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Smart Ration Distributor

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ABSTRACT

The Public Distribution System (PDS) plays an important role in providing essential food commodities to economically weaker sections of society. However, traditional ration distribution systems face several challenges, including manual verification, long waiting times, unauthorized access, identity fraud, and inefficient management of ration records.

To overcome these challenges, this research presents the design and development of a Smart Automatic Ration Distribution System using RFID authentication, face recognition, and One-Time Password (OTP) verification. The proposed system uses an ESP32 microcontroller as its main processing unit. RFID technology is used to identify registered ration cardholders, while face recognition provides an additional layer of identity verification. OTP authentication further improves security by ensuring that only authorized users can access the system.

An LCD display provides real-time instructions and system status, while servo motors operate the automatic locking mechanism. A buzzer and LED indicators provide audio and visual feedback during the authentication process.

The proposed system aims to improve the security, transparency, reliability, and efficiency of ration distribution. By integrating multiple authentication techniques, it reduces the possibility of unauthorized access and supports the development of a more secure and automated Public Distribution System.

KEYWORDS: *Smart Ration Distribution, ESP32, RFID Authentication, Face Recognition, OTP Verification, Internet of Things (IoT), Automation, Public Distribution System, Embedded System.*

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INTRODUCTION

The Public Distribution System (PDS) is an important government initiative in India that provides essential food commodities such as rice, wheat, and other necessities to eligible beneficiaries at subsidized prices. Traditional ration distribution systems generally involve manual verification of ration cards and beneficiary details. These processes may result in long queues, delays, human errors, improper record management, and unauthorized distribution of ration commodities.

With the advancement of automation, embedded systems, and Internet of Things (IoT) technologies, traditional distribution methods can be improved through intelligent and secure automated systems. The Smart Automatic Ration Distribution System is designed to modernize the ration distribution process by integrating RFID technology, face recognition, and OTP-based authentication.

The ESP32 microcontroller acts as the central processing unit and coordinates the authentication process. The RFID reader scans the beneficiary's card, the camera module captures facial information for identity verification, and OTP authentication provides an additional security layer. After successful verification, the system activates the servo motors to operate the access mechanism. The proposed system aims to provide a secure, efficient, user-friendly, and automated approach to ration distribution.

LITERATURE REVIEW

The development of automated ration distribution systems has gained attention with the advancement of embedded systems, RFID technology, biometric authentication, and IoT applications.

1. **RFID-Based Identification**: Radio Frequency Identification (RFID) is widely used in identification and access control applications. RFID systems consist of tags and readers that communicate wirelessly to identify registered users. This technology provides a convenient method for beneficiary identification.

2. **Face Recognition Technology**: Face recognition is a biometric identification technique that analyzes facial characteristics to verify an individual's identity. Camera-based recognition systems are increasingly used in security and access control applications.

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3. **OTP-Based Authentication:** One-Time Password (OTP) is a temporary verification code used to authenticate users. It provides an additional security layer and helps prevent unauthorized access.

4. **Microcontroller-Based Automation**: Microcontrollers are widely used in automation applications because they can process input signals, execute programmed instructions, and control output devices. ESP32 provides processing capabilities and wireless communication features suitable for smart automation projects.

5. **Research Gap**: Individual technologies such as RFID, face recognition, and OTP are commonly used for authentication. Integrating these technologies into a single automated ration distribution system provides a multi-level authentication approach that can improve access security.

