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AI-Enabled IoT Digital Notice Board with OCR, NLP Summarization, and Energy Optimization

J. Anitha[1]; Swetha B.[1]; Saradha Shree R.[1]

[1]Department of Artificial Intelligence and Data Science, Panimalar Engineering College, Chennai, India

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Abstract: In offices, public areas, and educational institutions, notice boards are an essential communication tool. However, because their displays are always on, conventional digital notice boards frequently require manual content entry and use constant power. This paper presents an AI-enabled Internet of Things digital notice board that combines Natural Language Processing (NLP) summarization for succinct content presentation, Optical Character Recognition (OCR) for automatic text extraction from uploaded images or PDFs, and a PIR sensor-based energy optimization mechanism to minimize needless power consumption. An ESP32 microcontroller with wireless connectivity controls the system, which allows remote uploads via a web interface. While the summary module reduces lengthy text into shorter, comprehensible notices, the OCR pipeline preprocesses scanned photos to improve recognition accuracy.In order to ensure energy-efficient operation, a PIR sensor automatically regulates the display's power state based on human presence. Compared to traditional always-on digital notice boards, experimental evaluation shows significant energy savings, lower update delay, and better readability of lengthy notices.

Keywords: *IoT, OCR, Text Summarization, PIR Sensor, ESP32, Digital Notice Board, Energy Optimization.*

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I. INTRODUCTION

One of the most popular forms of communication in public spaces, corporations, and educational institutions is the notice board. They give big audiences important messages, instructions, and updates. However, traditional notice boards mostly rely on manual posting, which is labor-intensive, rigid, and environmentally unsustainable because it uses paper. Although some of these issues have been addressed by the introduction of digital notice boards, the majority of current systems still require manual content entry and run continuously on power, which leads to inefficiency. Recent developments in machine learning (ML) and the Internet of Things (IoT) have made it possible to create intelligent systems that can optimize resource utilization and automate content processing. While Natural Language Processing (NLP) approaches like text summarization can reduce extensive information into shorter, more readable formats, optical character recognition (OCR) has made it possible to extract text from photos and scanned documents. Context-aware energy management in Internet of Things applications is made possible concurrently by the use of low-power microcontrollers and sensors, such as Passive Infrared (PIR) modules.[1-4].

This study describes an AI-enabled Internet of Things digital notice board that combines PIR-based sensing for energy-efficient display control, NLP summarizing for succinct message delivery, and OCR for automated text extraction. In order to enable remote uploads, display management, and automated power state switching based on human presence, the system makes use of an ESP32 microcontroller with wireless communication.

The suggested strategy increases accessibility, lowers energy use, and boosts the effectiveness of digital information distribution by combining these aspects. [5, 6].

➢ *The Following are This Paper's Main Contributions:*

- Automating information input and enhancing readability by integrating OCR and NLP summarizing into a digital noticeboardsystem.
- The creation of an ESP32-based Internet of Things architecture for content management and remote access.
- Using PIR-based energy optimization to reduce the display system's needless power usage.
- System performance is assessed in terms of energy savings, latency, summarization quality, and OCR accuracy.

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II. LITERATURE REVIEW

➢ *Cloud-Based Management of IoT-Enabled Digital Signage Systems*

- *Year:* 2020

✓ *Published In:* IEEE International Conference on Cloud Computing and Big Data Analysis (ICCCBDA)
✓ *Overview:* The management of IoT-enabled digital signage systems using cloud computing is examined in this research.The advantages of centralized control and real-time updates for digital signage applications are covered.
✓ *Relevance:* It offers a framework for managing digital signage in the cloud that is pertinent to the cloud integration of your project.

- *Drawbacks:*

✓ *Latency Problems:* Content updates may be delayed due to reliance on cloud services.
✓ *Data Security Risks:* Data stored on the cloud may be vulnerable to security lapses.
✓ *Service Downtime:* Because the system depends on third-party cloud services, any outage may have an impact on its functionality.

