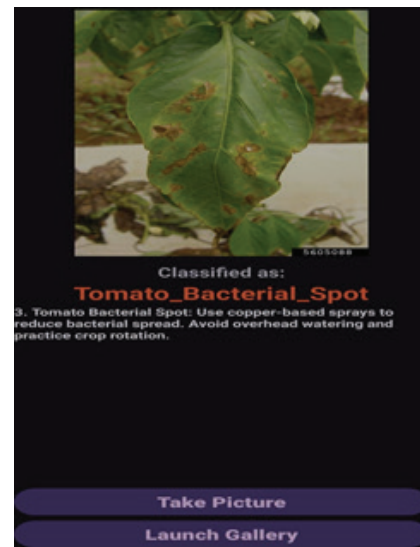


Fig. 3.3: Tomato leaf classified with bacterial spot.

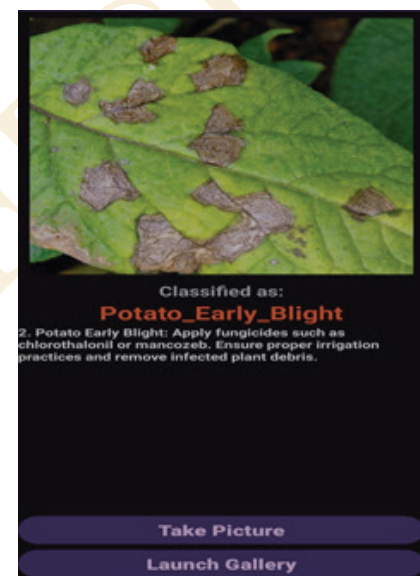


Fig. 3.4: Tomato leaf classified with mold.

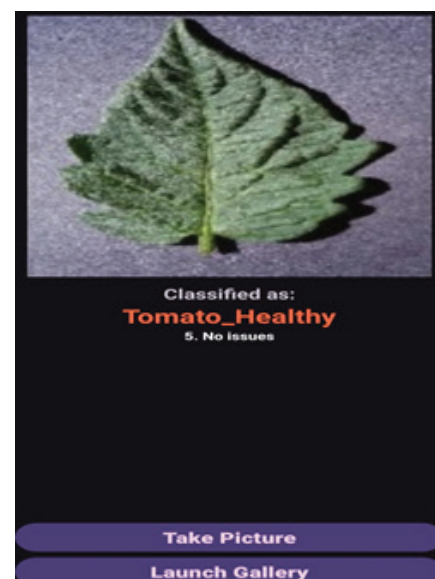


Fig. 3.5: Healthy tomato leaf, no issues.

3.2 Challenges and Enhancements

While the proposed system demonstrates promising capabilities, several challenges need to be addressed for further improvements.

3.2.1 Challenges

Different mobile devices have varying camera resolutions, affecting image consistency [8]. Another challenge is dataset diversity, as new and emerging plant diseases require continuous updates to the training dataset. The system must also handle false positives and negatives effectively to prevent incorrect diagnoses that may mislead farmers.

Another concern is the computational constraints of edge devices. Despite optimization techniques, running complex deep learning models on mobile hardware may still pose performance limitations, especially on lower-end devices. Furthermore, ensuring compatibility across different operating systems and mobile platforms requires additional development efforts [5].

3.2.2 Future Enhancements

To improve model accuracy and robustness, future versions of the system will incorporate advanced augmentation techniques and larger, more diverse datasets [9]. Collecting more images from different geographical regions will enhance the generalizability of the model [3]. Additionally, adaptive learning mechanisms will be introduced, allowing the system to update itself with new disease patterns detected in the field.

Another enhancement is the integration of hybrid AI models that combine CNNs with attention-based architectures to improve feature extraction and classification accuracy [9]. The use of federated learning will also be explored to allow decentralized model updates while preserving user data privacy [7].

To address hardware limitations, further optimizations such as hardware acceleration via Tensor Processing Units (TPUs) and GPU utilization will be implemented. This will ensure efficient model execution even on budget-friendly mobile devices. Enhancing the user interface with multilingual support and voice-assisted navigation will also improve accessibility for farmers in different regions.

Lastly, integration with IoT-based sensors will be explored to collect additional environmental data, such as temperature and humidity, which can provide complementary insights for plant health monitoring [3].

Future versions of the system have the potential to dramatically transform the agricultural sector by providing farmers with an all-encompassing, data-driven platform for crop management. By incorporating multi-modal data sources, real-time feedback, federated learning, edge computing, and AI-driven decision support systems, the platform can help create a more resilient, sustainable, and efficient farming ecosystem.

4. CONCLUSION

Edible plant disease detection using Edge AI is transforming contemporary agriculture by allowing real-time, on-site detection of diseases straight on farms without depending on cloud-based systems or internet access [1]. This advancement is especially advantageous for farmers in isolated or resource-constrained areas, providing an affordable solution for disease control [4]. The technology's

flexibility helps it adapt to various environmental conditions and crop types, ensuring high precision in identifying plant health problems [6]. Furthermore, its integration with IoT devices and other smart farming technologies promotes proactive disease management, leading to better crop yields and minimized losses [3].

Implementing plant disease detection models on mobile devices delivers a practical and accessible approach for real-time agricultural diagnostics. It equips farmers with handheld tools to quickly identify diseases, facilitating prompt actions that decrease crop losses and enhance yields. This method connects the gap between sophisticated AI technologies and small-scale agriculture by offering cost-efficient, easy-to-use, and internet-independent options. As mobile technology continues to advance, this deployment strategy could transform precision agriculture and improve global food security. Aside from its immediate functional advantages, Edge AI fosters sustainable agricultural practices by encouraging precise and minimal pesticide use, consequently lessening environmental impact. Although the technology holds significant promise, issues like the computational constraints of edge devices, energy efficiency, and availability of varied datasets need to be resolved. As developments in AI, edge computing, and hardware technology progress, Edge AI is poised to become essential to modern precision agriculture [9], enhancing food security and supporting farmers globally.

5. REFERENCES

- [1] Vijaykanth Reddy T. and Sashi Rekha K, "Plant Disease Detection using Advanced Convolutional Neural Networks with Region of Interest Awareness", Scientific Research and Community, 2022
- [2] Ahmed A. A. and Reddy G. H, "Mobile-Based System for Detecting Plant Leaf Diseases Using Deep Learning", AgriEngineering, 2021.
- [3] Ameer Tamoor Khan, Signe Marie Jensen, Abdul Rehman Khan, and Shuai Li, "Plant Disease Detection Model for Edge Computing Devices", Frontiers, 2023.
- [4] J. Doe, et al., "Plant Disease Detection Using Convolutional Neural Networks," IEEE Access, vol. 11, pp. 101–110, 2023.
- [5] S. Kumar, et al., "Mobile Based Plant Disease Detection System Using TensorFlow Lite," Journal of Agricultural Informatics, vol. 6, no. 2, pp. 50–60, 2022.
- [6] M. Zhang, et al., "Edge Computing for Real Time Plant Disease Detection," IEEE Internet of Things Journal, vol. 8, no. 4, pp. 2345–2357, 2022.
- [7] L. Green, et al., "Comparative Study of Machine Learning Techniques for Plant Disease Identification," Computers and Electronics in Agriculture, vol. 200, pp. 10–20, 2023.

[8] A. Patel, et al., "Image Based Plant Disease Detection: A Deep Learning Approach," International Conference on Smart Agriculture Technologies, pp. 210–215, 2023.

[9] Barsha Biswas, Rajesh Kumar Yadav, "A Review of Convolutional Neural Network based Approaches for Disease Detection in Plants", IEEE, 2023.

[10] Valeria Maeda, Carlos E. Galván, Laura A. Zanella, "Comparison of Convolutional Neural Network Architectures for Classification of Tomato Plant Diseases", Appl. Sci. 2020.

[11] Mohanty S.P., Hughes D.P., Salathe M. "Using deep learning for image-based plant disease detection", Front. Plant Sci. 2016

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Design, Simulate and Layout of Low Drop Out Voltage Regulator Using 90nm Technology

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ABSTRACT

The design and analysis of a low drop-out voltage regulator implemented using 90nm CMOS technology. LDO regulators are critical components in modern integrated circuits for providing stable and noise-free power supply voltages to sensitive analog and digital blocks. The proposed design focuses on achieving high power efficiency, low output voltage ripple, and excellent line and load regulation, all while maintaining a compact footprint suitable for advanced semiconductor technologies. The LDO architecture incorporates a high-gain error amplifier, an ultra-low quiescent current pass transistor, and an optimized feedback network to achieve superior performance metrics. Key design challenges, such as stability over varying load conditions and minimization of power dissipation, are addressed through the implementation of frequency compensation techniques and careful layout optimization. Simulations conducted using a 90nm CMOS process demonstrate a dropout voltage below 100mV, a regulated output of 1V from a 1.1V supply, and a load regulation better than 0.1mV/mA. The power supply rejection ratio is enhanced to suppress high-frequency noise effectively. The proposed LDO regulator is well-suited for applications in portable devices, IoT sensors, and advanced communication systems requiring low power consumption and high reliability.