SYSTEM ARCHITECTURE

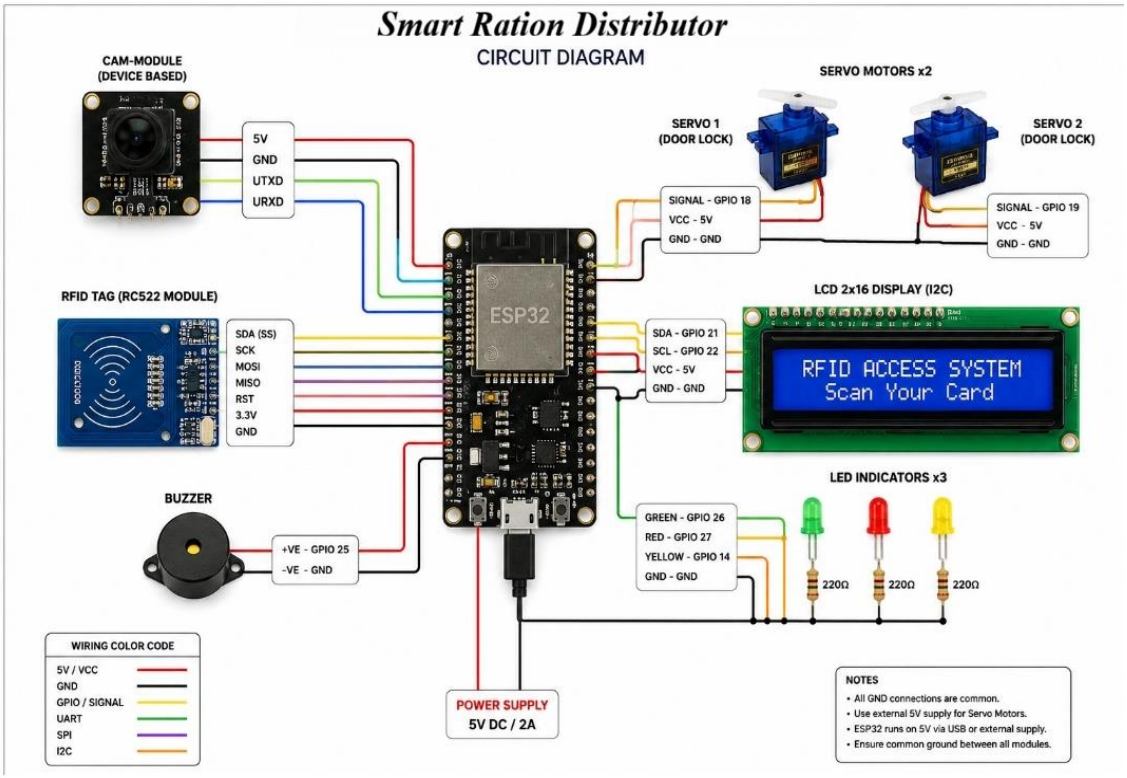


Figure 1: Block Diagram of System

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SYSTEM WORKING FLOW

The working of the Smart Ration Distribution System is based on a sequential authentication process. Initially, the ESP32 microcontroller initializes all the connected modules, including the RFID reader, camera, LCD display, and output devices. The beneficiary is instructed to scan the registered RFID card. The RFID reader reads the card identification number and sends it to the ESP32 for verification.

After successful RFID verification, the camera captures the beneficiary's facial information. The captured facial data is compared with the previously registered information using the configured face-recognition system. Once facial verification is completed, OTP authentication is performed. The beneficiary enters the received OTP to complete the verification process.

If all authentication stages are successful, the ESP32 sends a control signal to the servo motor to operate the locking mechanism. The LCD displays a successful authentication message, and the LED indicator provides visual confirmation. If any verification stage fails, the system denies access and provides an alert through the buzzer. This process ensures that only authorized beneficiaries can operate the ration distribution mechanism.

SOFTWARE REQUIREMENTS AND IMPLEMENTATION

The software plays an important role in controlling and coordinating the different hardware components of the Smart Ration Distribution System. The ESP32 is programmed to receive input signals, process authentication information, and control the output devices according to predefined conditions.

Arduino IDE can be used as the programming environment for developing and uploading the program to the ESP32 microcontroller. The program includes instructions for RFID card reading, authentication checking, and communication with the configured face-recognition system, OTP verification, LCD message display, and servo motor control.

The system follows conditional programming logic to determine whether the beneficiary is authorized. If the authentication information matches the registered details, the program allows the next verification stage. If the verification fails, the program prevents further access

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and activates the alert mechanism.

The software also manages communication between the ESP32 and the connected modules. Proper programming and testing are necessary to ensure reliable operation, accurate authentication, and coordination between hardware components.

Components used:

1. ESP32 Microcontroller

The ESP32 is the main processing and control unit of the Smart Automatic Ration Distribution System. It receives input signals from different modules, processes authentication data, and controls the connected output devices. It coordinates RFID verification, face recognition, OTP authentication, servo motor operation, and ration dispensing. It also supports Wi-Fi and Bluetooth connectivity for communication purposes.



Figure 2: ESP32 Microcontroller

2. RFID RC522 Module

The RFID RC522 is a radio frequency identification module used for contactless identification. It reads the unique identification number stored in an RFID card or tag and sends the information to the ESP32 through SPI communication. The module helps identify registered ration cardholders and initiates the authentication process.