➢ *Integration of OCR and IoT for Smart Notice Boards*

- *Year:* 2021

✓ *Published In:* IEEE International Conference on Internet of Things and Applications (IoTA)
✓ *Overview:* In order to automate the updating of digital notice boards, this study describes a system that combines Optical Character Recognition (OCR) with Internet of Things technology. Textual data from physical documents is captured by the system and processed for display. [7-10]
✓ *Relevance:* Complies with the use of OCR in your project to automatically update content on digital notice boards.

- *Drawbacks:*

✓ *OCR* Accuracy *Issues:* Handwritten or badly printed text may be misinterpreted by OCR technology, resulting in errors.
✓ *Environmental Factors:* OCR performance may be impacted by lighting and image quality.
✓ *Hardware Restrictions:* The effectiveness of the system is contingent upon the caliber and capabilities of the hardware employed.

➢ *Energy-Efficient IoT Devices for Smart Campus Applications*

- *Year:* 2022

✓ *Published In:* IEEE International Conference on Sustainable Energy Technologies (ICSET)
✓ *Overview:* The design and deployment of energy-efficient IoT devices for smart campus applications are covered in this study. It highlights how crucial reduced power consumption is to improving IoT systems' sustainability.
✓ *Relevance*: Gives information about IoT device energy optimization techniques relevant to the energy-efficient design *of your project.*

- *Drawbacks:*

✓ *High Initial Costs: The entire budget may be impacted by the higher upfront costs of energy-efficient components.*
✓ *Complicated Integration: It might be difficult and time-consuming to integrate energy-efficient devices with the current infrastructure.*
✓ *Performance Trade-offs: Devices' capabilities or performance may be compromised if energy efficiency is given priority.*

➢ *AI-Based Text Summarization for Digital Notice Boards*

- *Year:* 2023

✓ *Published In:* IEEE International Conference on Artificial Intelligence and Data Processing (AI&DP)
✓ *Overview:* This study investigates the use of artificial intelligence (AI) methods, specifically Natural Language Processing (NLP), to summarize long text that is posted on digital notice boards. The suggested approach seeks to give users clear and pertinent information.
✓ *Relevance:* It directly relates to the NLP-based summary for digital notice boards that is the focus of your project.

- *Drawbacks:*

✓ *Contextual Understanding Limitations:* AI models may have trouble comprehending context, which could result in summaries that are false or deceptive.
✓ *Resource-intensive:* Some implementations may not be able to use the substantial computer resources needed to create sophisticated AI models.
✓ *Data Privacy Issues:* Processing sensitive information through AI models could raise concerns about data privacy and security.

➢ *Smart Digital Notice Board Using IoT and Cloud Computing*

- *Year:*2024

✓ *Published In:* IEEE International Conference on Smart Computing and Communication (ICSCC)
✓ *Overview:* This paper presents an IoT-based smart digital notice board system that replaces traditional notice boards by enabling remote, real-time message dissemination through a mobile app. The system solves the shortcomings and inefficiencies of traditional notice boards, especially with regard to the time, effort, and resources needed for changes. To enable connectivity, it makes use of an Arduino microcontroller, a GSM or Ethernet module, and a mobile application. [11-14]
✓ *Relevance:* It shows how IoT is integrated for remote notification distribution, which directly relates to your project.

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- *Drawbacks:*

✓ *Limited Scalability:* When expanding to support several notice boards in various locations, the system could encounter difficulties.
✓ *Dependency on Internet Connectivity:* Real-time updates are mostly dependent on reliable internet connections, which might not be accessible everywhere.
✓ *Security Issues:* The system may be vulnerable to unwanted access due to potential flaws in the communication and mobile application modules.