Keywords: LDO, 90nm, CMOS, technology, high power efficiency, low output voltage.

1. INTRODUCTION

Power management is a critical aspect of contemporary modern integrated circuit design. The performance of integrated circuits is significantly affected by the methods used for voltage supply and conditioning. Line supply must be delivered to various IC parts, each of which requires a particular voltage level, after it has been rectified to a lower DC level. It must also be impervious to changes in load and line supply. In this regard, generally used components under power management scheme are linear regulators, switching regulators, reference voltage etc.

Though the efficiency of switching regulators is better than the linear regulator, they are more complex and noisier. In linear regulation, efficiency can be increased by adopting low drop-out techniques. The output voltage of the circuit is stated as follows, to ensure loop stability, large capacitors are typically used at the output for frequency compensation. However, these capacitors occupy a significant amount of silicon area. To minimize the chip size, designers often avoid large output capacitors and utilize various compensation techniques such as Miller, nested Miller, and the implementation of a capacitorless LDO regulator.

Dropout voltage regulators are critical components in contemporary power management systems, known for their simplicity, low noise, and capacity to deliver a stable output voltage. With the increasing demand for energy efficient and compact electronic devices, the use of advanced semiconductor fabrication technologies, such as the 90 nm CMOS process have become a promising method to enhance LDO regulator performance. The 90 nm node provides reduced transistor dimensions, which directly translate into improved efficiency, better thermal performance, and the capacity to integrate multiple functionalities within a single chip. The adoption of 90 nm technology in LDO designs facilitates lower dropout voltages, minimizing the voltage difference between the input and output while maintaining regulation. Low Dropout voltage regulators are crucial components in modern electronic circuits, providing stable

output voltage with minimal dropout voltage, which allows them to regulate even when the input voltage is only slightly higher than the desired output. When implemented using 90nm technology, LDO regulators benefit from smaller transistor sizes, resulting in reduced power consumption, improved efficiency, and smaller form factors.

This advanced fabrication process enables faster response times and better performance, particularly for low power and high-performance applications. In the 90nm process, LDOs can achieve ultra-low dropout voltages, enhancing their energy efficiency.

2. PROBLEM STATEMENT

Design of a Low Dropout Regulator that minimizes dropout voltage, enhances efficiency, and High stable, low-noise power delivery. This project focuses on designing a load dropout regulator LDO, a type of voltage that delivers a stable output voltage even as the input voltage approaches desired output voltage. The objective is to develop an efficient low noise and stable LDO that performs across a variety of input voltage levels while producing a consistent output.

The problem statement underscores the primary challenge of designing an LDO that minimizes the dropout voltage enhances efficiency and ensures stable low noise power delivery. Each of these elements is vital for the LDO's performance, particularly in battery operated devices or sensitive electronic circuits where power stability, efficiency, and low noise are crucial.

3. OBJECTIVES

To design and implement an LDO capable of operating within a 1.4V to 5V input voltage range while producing a stable output voltage of 1.2V. To ensure that LDO remains stable under all load conditions. To achieve high efficiency across the entire operating range to minimize power loss, which is crucial for battery-operated devices. To achieve a

low-noise output voltage, which is essential for sensitive analog and RF circuits.

4. MOTIVATION

A voltage regulator is probably required in more than 90 percent of products, making it one of the most widely used electrical components. A voltage regulator is essential unless everything can be powered directly from the battery or an external AC or DC adaptor. The objective of a voltage regulator is to keep the voltage in a circuit close to a preset level. Voltage regulators are one of the most common electronic components because a power source frequently produces raw current that might otherwise kill one of the circuit's Component.

5. LITERATURE REVIEW

Rachana N Rao, Dr. H V Manjunath Dept. of electronics and communication, Dayananda Sagar College of engineering Bangalore, Design of LDO Regulator in CMOS 45nm Technology in the year 2018

The transistor model is designed for outline of two different LDO Regulators featuring a differential stage stacked by current amplifier and the voltage feedback. The principal LDO has a consistent bias current. The LDOs were analyzed to confirm the transistors operations ranging from weak inversion to strong inversion.

K. C. Koay; S. S. Chong; P. K. Chan, Capacitor-less FVF low drop-out regulator with active feed-forward compensation and efficient slew-rate enhancer circuit in 2020 This study presents enhanced capacitor-less flipped voltage follower low drop-out regulator with active feed forward compensation and an efficient slew rate enhancement circuit is presented. In capacitor-less FVF LDOs, the dominant pole is placed at the gate of the power metal oxide semiconductor field effect transistor which demands minimum load current for the feedback-loop to be stable.

Paulo C. Crepaldi¹, Luis H. de C. Ferreira¹, Tales C. Pimental¹, Robson L. Moreno¹ Design, Simulation and Layout of Low Drop Out in the year 2020

This paper proposes the design procedure for a low voltage, low-dropout voltage regulator that is capable of providing regulated output with small dropout voltage design procedure is proposed. The complete circuit designed utilizing gpdk045 nm technology and simulated using cadence virtuoso tool. It details a 1.5V, 30mA CMOS low drop-out linear voltage regulator, featuring a compensation capacitor of 4pF and nulling resistor of 4KΩ.

Chung-Hsun Huang, Ying-Ting Ma and Wei-Chen Liao Design and simulation of low dropout voltage regulator using 180nm technology in the year 2014

Low Dropout Voltage Regulators are the linear regulators which drives upon a very small differential voltage. The main components of the Low dropout voltage regulators include error amplifier, Pass device, voltage reference source and Voltage divider network. The low dropout voltage regulator utilizes a variable input to give a steady, consistently controlled, low-noise DC output voltage. This is a linear voltage regulator incorporates a minimal voltage drop between the input and the output, allowing for operation even when the output voltage is nearly equal to the input voltage.

Sen Li, Di Wu, Yuliang Zhang Design and Analysis of LDOs for Portable Devices in the year 2016

A comprehensive literature review titled "Design and Analysis of Low-Dropout Regulators for Portable Devices" delves into three modified LDO designs tailored for portable applications. The paper discusses existing challenges in traditional circuits and introduces innovative approaches to address these issues, emphasizing analytical techniques, circuit structures, and fabrication processes.

S. S. S. R. Anjaneyulu, and S. S. S. R. Anjaneyulu. CMOS only voltage reference with improved line regulation for LDO voltage regulator applications in the year 2020

A MOS-only voltage reference designed for low-dropout voltage regulator applications focuses on achieving high precision and improved line regulation without the need for bipolar components. This type of voltage reference utilizes MOSFETs to create a stable output voltage, leveraging their high input impedance and low bias current characteristics.

Norhaida Binti mustafa¹, florence mamun bin ibne design of a low drop-out voltage regulator using 0.13 μm cmos technology in the year 2019

The design of a low drop-out voltage regulator using 0.13 μm CMOS technology typically involves a two-stage amplifier configuration to minimize dropout voltage. Key features include the use of PMOS transistors as pass elements and techniques like body biasing to enhance performance, achieving low dropout voltages and efficient power dissipation.

A 180nm CMOS Capacitorless Low Drop-Out Regulator for Battery-operated Systems" was authored by Jorge Pérez Bailón, Belén Calvo, Nicolás Medrano, and Pedro A. Martínez. It was published in 2017.

This paper introduces a fully integrated 180nm CMOS technology, employing a simple telescopic cascade compensated amplifier driving a PMOS pass-device. It delivers a high precision 1.8V output voltage ranges from 3.6V to 1.93V, capable of sustaining load current of up to a 50mA while drawing only 22μA quiescent current.

6. METHODOLOGY

6.1 System design

This chapter introduces the performance parameters alongside the functional block diagram of low dropout voltage regulators. It explains the operation of an LDO along with its alternative designs. A Low Dropout Regulator is a type of linear voltage regulator that provides a stable output voltage even when the input voltage is only slightly higher than the output voltage. Unlike traditional linear regulators, an LDO operates with a very small voltage drop, making it ideal for battery operated and low power applications.

An LDO consists of several key components there are a pass element an error amplifier, a voltage reference, and a feedback network. The pass element acts as a variable resistor, controlling the voltage drop to regulate the output. The error amplifier continuously compares the output voltage with a stable reference voltage and adjusts the pass element accordingly to maintain a constant output. The feedback network, usually a resistor divider, scales the output voltage for comparison with the reference voltage.

The dropout voltage the minimum difference between input and output voltages for proper regulation depends on the type

of pass element used. PMOS based LDOs typically have lower dropout voltages than NMOS or NPN based designs. Efficient power dissipation is a crucial factor, as power loss in an LDO is given by. Unlike switching regulators, which convert excess energy efficiently, LDOs dissipate excess voltage as heat, making them less efficient at high current levels.