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Figure 3: RFID RC522 Module

3. Camera Module

The camera module is used to capture the facial image of the beneficiary for identity verification. The captured facial information is processed through the configured face-recognition system and compared with registered facial data. This technology provides an additional layer of security and helps prevent unauthorized access.



Figure 4: Camera Module

4. LCD 16×2 Display (I2C)

The 16×2 LCD display is used to provide information and instructions to the beneficiary. It displays messages related to RFID card scanning, face authentication, OTP verification, and access status. The I2C interface reduces the number of connections required between the

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display and the ESP32, making the circuit simpler.



Figure 5: LCD 16×2 Display (I2C)

ADVANTAGES OF THE PROPOSED SYSTEM

The Smart Ration Distribution System offers several advantages compared with conventional ration distribution methods.

Improved Security: Multiple authentication methods help reduce unauthorized access and identity misuse.

Reduced Manual Work: Automated verification reduces the need for repeated manual checking of ration cards and beneficiary information.

Time Efficiency: The sequential authentication process can help reduce delays during beneficiary verification.

User-Friendly Operation: The LCD display, buzzer, and LED indicators provide clear instructions and feedback.

Reliable Identification: RFID and facial recognition provide additional methods of confirming beneficiary identity.

Automation: Servo motor-based locking reduces the need for manual operation of the access mechanism.

Future Expandability: ESP32 wireless connectivity provides opportunities for integrating cloud services and remote monitoring in future versions.

These advantages demonstrate how embedded systems and automation can contribute to improving the reliability and security of public distribution services.

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APPLICATIONS

The proposed Smart Ration Distribution System has several practical applications in public distribution and automated access control.

Government Ration Shops: The system can be used in ration shops to improve beneficiary identification and reduce manual verification.

Public Distribution Centres: It can support secure distribution of essential commodities to registered beneficiaries.

Automated Food Distribution: The authentication mechanism can be adapted for automated distribution of food products in controlled environments.

Smart Inventory Management: With additional monitoring features, the system can help manage ration stock and distribution records.

Secure Access Control: The combination of RFID, facial recognition, and OTP can be adapted for other applications requiring multi-level user authentication.

FUTURE SCOPE

The Smart Ration Distribution System has considerable potential for future development. One important improvement is the integration of cloud-based data storage to maintain beneficiary records and distribution information. This would allow authorized administrators to monitor system activities and access records remotely.

A mobile application could also be developed to provide beneficiaries with information about their ration availability, distribution status, and transaction history. Integration with government databases could improve the accuracy of beneficiary information, subject to appropriate authorization and data protection requirements.

Another possible improvement is the addition of automatic weighing sensors to measure and dispense the correct quantity of ration commodities. Multiple storage compartments could be introduced to support the distribution of different products, such as rice, wheat, and sugar. Real-time stock monitoring could also help administrators identify low-stock conditions and manage inventory more efficiently.

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Furthermore, advanced facial recognition algorithms and improved OTP communication methods could increase authentication reliability. Solar power or battery backup could be considered to support operation during power interruptions. These developments could transform the proposed prototype into a more comprehensive and scalable smart ration distribution solution.

SYSTEM LIMITATIONS

Although the proposed system provides multiple authentication methods, certain limitations must be considered. The system requires a continuous power supply for reliable operation of the ESP32 and connected modules. RFID cards may be lost or damaged, which can create difficulties during beneficiary identification.

Face recognition performance may be affected by lighting conditions, camera quality, and changes in facial appearance. OTP verification also depends on the availability of a suitable communication method and registered contact information. In addition, the initial installation and maintenance of electronic components may increase implementation costs.

These limitations can be reduced through proper maintenance, improved authentication algorithms, backup power arrangements, and secure management of beneficiary records.

CONCLUSION

The Smart Automatic Ration Distribution System presents an automated approach to improving the security and efficiency of the traditional Public Distribution System.

The proposed system integrates RFID technology, face recognition, and OTP verification to provide multi-level beneficiary authentication. The ESP32 microcontroller coordinates the authentication process and controls the connected hardware components.

The integration of servo motors, an LCD display, a buzzer, and LED indicators provides an automated and user-friendly access control mechanism.

The system aims to reduce unauthorized access, minimize manual intervention, and improve the reliability of ration distribution.

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Overall, the proposed system demonstrates the potential of embedded systems, automation, and authentication technologies in developing a secure and efficient ration distribution mechanism.

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