III. METHODOLOGY

The suggested system's technique combines Internet of Things (IoT) and artificial intelligence (AI) technology to optimize energy use and automate notice handling. The procedure starts with the acquisition of notices in the form of PDFs or photographs, which are then processed for text extraction using optical character recognition (OCR). A Natural Language Processing (NLP) summarizing module is then used to produce legible and succinct content from the retrieved text.

As the core processing unit, the ESP32 microcontroller manages OCR, NLP, data storage, and display functions. Notifications that have been summarized are shown in real time and kept for future reference. In order to ensure that the display is only turned on when necessary, the system incorporates a Passive Infrared (PIR) sensor to detect human presence.By reducing wasteful energy use, this process improves efficiency.[15, 16]

➢ *System Architecture*

The system architecture of the AI-enabled IoT digital notice board is organized into four functional layers:

- *Input Layer*

✓ Gathers notice data by uploading PDFs or taking pictures.
✓ Offers the unprocessed input for OCR-based operations.

- *Processing Layer (ESP32 Module)*

✓ Uses OCR techniques to extract text.Co
✓ ndenses long notices using NLP summarization.

- *Sensing Layer (PIR Sensor)*

✓ Tracks the presence of people in the surroundings.
✓ Transmits trigger signals to the ESP32 to regulate the display's power condition.

- *Output Layer (Digital Display Unit)*

✓ Operates in an energy-efficient manner by only turning on when the PIR sensor is triggered.
✓ Provides users with summary notifications in real time.

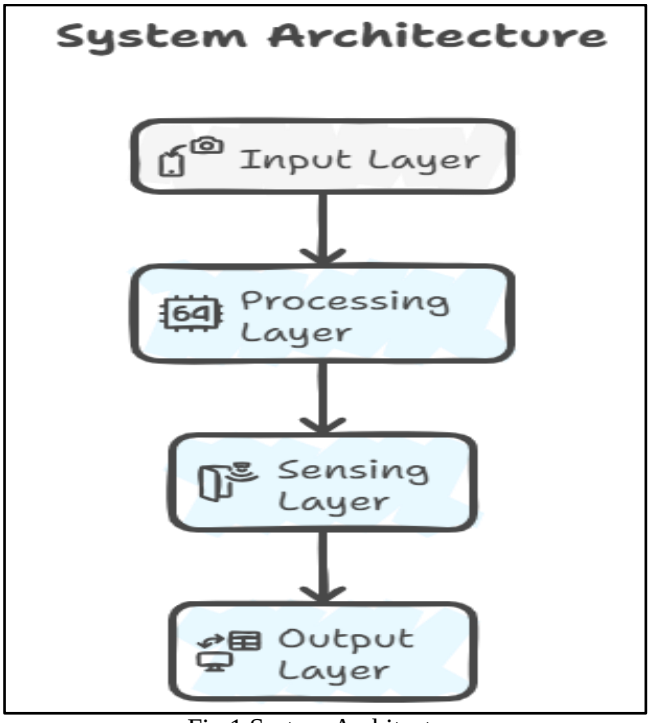

Fig 1 System Architecture

IV. EXISTING SYSTEM

Manual notice boards have given way to digital and Internet of Things-based systems for the distribution of notices in public areas, workplaces, and educational institutions. Each strategy has intrinsic constraints in terms of efficiency, accessibility, automation, and energy consumption despite technological developments. Recognizing these flaws highlights the need for an energy-efficient, AI-enabled solution.

➢ *Manual Notice Boards*

Manual notice boards require staff and students to physically pin printed notices. This approach is simple and economical, but it is slow and ineffective. It takes a lot of manual labor to print, arrange, and post notifications, which frequently causes delays in reaching the target audience. Continuous paper use raises operating expenses and leads to environmental waste. Furthermore, administrators must update content on these boards in person due to their lack of remote connectivity, which is cumbersome for large schools or multi-campus setups.

- *Limitations:*

✓ No automatic or remote access
✓ Time-consuming changes
✓ Delays in information distribution.