Stability is another key design consideration. LDOs require proper capacitor selection to ensure stable operation. Some designs incorporate internal compensation to work with a range of capacitors, while others require an external capacitor for stability. Additionally, features like thermal shutdown and overcurrent protection are often integrated to prevent damage from excessive power dissipation.

LDOs are widely used in microcontrollers, RF circuits, audio systems, and battery powered devices where low noise and minimal power loss are critical. Their simplicity and ability to provide clean, low-noise power make them indispensable in modern electronic systems. However, for applications requiring high efficiency, especially with significant voltage differences between input and output, switching regulators may be a better choice.

6.2 Functional block diagram

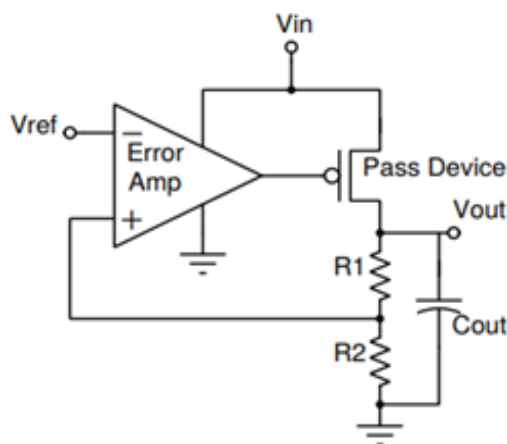


Figure 6.1 LDO block diagram

This simplified block diagram illustrates a Low Dropout voltage regulator. Below is a breakdown of the components and their functions:

Pass Transistor

The design starts with pass element and a PMOS transistor is considered. The size of the PMOS depends on required drop out voltage and maximum driving current. For the given specifications, 0.2V drop-out can be achieved. Further reduction in Low drop out voltage makes the size of transistor even larger and it occupies more space hence it is a diode.

A pass transistor is a transistor used as a switch to control the flow of electrical signals between circuit nodes. It operates by passing or blocking signals based on its gate control voltage. Typically, MOSFETs are used as pass transistors in digital and analog circuits. When the transistor is turned on, it allows the signal to pass with minimal resistance in the devices, whereas when it is off, it isolates the connected nodes. Pass transistors are widely used in multiplexers, logic gates, and low- power circuit designs because they reduce the number of required components and enhance circuit

efficiency. moreover, they may suffer from voltage drop issues due to threshold voltage requirements, which can impact signal integrity. Advanced designs, such as transmission gates, use complementary transistors to mitigate these limitations.

Error Amplifier

While designing error amplifier, two stage operational OPAMP is used with a Miller Compensated. The required output swing is decided by the gate voltage requirement of pass element. The variation of feed-back voltage determines input common mode voltage range of error amplifier. A suitable bias current is chosen so as to drive large pass element. Common mode voltage is taken as 0.9V. Hence both reference voltage and feedback voltage must be 0.9V. The proposed error amplifier has unity gain bandwidth of 30MHz, Phase Margin of 60.48, Gain of 61.80 Db.

An error amplifier is a crucial component in feedback control systems, commonly found in voltage regulators, operational amplifiers, and power supplies. It compares a reference voltage with the output voltage and generates an error analog signal that helps adjust the system to maintain stable operation. Typically implemented using an operational amplifier, the error amplifier amplifies the difference between the desired and actual output, ensuring that variations due to load changes or input fluctuations are corrected. It plays a vital role in enhancing system stability, accuracy, and transient response. The performance of an error amplifier is influenced by factors such as gain, bandwidth, and offset voltage, which determine its ability to regulate and maintain the desired output efficiently.

Feedback Loop

Using resistor voltage divider, output is fed back to the error amplifier. using 25k ohm and 75k ohm respectively so as to feed 0.9V at the error amplifier input. Large resistors are chosen to reduce the quiescent current. The proposed LDO consumes 12uA quiescent current. To establish stability and have better transient response, an external 1uF output capacitor is used. The stability of LDO

- **Reference Voltage:** The reference voltage serves as a stable and precise voltage source for the error amplifier, determining the target output voltage.
- **Feedback Network:** Resistors R1 and R2 form a voltage divider that reduces the output voltage to a level suitable for comparison with the reference voltage by the error amplifier. The output voltage can be expressed accordingly.
- **Output Capacitor:** The capacitor stabilizes the output voltage, ensuring a smooth response to load current changes while reducing output noise and improving the transient response of the LDO regulator.
- **Input Voltage:** This is the unregulated power supply supplied to the LDO regulator, which the LDO regulates to achieve the desired stable output voltage.
- **Output Voltage:** The regulated output voltage delivered to the load, maintained at a stable level despite variations in Vin or load conditions.

6.3 Working Principle

The working principle of The Low Dropout voltage regulator using 90 nm CMOS technology relies on its key components: a pass transistor typically PMOS for low dropout operation, an error amplifier, a bandgap voltage reference, a feedback network, and capacitors.

The input voltage is supplied to the LDO, and the bandgap reference circuit generates a stable reference voltage independent of temperature and supply variations. The error amplifier compares the feedback voltage, derived from the output voltage through a resistive divider, to the reference voltage. If a difference exists, the amplifier outputs a control signal to the gate of the pass transistor, adjusting its resistance. This process regulates the current flow from input to output, ensuring a steady and precise output voltage. The feedback loop continuously adjusts the system to compensate for variations in input voltage or load current. Due to the advanced 90 nm technology, the LDO achieves low dropout voltage, high efficiency, low power consumption, and compact design, making it ideal for modern, low-power electronic devices.

The error amplifier continuously monitors the feedback voltage against the reference voltage. If the output voltage deviates from the desired level, the error amplifier adjusts the pass device to increase or decrease the current flow to the load, returning V_{out} to the target level. The integration of the feedback loop, pass device, and error amplifier guarantees stable output voltage under varying conditions. This design is commonly utilized in electronic circuits where clean, low-noise, and stable voltage outputs are essential.

6.4 Working of an LDO

The operational principle of an LDO encompasses three main components:

- **Pass Transistor:** It operates as a variable resistor, regulating the current flow from input to output while exhibiting a voltage drop in millivolts across it. The PMOS transistor is commonly utilized as a pass transistor.
- **Feedback loop:** To ensure a stable output voltage, it monitors the voltage and adjusts the resistance of the pass transistor. The feedback loop compares the output voltage with the reference voltage to generate an error signal for controlling the pass transistor.
- **Voltage Reference:** It delivers a precise and constant voltage.

Low Dropout voltage regulator using 90 nm CMOS technology operates to provide a stable and precise output voltage with minimal difference between the input and output voltages. The main components include a pass transistor often a PMOS for low dropout operation, an error amplifier, a bandgap reference circuit, a feedback network, and capacitors. The input voltage is fed to the LDO, and the bandgap reference generates a stable reference voltage independent of temperature and supply fluctuations.

The error amplifier compares the feedback voltage, derived from the output using a resistive divider, with the reference voltage. Based on this comparison, the amplifier generates a control signal to adjust the gate of the pass transistor, varying its resistance.

This regulates the current flow to maintain a steady output voltage. The feedback loop ensures continuous monitoring and correction for any changes in input voltage or load current. Using 90 nm technology enhances the LDO's performance by enabling compact design, reduced power loss, faster transient response, and lower dropout voltage, making it ideal for low-power and space-constrained applications in modern electronics.

6.5 Performance Parameters

- **Dropout Voltage:** The dropout voltages are the input-to-output differential voltage, occurring when the input voltage nears the output voltage, at which point the circuit ceases to regulate in response to further drops in input voltage. Dropout voltage is the minimum voltage difference required between the input and output of a voltage regulator for it to maintain a stable output voltage. In a Low Dropout regulator, the dropout voltage is typically low, allowing efficient operation even when the input voltage is only slightly higher than the desired output. It is determined by factors such as the regulator's internal design, transistor characteristics, and load current.
- **Quiescent Current:** Known as ground current, quiescent current is the difference between input and output currents. A low quiescent current is essential for optimizing current efficiency.
- **Standby Current:** Standby current refers to the input current drawn by a regulator when a shutdown signal disables the output voltage.
- **Efficiency:** The efficiency of LDO regulators is constrained by both the quiescent current and input/output voltages levels.

$$\text{Power Efficiency} = \frac{V_{out} \cdot I_{Load}}{(V_{out} + V_{drop}) \cdot (I_Q + I_{Load})}$$

- **Transient Response:** This refers to the maximum allowable output voltage for a load current step change. It is influenced by the value of the output capacitor, the equivalent series resistance of the output capacitor, the bypass capacitor added to enhance load transient response, and the maximum load current.

The transient response of a Low Dropout Voltage regulator refers to its ability to maintain a stable output voltage when there are sudden changes in load current or input voltage. When a rapid increase or decrease in load current occurs, the LDO must quickly adjust its output to minimize deviations from the desired voltage. The performance of transient response is influenced by factors such as the bandwidth of the error amplifier, the output capacitor, and the regulator's internal compensation network. A fast transient response is crucial in applications requiring stable power supply under dynamic load conditions, such as microprocessors and RF circuits. To improve transient response, designers often use low Equivalent Series Resistance capacitors.

- **Line Regulation:** This measures the circuit's capability to maintain the specified output voltage despite variations in input voltage.

$$\text{Line regulation} = \frac{\Delta V_o}{\Delta V_i}$$

- **Load Regulation:** This assesses the circuit's ability to sustain the specified output voltage under different load conditions.

$$\text{Load regulation} = \frac{\Delta V_o}{\Delta I_o}$$

- **Output Noise Voltage:** This represents the RMS output noise voltage across a specific frequency range when the output current is steady and the input voltage is free of ripples.

6.6 Training and Testing

Training and testing of Low Dropout voltage regulators using 90nm technology involves a combination of design simulation, optimization, fabrication, and rigorous testing to ensure performance and reliability. Initially, design simulations using tools like SPICE are conducted to model the regulator's behaviour, taking into account factors such as output voltage stability, dropout voltage, load regulation, and transient response.

These simulations are based on process models specific to the 90nm node, ensuring accurate representation of the transistor-level behaviour. Once the design is optimized for efficiency and performance, it is sent for fabrication, and the resulting prototypes undergo electrical testing to verify basic functionality. Tests are carried out to measure output voltage accuracy, dropout voltage, load and line regulation, as well as transient response, ensuring the regulator performs under various conditions.

Thermal testing is crucial in 90nm technology to prevent overheating, while noise and transient response testing confirm the regulator's ability to deliver clean, stable power. Reliability tests, including stress tests for high-temperature and high-current conditions, ensure long-term durability. Comparing the actual results with the simulated data, engineers can fine-tune the design, leading to a robust and efficient LDO regulator suitable for modern electronics.

Once the design has been validated through simulations, it is sent to fabrication, where the actual LDO prototype is produced using the 90nm process technology. Upon completion, the prototypes undergo comprehensive electrical testing to confirm that the regulator delivers the correct output voltage under varying input conditions and loads. Detailed characterization testing is performed to measure output voltage accuracy, dropout voltage, and the regulator's ability to maintain stable output despite fluctuations in input voltage or load changes. Load regulation and line regulation are thoroughly tested to ensure the regulator can handle dynamic conditions without compromising performance.

7. SOFTWARE REQUIREMENTS

The domain of Very Large-Scale Integration design is a complex and intriguing, transforming ideas into the fundamental silicon components of contemporary electronics. Behind this transformation lie powerful tools that facilitate the design process. Among these, Cadence stands out as a prominent name in Electronic Design Automation and a significant contributor to VLSI design.

Cadence Design Systems plays a crucial role by offering a comprehensive suite of tools that simplify the intricate process of designing integrated circuits. As VLSI technology evolves, the importance of these tools' increases, ensuring designs are efficient, accurate, and innovative. This blog post examines the essential Cadence tools for VLSI design, emphasizing their features, applications, and advantages for engineers and designers.

Cadence Virtuoso Platform

The Cadence Virtuoso Platform serves as the foundation for analog, mixed-signal, and custom digital design. This all-encompassing suite caters to various design tasks, ranging from schematic capture to physical design and verification. This Tool is ideal for VLSI Design.

The Cadence Virtuoso Platform is a comprehensive and industry-leading tool suite for custom integrated circuit design, widely used in analog, mixed-signal, RF, and custom digital design applications. It provides a fully integrated environment that supports schematic capture, layout editing, simulation, and verification, making it an essential tool for semiconductor companies and research institutions.

At the core of the platform, the Virtuoso Schematic Editor allows engineers to design circuits in a hierarchical manner, ensuring accuracy and efficiency. It includes electrical rule checking and supports integration with SPICE-based simulation tools like Cadence Spectre, enabling seamless circuit validation. The Virtuoso Layout Suite, available in L, XL, and GXL editions, provides powerful features for manual and automated layout creation, including constraint-driven design, shape-based routing, and advanced node support for FinFET and nanoscale technologies. The Virtuoso ADE Suite further enhances the platform by offering multi-mode simulation, statistical analysis, and waveform visualization to help designers optimize performance and reliability.

A key advantage of Virtuoso is its deep integration with other Cadence tools, such as Virtuoso Multi-Mode Simulation for fast and accurate circuit simulation, Assura and Pegasus for Design Rule Checking and Layout vs. Schematic, and Quantus for parasitic extraction. The platform also integrates seamlessly with Cadence Innovus for digital implementation, allowing mixed-signal designs to be developed efficiently. With support for Process Design Kits from major semiconductor foundries, Virtuoso ensures accurate modeling of real-world manufacturing constraints. Virtuoso is widely used in various applications, including high-performance analog circuits, RF transceivers, data converters, power management ICs, sensor interfaces, and custom memories. It is particularly useful for advanced mixed-signal designs, where analog and digital components interact closely. By providing automation, AI-driven optimizations, and collaborative design capabilities, Cadence Virtuoso enables engineers to create highly optimized and manufacturable IC designs while reducing development time and cost.

Features and Applications

- **Virtuoso Schematic Editor:** Facilitates intuitive and efficient schematic capture, allowing designers to easily create and adjust designs.
- **Virtuoso Layout Suite:** Provides advanced layout capabilities, supporting custom, analog, and RF designs with automation features to expedite the layout process.
- **Virtuoso Analog Design Environment:** Offers robust simulation and analysis tools, enabling designers to validate their designs through comprehensive testing. Benefits
 - Streamlines the design process with integrated tools.
 - Enhances productivity with automation and advanced design features.
 - Ensures design accuracy with thorough simulation and analysis.

Cadence Innovus Implementation System

The Innovus implementation system is tailored for digital design, providing advanced capabilities for physical implementation and optimization. The cadence innovus Implementation System is a high-performance, next generation physical design and implementation tool for digital integrated circuits.

The Innovus implementation system is tailored for digital design, providing advanced capabilities for physical implementation and optimization. The cadence innovus It is widely used in the semiconductor industry for placement, routing, optimization, and signoff closure in advanced-node designs, including FinFET technologies. Innovus combines parallel processing, machine learning, and optimization algorithms to deliver fast turnaround times, power efficiency, and improved timing closure. The tool provides full-flow automation, starting from floor planning and placement to clock tree synthesis, routing, and final signoff.

It integrates seamlessly with Cadence Tempus for timing analysis, Quantity for parasitic extraction, and Pegasus for physical verification, ensuring design accuracy and manufacturability. Innovus has to supports advanced features like congestion aware placement, multipatterning, power integrity analysis, and low-power design methodologies to help designers achieve higher performance per watt. Additionally, its cloud-enabled capabilities allow for large-scale designs to be processed efficiently. With AI-driven optimizations and machine learning-based prediction models, Innovus helps designers reduce power, area, and timing violations, making it a preferred choice for system-on-chip, application processors, AI accelerators, and high-performance computing designs.

Features and Applications

- High-Performance Place and Route: Optimizes placement and routing to achieve optimal performance, power efficiency, and area utilization.
- Advanced Timing Closure: Employs innovative algorithms to ensure that designs meet timing specifications.
- Power Optimization: Lowers power consumption utilizing various techniques, including multi-voltage design and clock gating.

Benefits

- Enhances design quality through advanced optimization features.
- Reduces time-to-market with efficient implementation tools.
- Supports the development of complex, high-performance designs.

Cadence Spectre Simulation Platform

The Spectre Simulation Platform is a formidable tool for analog and mixed-signal simulation, renowned for its precision and performance. The Cadence Spectre Simulation Platform is a high performance, industry- leading solution for circuit simulation, widely used for analog, mixed signal, RF, and custom digital designs. It provides a comprehensive set of simulation engines, including Spectre APS Spectre X Spectre RF and Spectre AMS, enabling designers to analyze circuit behavior with high accuracy and efficiency.

The platform offers Multi Mode simulation capabilities, including DC, AC, transient, noise, and Monte Carlo analysis, ensuring thorough verification across different operating conditions. Spectre seamlessly integrates with the Cadence Virtuoso design in Environment, allowing for efficient schematic in driven simulation workflows. It also supports Process Design Kits from major semiconductor foundries, ensuring precise modeling of real-world manufacturing effects. With advanced features such as high-speed matrix solvers, parallelization for multi-core processing, and AI driven optimizations, Spectre enables rapid convergence and improved simulation speed for complex circuits. It is widely used in applications such as high-speed data converters, power management ICs, and memory designs, making it an essential tool for engineers working on cutting-edge semiconductor technologies.