➢ *Basic Digital Notice Boards*

LED or LCD display boards that are linked to computers or microcontrollers are used by certain establishments. Although notices can be shown digitally on these boards, manual content entry is still necessary. They lack automation for extracting and updating information, and long messages are displayed in full without summarization, which may overwhelm viewers.

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- *Limitations:*

✓ Content must be manually entered.
✓ No automation or intelligent processing of information.
✓ Continuous power consumption without energy-saving mechanisms.

➢ *IoT-Based Notice Board*

Administrators can remotely upload content to modern IoT-based notice boards using web or mobile apps, providing convenience and real-time changes. Nevertheless, the majority of these devices lack AI-powered processing and only show unprocessed text or images. They lack Natural Language Processing (NLP) to summarize long notices and Optical Character Recognition (OCR) to transform scanned documents into editable text. Moreover, even when no one is seeing the display, these devices continue to use power.

- *Limitations:*

✓ No automation in content extraction or summarization.
✓ Continuous energy consumption without presence-based optimization.
✓ Limited intelligence and interactivity.[17, 18]

V. PROPOSED SYSTEM

Optical Character Recognition (OCR), Natural Language Processing (NLP) summary, and energy optimization are all integrated in the suggested AI-enabled Internet of Things digital notice board to offer an intelligent, automated, and sustainable notice distribution solution. In order to facilitate remote management and effective operation, the system makes use of the ESP32 microcontroller for processing and wireless networking.

➢ *System Overview*

The management and display of notices in offices, public areas, and educational institutions are automated by the suggested system. A online interface allows notices to be uploaded as PDF documents or as pictures. The system employs NLP algorithms to condense lengthy alerts into readable formats and OCR to retrieve textual content from the submitted files. A digital screen with summarized content is activated only when viewers are present thanks to a PIR sensor that senses human presence. In comparison to traditional digital notice boards, the system minimizes power consumption, decreases operating delays, and enhances readability by integrating automation, intelligence, and energy management.

➢ *Overview of Architecture*

The system architecture is organized into four functional layers:

- *Input Layer*

✓ Collects notice data from images or PDF uploads.
✓ Provides the raw input for OCR processing.
✓ Web interface allows remote uploads by administrators.

- *Processing Layer (ESP32 Module)*

✓ Performs OCR to extract text from scanned documents.
✓ Applies NLP summarization to condense lengthy content into short, readable messages.
✓ Manages local data storage of both original and summarized text for record-keeping.
✓ Coordinates display operations and energy management.

- *Sensing Layer (PIR Sensor)*

✓ Monitors the environment for human presence.
✓ Ends trigger signals to the ESP32 to switch the display on or off.
✓ Ensures energy-efficient operation by avoiding continuous power usage.

- *Output Layer (Digital Display Unit)*

✓ Displays summarized notices in real time.
✓ Supports energy-efficient operation by powering the display only when activated by the PIR sensor.

➢ *System Workflow*

- *Notice Upload*

✓ Administrators upload notices as PDF or image files through secure web interface.

- *Text Extraction (OCR Module)*

✓ Textual material is extracted from the submitted files using OCR methods.
✓ Preprocessing methods that improve recognition accuracy include thresholding and noise reduction.

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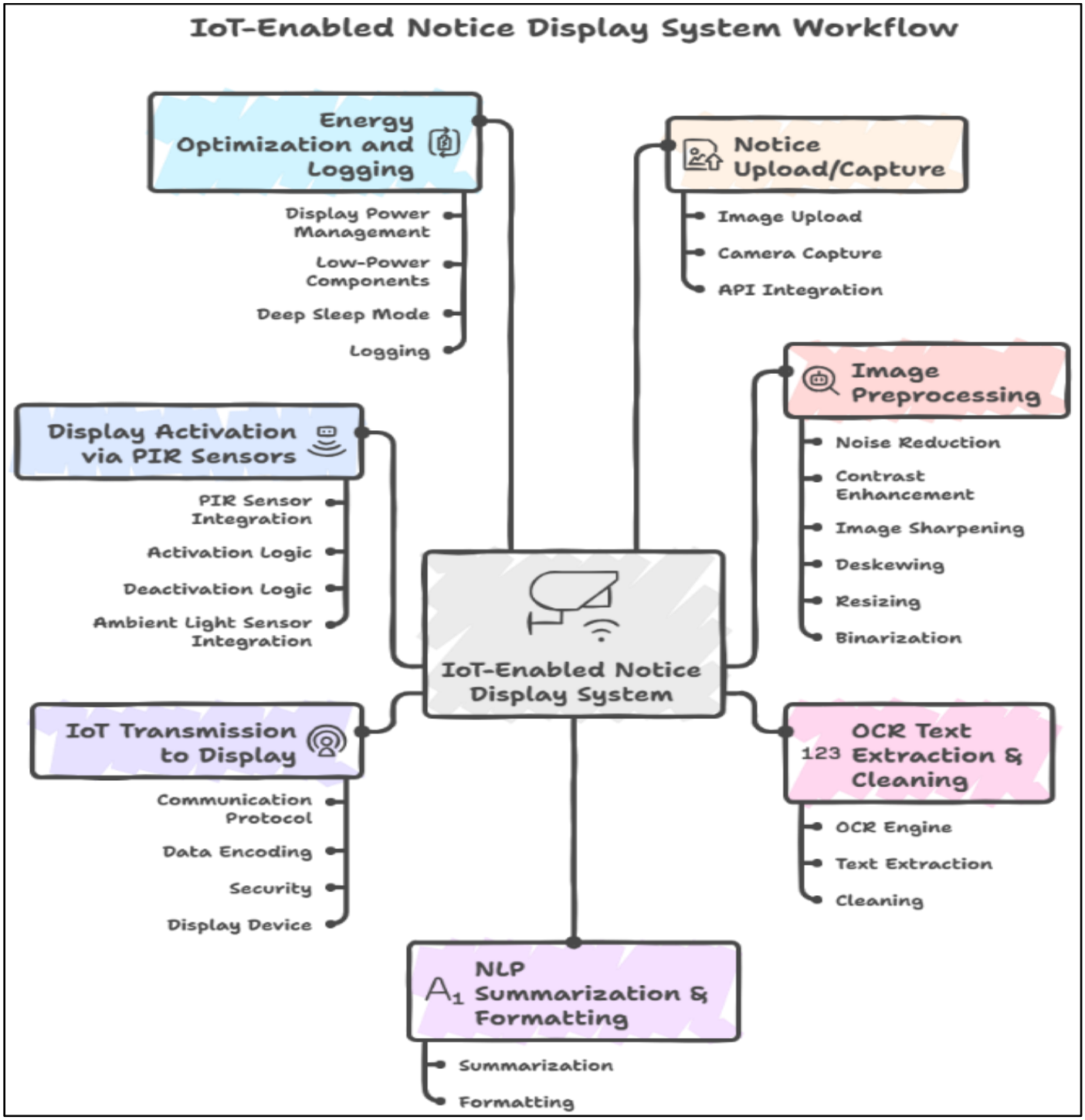

Fig 2 Workflow Diagram

- *Content Summarization (NLP Module)*

✓ NLP-based summarizing techniques are used to analyze the extracted text.
✓ Concise messages are created from lengthy notices without sacrificing important details.

- *Data Storage and Management*

✓ The ESP32's memory contains both original and condensed notices.

- *Energy-Efficient Display Activation*

✓ The presence of people in front of the notice board is constantly monitored by the PIR sensor.
✓ The ESP32 turns on the display to show the condensed notice when it detects presence.
✓ In order to conserve energy, the display automatically turns off when no motion is detected for a predetermined amount of time.