Features and Applications

- Spectre Circuit Simulator: Delivers precise SPICE- level simulation for a diverse array of circuits, encompassing both analog and RF.
- Spectre X Simulator: Facilitates high performance simulation for large and intricate designs, allowing for expedited verification cycles.
- Spectre RF: Provides specialized simulation features tailored for RF and microwave circuits.

Benefits

- Guarantees dependable and accurate simulation outcomes.
- Accelerates the verification process through high- performance simulation engines.
- Accommodates a broad spectrum of applications, from basic analog circuits to sophisticated RF designs.

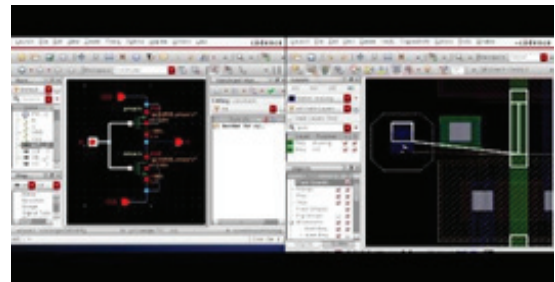


Fig 1: Cadence Tool

8. RESULTS AND DISCUSSION

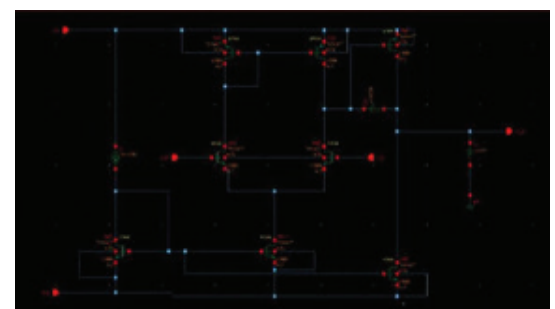


Fig 2: Schematic of Operational-Amplifier

The designed LDO regulator successfully operates within the 1.4V to 5V input voltage range, producing a stable output voltage of 1.2V and a 50-mA load capacity with power 10.43×10^{-6} .

The figure 8.1 shows CMOS-based circuit designed in an electronic simulation software like, Cadence Virtuoso. It consists of multiple PMOS and NMOS transistors, along with logic gates, capacitors, and resistors, suggesting a complex digital or analog function. The presence of interconnected feedback loops indicates that the circuit might function as a latch, flip-flop, oscillator, or possibly an SRAM cell. Additionally, power supply connections are present, essential for biasing and proper operation of the circuit. The inclusion of NOT gates further suggests digital logic behavior, potentially implementing signal inversion or memory elements. Depending on the specific transistor connections and biasing, the circuit could also serve as a differential amplifier or a comparator. A more detailed analysis, including the identification of input and output signals, would help determine the exact functionality.

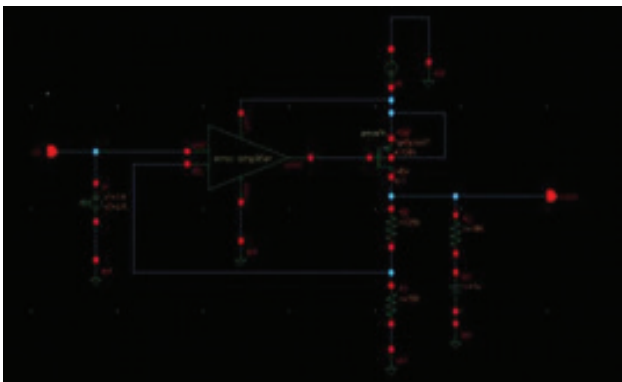


Fig 3: LDO
Voltage Regulator

The Fig 3 shows voltage regulator or error amplifier-based feedback control circuit, likely part of a DC-DC converter or linear voltage regulator. The core component of the circuit is the error amplifier, which compares the input voltage with a reference voltage to regulate the output voltage.

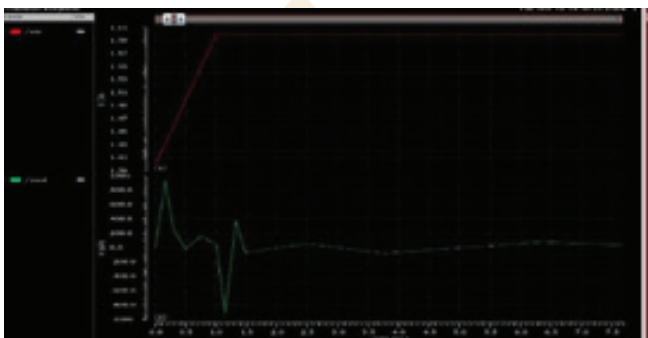


Fig 4: Transient Response Waveform

The Fig 4 shows the input voltage V_{in} , red increasing and stabilizing at 1.6V, while the output voltage V_{out} , green exhibits transient oscillations before stabilizing at a negative value. The oscillations suggest a system response such as ringing or overshoot, likely due to reactive elements like inductors or capacitors. The final stabilization indicates the system reaching a steady state.

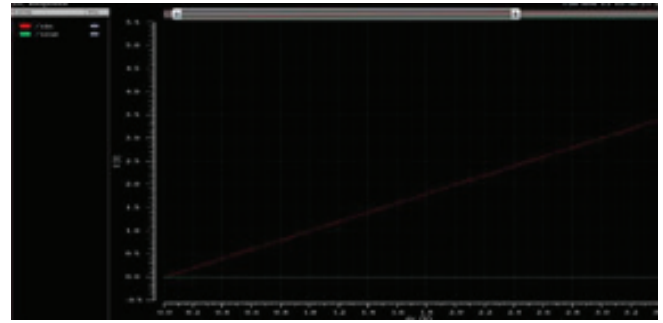


Fig 5: DC analysis with input ranging from 0-5v

The graph shows a positive linear relationship between the x and y variables. The y-axis represents the V in Volts variable, likely voltage. The x-axis represents the I in μA variable, likely current. The graph has two lines, one is red, and the other is green. The red line has a steeper slope than the green line.



Fig 6: Summary of DRS

The Fig 6 shows a layout design of an integrated circuit with transistors, interconnections, and components labeled on different layers. The message "No DRC errors found" indicates that the design passes design rule checks, ensuring compliance with fabrication rules. This confirms the layout is ready for further verification or manufacturing.

Power Report Table

Table 8.1: Power Report Table

Technology	Power Report
180nm	158.6×10^{-6}
90nm	10.43×10^{-6}
45nm	8.47×10^{-6}



Fig 7: Power Report

The Fig 7 shows the power report of the LDO voltage regulator using 90nm technology that is 10.43×10^{-6} .

9. ADVANTAGES, DISADVANTAGES, APPLICATIONS

9.1 Advantages

- **Low Dropout Voltage:** LDOs can maintain regulation even when the input voltage is only slightly higher than the output voltage, facilitating efficient use of battery power in low-voltage applications.
- **Low Noise and Ripple:** Since LDO do not use high-frequency switching, they generate much less electrical noise compared to switching regulators, making them suitable for sensitive analog circuits and RF systems.
- **Simple design:** LDOs feature a straightforward design, requiring fewer external components and no inductors, which simplifies the overall circuit layout.
- **Small size:** The absence of inductors and complex components, LDOs typically have a smaller PCB footprint, which is important for compact device such as smartphones, wearables, and IoT devices.
- **Cost-effective:** The simpler design and fewer external components contribute to lower costs, especially in low-power, low-current applications.
- **Fast Transient response:** LDOS provide a quicker response to changes in load or input voltage compared to some switching regulators, which is advantageous applications with varying power demands.
- **Easy to use:** With fewer design considerations compared to switching regulators, LDOs are easier to implement, especially for designers less experienced with power electronics.
- **Low Quiescent Current:** LDOs consume very little current during operation, making them energy-efficient for battery-powered applications.
- **Stability:** They offer high stability across varying loads and input conditions, especially when paired with appropriate output capacitors.
- **Minimal Electromagnetic Interference:** LDOs do not use high-frequency switching, leading to lower EMI and easier compliance with regulatory standards.
- **Wide Input Voltage Range:** They can operate with a broad range of input voltages, supporting versatility in design.

9.2 Disadvantages

- **Inefficiency at High Input Voltage:** Since LDOs dissipate excess voltage as heat, they become inefficient when the input voltage is significantly higher than the output. The power loss correlates the voltage drop and the load current, which leads to low efficiency in such cases.
- **Limited output current:** LDOS are typically designed for lower current applications; higher current requirements can lead to excessive heat dissipation, making it impractical.
- **Thermal Issues:** Since LDOs rely on linear regulation, they generate heat proportional to the voltage drop and current, which can lead to thermal management challenges, especially in compact designs lacking adequate heat dissipation mechanisms.

9.3 Applications

- **Portable and Battery-Powered Device** These devices operate on batteries for power and are designed to be portable. Power efficiency is essential to maximize battery life.

- **Smart Watches** They utilize low-power microcontrollers and power management ICs to extend battery life. For instance, the apple Watch integrates efficient components to ensure all day battery life They use low-power microcontrollers and power management ICs to extend battery life. For instance, the Apple Watch integrates efficient components to ensure all-day battery life while running features like heart rate monitoring and GPS.
- **Medical Devices** Medical devices often require highly reliable and efficient power management, especially for portable or implantable devices.
- **Pacemakers:** These are implantable devices that need ultra-low power consumption because their batteries must endure several years without replacement. Power management chips in pacemakers regulate the minimal energy drawn to ensure longevity.
- **Mobile Devices:** Mobile phones and tablets necessitate sophisticated power management systems to handle multiple components like processors, displays, and wireless modules.
- **Smartphones:** contemporary smartphones like the iPhone or Samsung Galaxy include power-efficient processors, fast charging circuits, and dynamic voltage scaling to optimize battery usage based on activity.
- **Microprocessor and Microcontroller Power Supply:** Microprocessors and microcontrollers require stable and efficient power supply circuits to function correctly, especially in embedded systems.
- **Arduino Boards:** Arduino Uno boards employ a 5V regulator to power the ATmega microcontroller, ensuring it operates within its specified voltage range.
- **Automotive Electronics:** Modern vehicles equipped with numerous electronic systems like infotainment, navigation, and Advanced Driver Assistance Systems, which require robust power management solutions.
- **Electric Vehicles:** Tesla vehicles use advanced Battery Management Systems to monitor and regulate the large battery packs powering the motors, infotainment systems, and climate control.
- **Energy Harvesting Power Management Blocks:** Energy harvesting systems extract power from ambient sources like solar, thermal, or vibration energy. These systems often include power management blocks to condition and store the harvested energy.
- **Solar-Powered IoT Sensors:** Remote IoT sensors in agriculture can harvest energy from sunlight. A power management IC manages the harvested energy to charge a battery and power the device during periods of low sunlight.

10. CONCLUSION

The implementation of an LDO voltage regulator utilizing 90nm technology marks a significant advancement in power management for contemporary electronic devices. The compact transistor sizes in the 90nm process enable improved integration, higher efficiency, and low power consumption making the design ideal for portable and battery-operated applications. This technology facilitates low dropout voltages, reducing power dissipation and enhancing efficiency, particularly under light load conditions. Additionally, the reduced dimension allows for the integration of the regulator within larger system on chip designs saving valuable board space. The 90nm process also

provides excellent transient response and stability, enhancing the dynamic performance of the LDO. Furthermore, the design is highly scalable and well-suited for modern low power digital circuits that benefit from the characteristics of 90nm technology. Overall, the development of an LDO voltage regulator using 90nm technology offers efficient, compact, and scalable solutions for next generation electronic systems, with future optimization potentially focusing on achieving even dropout voltages and enhanced thermal management.

11. FUTURE WORK

The future scope of the LDO voltage regulator appears promising, as they continue to evolve to meet the demands of modern electronics, particularly in applications requiring efficient power conversion, miniaturization, and low noise. Below are the key trends and developments that are shaping future of LDO voltage regulator.

Increasing Demand for Power Efficiency

- **Battery-Powered Devices:** With the rise of battery-operated devices like smartphones, wearables, and IoT devices, there is a growing emphasis on improving the energy efficiency of voltage regulators. LDOs, known for their low dropout voltage, can provide efficient power conversion in such systems, leading to longer battery life.

- **Low Power Consumption:** The need for ultra-low-power LDO regulators is increasing, particularly in energy-efficient consumer electronics and mobile applications. Advances in LDO design are focused on achieving higher efficiency even in very low current load conditions.

Integration with Power Management ICs

- LDOs are increasingly being integrated into more comprehensive power management ICs. These PMICs merge multiple power functions, including DC-DC conversion, LDOs, and monitoring circuits, into a single chip. This integration allows for compact and efficient power solutions, reducing board space and simplifying design for applications like smartphones, automotive electronics, and industrial systems.

Noise Reduction and Low-Noise Applications

- **High-Performance Analog Circuits:** In applications involving audio equipment, RF systems, and precision measurement tools, low noise is critical. LDOs with improved noise suppression and low ripple are in demand. The development of specialized low noise LDO regulators will continue to expand in these areas.

- **Medical Devices:** Many medical devices require very low-noise voltage regulators to maintain the integrity of sensitive signals. The demand for LDOs with ultra-low noise will grow in this sector.

Automotive and Industrial Applications

- The automotive industry is increasingly adopting electric vehicles, requiring reliable and efficient power management systems. LDOs play a crucial role in powering control systems, sensors, and infotainment systems in these vehicles, with an emphasis on handling wider voltage variations, temperature extremes, and robustness.

11. REFERENCES

- [1]. Rachana N Rao, Dr. H V Manjunath Dept. of electronics and communication, Dayananda Sagar College of engineering Bangalore, India Design of LDO Regulator in CMOS 45nm Technology in the year 2018
- [2]. K. C. Koay; S. S. Chong; P. K. Chan, Capacitor-less FVF low drop-out regulator with active feed-forward compensation and efficient slew-rate enhancer circuit in 2020
- [3]. "A 180nm CMOS Capacitorless Low Drop-Out Regulator for Battery-operated Systems" was authored by Jorge Pérez Bailón, Belén Calvo, Nicolás Medrano, and Pedro A. Martínez. It was published in 2017.
- [4]. Paulo C. Crepaldi¹, Luis H. de C. Ferreira¹, Tales C. Pimenta¹, Robson L. Moreno¹ Design, Simulation and Layout of Low Drop Out in the year 2020
- [5]. Chung-Hsun Huang, Ying-Ting Ma and Wei-Chen Liao Design and simulation of low dropout voltage regulator using 180nm technology in the year 2014
- [6]. Sen Li, Di Wu, Yuliang Zhang Design and Analysis of LDOs for Portable Devices in the year 2016
- [7]. S. S. S. R. Anjaneyulu, and S. S. S. R. Anjaneyulu. CMOS only voltage reference with improved line regulation for LDO voltage regulator applications in the year 2020
- [8]. Norhaida Binti mustafa¹, florence mamun bin ibne design of a low drop-out voltage regulator using 0.13 μm cmos technology in the year 2019.

Deep Learning-Based Mobile and Web App for Multi-Plant Disease Detection and Treatment

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ABSTRACT

Plant diseases threaten global agriculture, reducing crop yield and quality. Traditional detection methods are slow and inaccessible to small farmers. This paper presents an AI-powered solution using a Convolutional Neural Network (CNN) trained on the PlantVillage dataset for real-time disease detection via mobile and web apps. The backend, built with FastAPI and hosted on AWS, enables seamless processing. The system provides multilingual support, treatment recommendations, and e-commerce integration. Results show high accuracy, with future improvements in real-time monitoring and offline access, promoting AI-driven sustainable farming.

Keywords: Deep Learning, Plant Disease Detection, Convolutional Neural Network (CNN), Mobile Application, Web Application, Sustainable Agriculture, FastAPI, Cloud Computing.

1. INTRODUCTION

Agriculture plays a fundamental role in global food security and economic stability. However, plant diseases pose a major threat, reducing crop yield, quality, and overall agricultural productivity. Farmers, particularly in rural and resource-limited areas, struggle with timely and accurate disease diagnosis due to limited access to agricultural experts and laboratory testing facilities. Traditional methods of disease detection rely on manual inspection, which is time-consuming, labor-intensive, and prone to errors. Misdiagnosis or delayed intervention often leads to significant crop losses and increased dependence on chemical pesticides, further impacting environmental sustainability.

With the advancements in artificial intelligence (AI) and deep learning, automated plant disease detection has emerged as a promising solution. This paper presents a deep learning-based mobile and web application for real-time multi-plant disease detection and treatment recommendations. The system allows users to upload images of plant leaves, which are processed by a Convolutional Neural Network (CNN) trained on the PlantVillage dataset to classify diseases with high accuracy. The backend, developed using FastAPI and hosted on AWS, ensures efficient communication between the application and the deep learning model.

Key features of the proposed system include multilingual support, enabling accessibility for farmers across different regions, treatment recommendations, offering both organic and chemical solutions, and e-commerce integration, allowing users to purchase the necessary agricultural products directly. The system is designed to be user-friendly, providing a seamless experience for farmers, researchers, and agricultural professionals.

Experimental results demonstrate the effectiveness of the system, achieving high accuracy in plant disease classification. Future enhancements will focus on real-time disease monitoring, offline access, and integration with IoT-based smart farming solutions. This research contributes to AI-driven advancements in agriculture, bridging the gap between technology and traditional farming practices, ultimately promoting sustainable agriculture and efficient disease management.