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- *Real-Time Display*

✓ Summarized Viewers can easily see summarized content on the digital screen, which is updated instantly each time fresh announcements are uploaded.

➢ *Features*

- *Automated Content Extraction:* OCR removes the need for human entry by converting scanned photos or PDFs into editable text.
- *NLP-Based Summarization:* For better accessibility, lengthy notices are reduced to brief, readable representations.
- *Energy Optimization:* By ensuring that the display only turns on when a human presence is sensed, the PIR sensor lowers power usage.
- *Remote Management:* Using a web interface, administrators may upload and manage notices from any place.

VI. RESULT

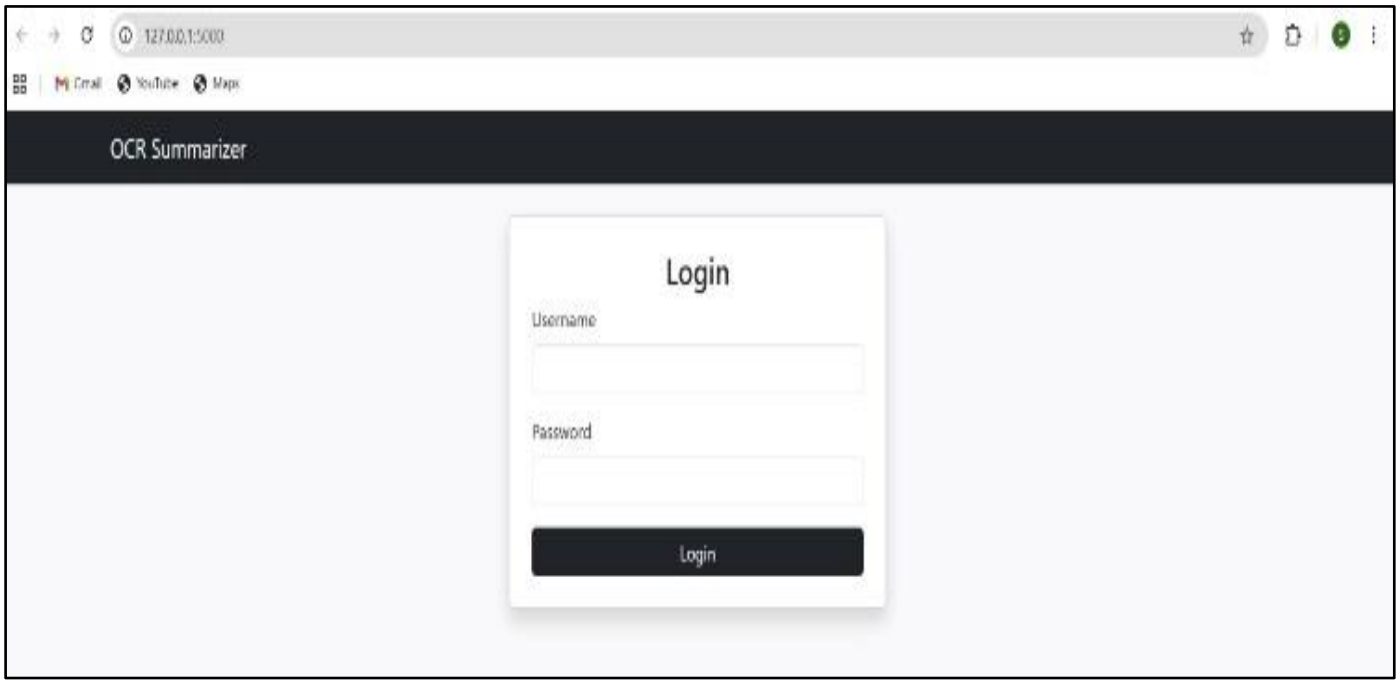