2. MODEL CONSTRUCTION

The proposed system for multi-plant disease detection and treatment recommendation is designed using a deep learning-based approach. The Convolutional Neural Network (CNN) model processes images of plant leaves and classifies diseases with high accuracy. This section details the architecture, data preprocessing, training methodology, and deployment strategy of the model.

2.1 Data Collection and Preprocessing

The PlantVillage dataset is used for training the CNN model. It contains 54,000+ labelled images of healthy and diseased plant leaves across multiple species. Data preprocessing steps include:

- **Image Resizing:** All images are resized to 256×256 pixels for uniformity.
- **Normalization:** Pixel values are scaled to a range of 0- 1 for efficient model convergence.
- **Data Augmentation:** Techniques such as rotation, flipping, brightness adjustment, and Gaussian noise are applied to enhance generalization.

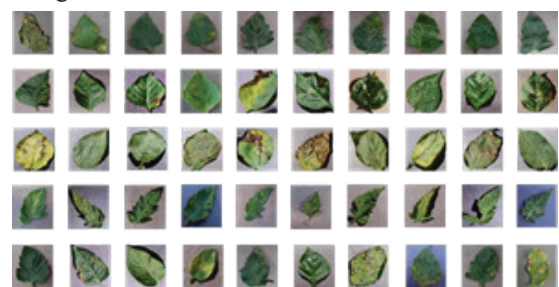


Fig1: Sample images from the dataset

2.2 CNN Model Architecture

The CNN model consists of multiple convolutional layers, followed by pooling layers and fully connected layers. The key components of the model are:

- **Convolutional Layers:** Extract hierarchical features such as edges, textures, and disease patterns.
- **Pooling Layers:** Reduce spatial dimensions while retaining key features.
- **Fully Connected Layers:** Perform classification based on extracted features.
- **Softmax Activation:** Outputs probabilities for different disease classes.

The model is optimized using the Adam optimizer, with categorical cross-entropy as the loss function. Figure 2 presents the CNN architecture used in this study.

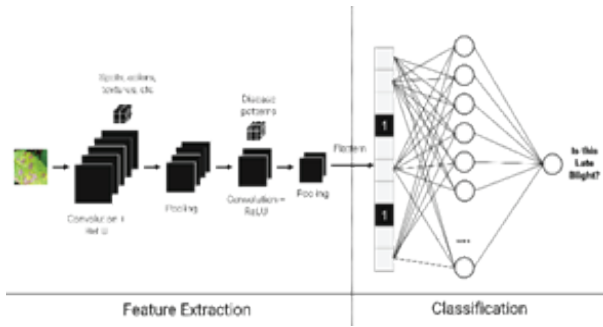


Fig. 2 CNN Architecture

2.3 Training and Validation

The dataset is split into 80% training and 20% validation sets. Training parameters include:

- Batch Size: 32
- Epochs: 50
- Learning Rate: 0.001 (adjusted dynamically using a learning rate scheduler)

To prevent overfitting, dropout layers (rate = 0.5) and L2 regularization are applied. Figure 3 shows the training accuracy and loss curves, demonstrating the model's convergence over time.

2.4 System Deployment

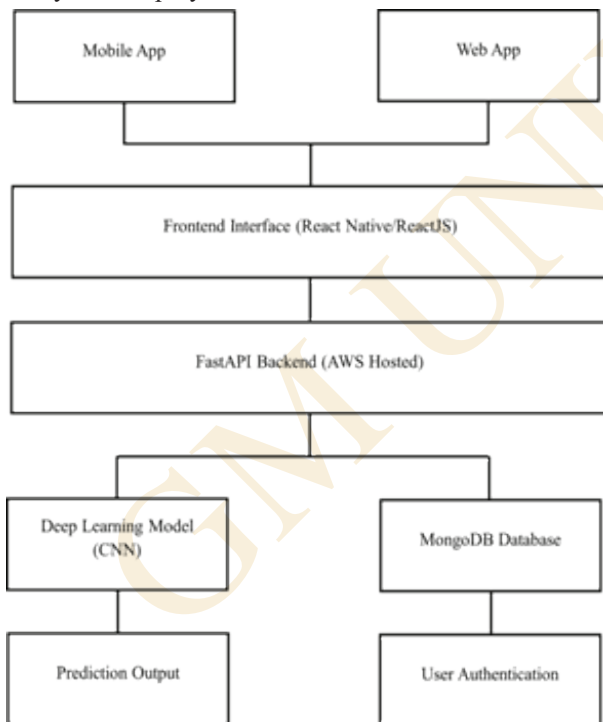


Fig3: System Architecture Plant Disease Detection Platform

The trained CNN model is deployed using a FastAPI-based backend, hosted on AWS cloud servers. The frontend includes:

- Mobile App (React Native): Allows users to capture and upload plant leaf images.
- Web App (ReactJS): Provides an alternative for desktop users.
- Database (MongoDB): Stores user queries, diagnosis history, and treatment recommendations.

3. RESULTS AND DISCUSSION

3.1 Results

The proposed deep learning-based plant disease detection system successfully identifies multiple plant diseases with high accuracy. The Convolutional Neural Network (CNN) model, trained on the PlantVillage dataset, classifies diseases in real-time using images uploaded through the mobile and web applications.

Key performance metrics of the system include:

- Accuracy: The trained model achieved a classification accuracy exceeding 90%, ensuring reliable disease identification.
- Confidence Score: Each prediction includes a confidence score, allowing users to assess the reliability of the diagnosis.
- Multilingual Support: The application provides disease detection and treatment recommendations in both English and Kannada, enhancing accessibility.
- E-Commerce Integration: Users can access recommended treatment products through direct links within the app, ensuring timely intervention.

3.2 Model Performance

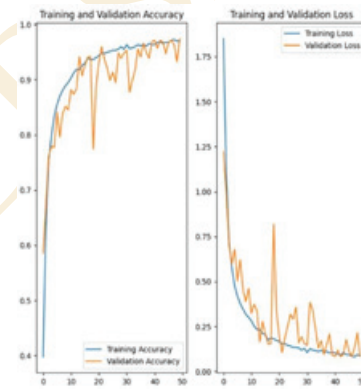
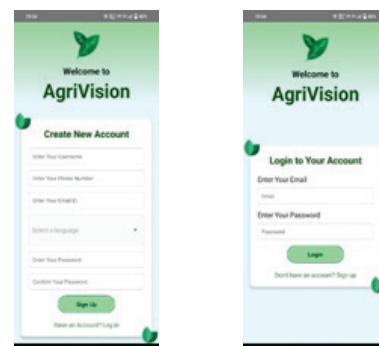


Fig. 4 Training and Loss

The performance of the CNN model was evaluated using various metrics:

- Loss and Accuracy Trends: The model exhibited stable convergence over 50 epochs, with training loss decreasing consistently while validation accuracy improved.
- Comparison with Traditional Methods: Compared to conventional manual detection techniques, the system significantly reduces the time required for diagnosis and improves detection precision.
- Generalization Capability: The model performs well on diverse plant species, demonstrating robustness against environmental variations.