Fig 3 User Interface

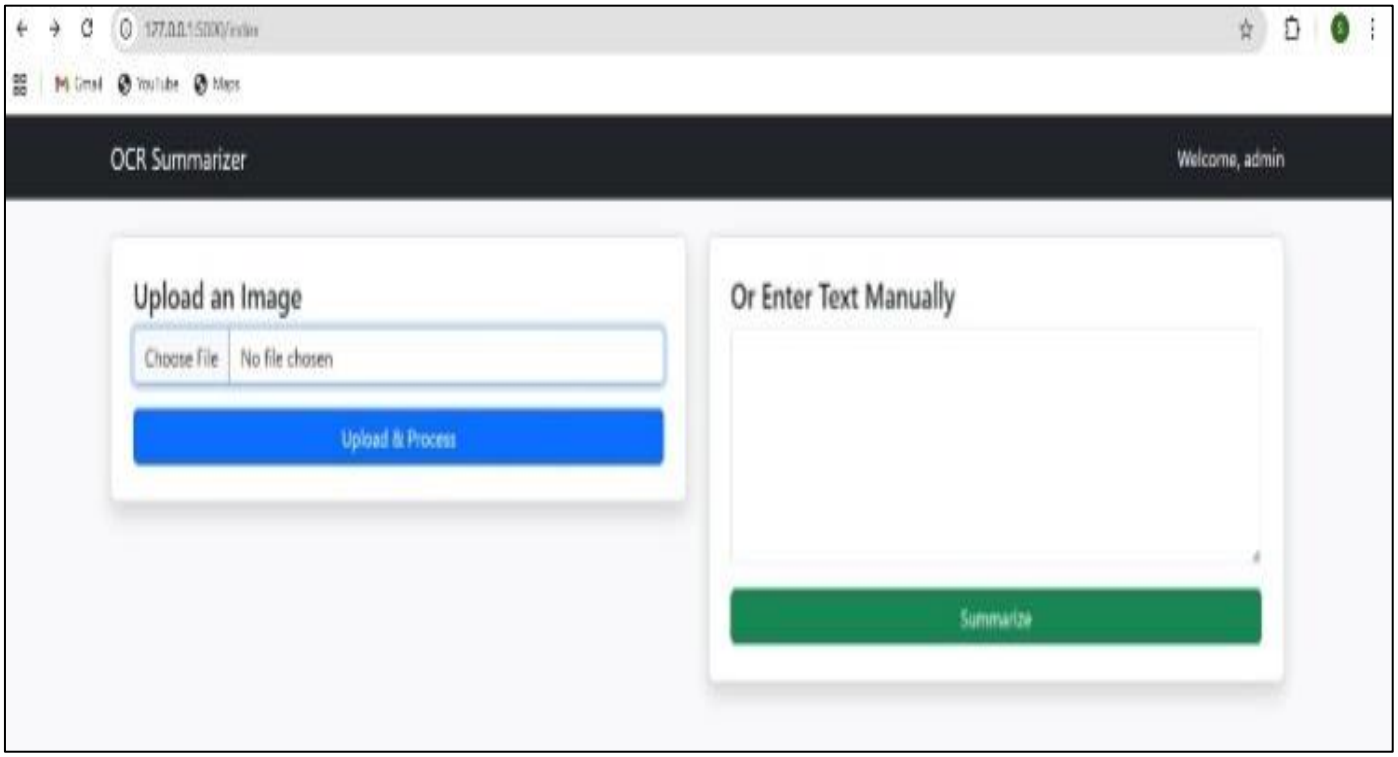

Fig 4 OCR and Summarization

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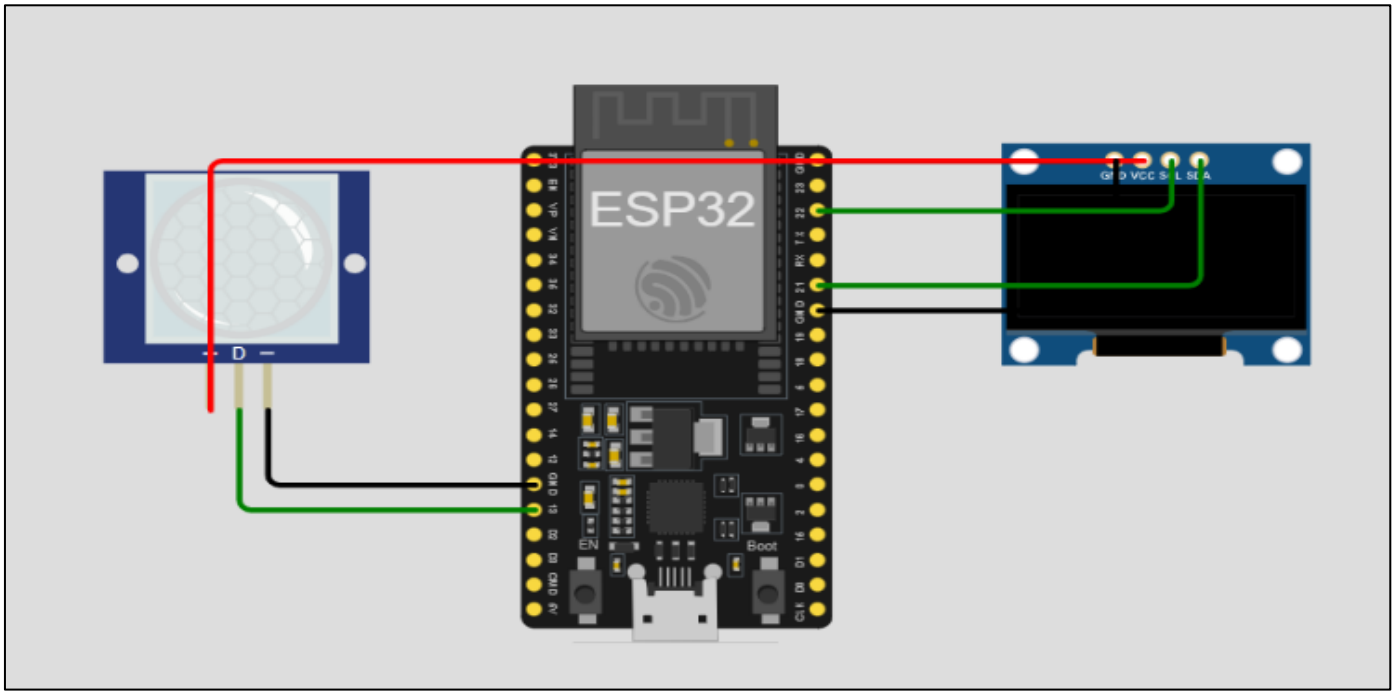

Fig 5 AI-IoT Notice Board Hardware Setup

VII. CONCLUSION

The AI-enabled IoT digital notice board described in this work combines PIR sensor-based energy optimization, NLP summarizing for succinct information delivery, and OCR for automated content extraction. By automating notice processing, enhancing readability, and lowering power consumption, the system solves the shortcomings of conventional manual and simple digital notice boards. High OCR accuracy, efficient summarization, quick content updates, and notable energy savings are all confirmed by experimental results. The suggested solution offers a clever, automatic, and long-lasting method for contemporary notice distribution in offices and educational institutions.[19, 20].

FUTURE ENHANCEMENTS

➢ *Future Enhancements to the System Can Consist of:*

- *Handwriting Recognition:* Text can be reliably extracted from handwritten notes using sophisticated OCR models.
- *Multilingual Support:* To accommodate a variety of user groups, summaries and displays are provided in multiple languages.
- *Mobile Notifications:* Instant alerts of fresh announcements are provided through integration with mobile apps.
- *Solar-Powered Display:* Using solar panels to improve sustainability and lessen reliance on energy.
- *Text-to-Speech:* Including audio for users who are blind or visually impaired.

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