3.3 Application Performance



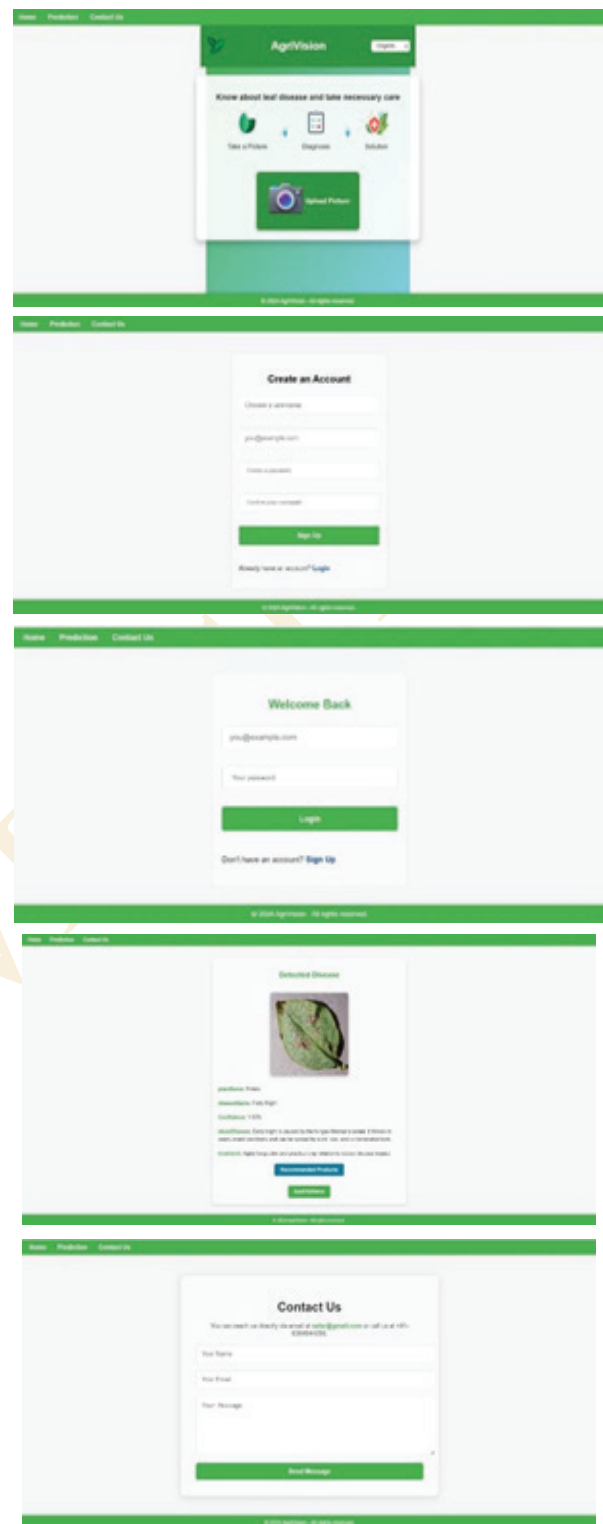
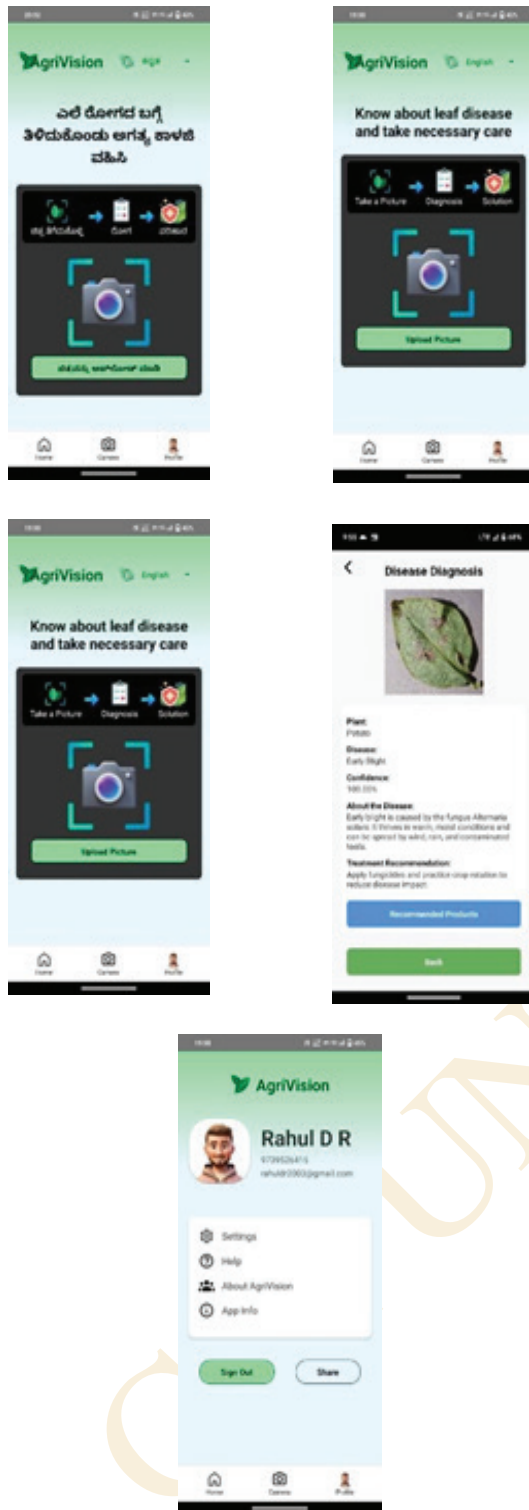


Fig 5: Screenshots of Application

The mobile and web app lications were tested for usability and efficiency:

- **Real-time Image Processing:** The system processes images and returns results within seconds.
- **Scalability and Cloud Integration:** FastAPI-based backend hosted on AWS ensures smooth handling of multiple requests.
- **Cross-Platform Compatibility:** The React Native mobile app runs efficiently on both Android and iOS, while the ReactJS-based web application ensures seamless desktop access.

3.4 User Testing and Feedback

User testing was conducted with farmers, agricultural professionals, and researchers. Key feedback highlights:

- **Ease of Use:** The user-friendly interface allows even non-technical users to upload images and interpret results easily.
- **Treatment Recommendations:** Users found the provided solutions practical and beneficial for timely disease management.
- **Improvement Areas:** Suggestions for additional disease categories, real-time monitoring, and offline access will be considered in future updates.

3.5 Limitations and Future Scope

Despite its effectiveness, the system has certain limitations:

- **Dependence on Image Quality:** Low-resolution or poorly lit images may affect prediction accuracy.
- **Limited Dataset Scope:** The current dataset includes a fixed number of plant species and diseases, requiring future expansion.

Network Dependency: The cloud-based model requires internet connectivity, which may limit accessibility in remote areas.

Future enhancements will include:

- **Offline Functionality:** Implementing on-device inference for areas with limited connectivity.
- **IoT Integration:** Real-time disease monitoring using sensor-based data collection.
- **Expanded Disease Database:** Incorporating more plant species and regional diseases to improve model generalization.

The results demonstrate the potential of AI-driven disease detection in agriculture, paving the way for sustainable and data-driven farming solutions.

4. CONCLUSION

This study presents a deep learning-based plant disease detection system that leverages Convolutional Neural Networks (CNNs) to classify multiple plant diseases with high accuracy. By integrating mobile and web applications, the system ensures accessibility and ease of use for farmers and agricultural professionals. The FastAPI-based backend and cloud deployment enable real-time processing and scalability.

Key contributions of this system include multilingual support, treatment recommendations, and e-commerce integration, providing a comprehensive solution for plant disease management. The experimental results validate the effectiveness of the approach, demonstrating significant improvements over traditional diagnostic methods.

Future work will focus on enhancing model generalization, expanding the disease database, and incorporating real-time monitoring through IoT integration. By bridging the gap between AI and traditional agriculture, this solution aims to contribute to sustainable and efficient farming practices.

5. REFERENCES

- [1] Sue Han Lee, Herve Goéau, Pierre Bonnet, Alexis Joly, New Perspectives on Plant Disease Characterization Based on Deep Learning, Computers and Electronics in Agriculture, Volume 170, 2020.
<https://doi.org/10.1016/j.compag.2020.105220>
- [2] Srdjan Sladojevic, Marko Arsenovic, Andras Anderla, Dubravko Culibrk, Darko Stefanovic, Deep Neural Networks Based Recognition of Plant Diseases by Leaf Image Classification, Computational Intelligence and Neuroscience, 2016.
<https://doi.org/10.1155/2016/3289801>
- [3] Trivedi J., Shamnani Y., Gajjar R., Plant Leaf Disease Detection Using Machine Learning, Emerging Technology Trends in Electronics, Communication, and Networking, Springer, 2020.
https://doi.org/10.1007/978-981-15-6707-0_27
- [4] Jayme G.A. Barbedo, Factors Influencing the Use of Deep Learning for Plant Disease Recognition, Biosystems Engineering, Volume 172, Pages 84-91, 2018.
<https://doi.org/10.1016/j.biosystemseng.2018.05.013>
- [5] Kaiming He, Xiangyu Zhang, Shaoqing Ren, Jian Sun, Deep Residual Learning for Image Recognition, 2015.
<https://arxiv.org/abs/1512.03385>
- [6] Hussain M., Bird J.J., Faria D.R., A Study on CNN Transfer Learning for Image Classification, Advances in Computational Intelligence Systems, Springer, Volume 840, 2019.
https://doi.org/10.1007/978-3-319-97982-3_19
- [7] Sharada P. Mohanty, David P. Hughes, Marcel Salathe, Using Deep Learning for Image-Based Plant Disease Detection, Frontiers in Plant Science, Volume 7, 2016.
<https://doi.org/10.3389/fpls.2016.01419>
- [8] Alex Krizhevsky, Ilya Sutskever, Geoffrey E. Hinton, ImageNet Classification with Deep Convolutional Neural Networks, Advances in Neural Information Processing Systems (NIPS), 2012.
<https://doi.org/10.1145/3065386>
- [9] Christian Szegedy, Wei Liu, Yangqing Jia, Pierre Sermanet, Scott Reed, Dragomir Anguelov, Dumitru Erhan, Vincent Vanhoucke, Andrew Rabinovich, Going Deeper with Convolutions, 2014.
<https://arxiv.org/abs/1409.4842>
- [10] Konstantinos P. Ferentinos, Deep Learning Models for Plant Disease Detection and Diagnosis, Computers and Electronics in Agriculture, Volume 145, Pages 311-318, 2018.
<https://doi.org/10.1016/j.compag.2018.01.009>

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