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Offline Biometric Authentication for rural area Ration shop

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1. ABSTRACT

In rural areas, the effectiveness of digital authentication systems in ration shops is often limited by unreliable or unavailable internet connectivity, leading to transaction failures and increased opportunities for fraud. To address this challenge, this paper proposes an offline multimodal biometric authentication system designed specifically for rural ration shop environments. The proposed system integrates RFID-based identification with face recognition to provide secure and reliable beneficiary authentication without
dependence on network connectivity. Arduino is used for hardware control and RFID processing, while a Python-based application employing OpenCV and face recognition libraries performs facial verification using locally stored biometric data. During each transaction, the beneficiary's RFID tag is validated and the captured facial image is matched against the local database before access is granted. Authentication results and user details are displayed on an LCD, accompanied by buzzer alerts and voice feedback for transaction status. Experimental observations demonstrate that the system effectively reduces impersonation, minimizes manual errors, and ensures fair distribution of ration commodities in offline conditions. The proposed solution is cost- effective, scalable, and well-suited for deployment in rural public distribution systems.

2. KEYWORDS

Offline Biometric Authentication, RFID, Face Recognition, Rural Ration Shop, Public Distribution System, Arduino, Fraud Prevention

3. INTRODUCTION

The Public Distribution System (PDS) plays a crucial role in ensuring food security for millions of people in rural and economically weaker sections of society. In India, ration shops are responsible for distributing essential commodities such as rice, wheat, sugar, and kerosene at subsidized rates. However, traditional ration distribution systems often suffer from issues like identity fraud, duplicate beneficiaries, manual errors, and misuse of resources, leading to leakage and corruption. In recent years, biometric authentication systems have been introduced to improve transparency and accountability in ration distribution. Most existing systems depend heavily on online connectivity and centralized databases such as Aadhaar-based authentication. Unfortunately, many rural areas still face challenges like poor internet connectivity, power fluctuations, and lack of technical infrastructure. These limitations result in authentication failures, denial of services to genuine beneficiaries, and delays in ration

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distribution. To overcome these challenges, this project proposes an Offline Biometric Authentication System for Rural Area Ration Shops. The system is designed to function without continuous internet access by using locally stored biometric data and RFID-based identification. Face recognition technology is employed as a biometric modality to verify beneficiaries accurately, while RFID cards serve as an additional authentication factor. This multimodal approach enhances security and reduces the chances of impersonation or fraud. The proposed system integrates embedded hardware such as Arduino with software tools like Python and OpenCV to perform real-time biometric verification. By enabling offline authentication, the system ensures uninterrupted ration distribution even in remote rural locations. This approach improves reliability, enhances trust among beneficiaries, and supports the government's objective of fair and transparent distribution of essential commodities.

4. OBJECTIVES

To design and develop an **offline biometric authentication system** for rural ration shops to ensure uninterrupted service in areas with poor or no internet connectivity.

- To implement **face recognition–based authentication** for accurate and reliable identification of ration beneficiaries.
- To integrate **RFID technology** as an additional authentication factor for enhancing system security and reducing impersonation and fraud.
- To store and manage beneficiary details in a **local database**, enabling fast verification without dependency on centralized online servers.
- To reduce **fraud, duplicate entries, and misuse of ration commodities** by ensuring that only genuine beneficiaries receive their entitled supplies.
- To provide a **low-cost, easy-to-use solution** suitable for deployment in rural and remote areas.
- To improve **transparency, efficiency, and trust** in the Public Distribution System (PDS

5. LITERATURE SURVEY

The Public Distribution System (PDS) has undergone significant technological advancements aimed at improving transparency and reducing fraud in ration distribution. Several researchers have proposed biometric-based authentication systems to address issues such as duplicate beneficiaries, identity fraud, and manual errors in traditional ration shops.

Many existing studies focus on **Aadhaar-based online biometric authentication systems**, where fingerprint or iris data is verified through centralized servers. These systems have shown improvements in transparency and accountability; however, researchers have reported major limitations related to **internet dependency**, server downtime, and authentication failures, particularly in rural and remote regions. Such failures often result in denial of ration to genuine beneficiaries.

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To overcome connectivity issues, some researchers proposed **smart ration card systems** using RFID and microcontroller-based automation. RFID-based solutions reduce manual intervention and speed up the ration distribution process. However, RFID-only systems are vulnerable to card loss, duplication, and unauthorized usage, as they lack strong biometric verification.

Recent studies have explored **multimodal biometric authentication**, combining biometric traits such as fingerprint, face recognition, or iris scanning with smart cards. Face recognition-based systems using image processing techniques and OpenCV have gained attention due to their contactless nature and ease of use. These systems reduce hygiene concerns and are suitable for large-scale deployment. Nevertheless, many face recognition implementations still rely on cloud servers for processing and storage, making them unsuitable for offline rural environments.

A few researchers have attempted **offline biometric verification** using local databases and embedded systems. While these approaches address connectivity challenges, they often suffer from limited accuracy, high hardware cost, or lack of scalability. Moreover, most existing offline systems focus on a single biometric modality, which reduces overall system reliability.

Based on the analysis of existing literature, it is evident that there is a need for a **cost-effective, offline, and secure multimodal biometric authentication system** specifically designed for rural ration shops. The proposed system addresses this research gap by integrating **face recognition and RFID authentication** with a local database, ensuring reliable ration distribution without internet dependency while minimizing fraud and authentication failures.

6. CONTRIBUTION OF THE PAPER

This paper makes the following key contributions:

6.1 Offline Authentication Framework

The paper proposes a complete **offline biometric authentication framework** for rural ration shops, eliminating dependency on continuous internet connectivity and centralized servers.

6.2 Multimodal Biometric Approach

A **combined authentication mechanism** using face recognition and RFID is introduced to improve identification accuracy and reduce impersonation and fraud compared to single- factor systems.

6.3 Local Database-Based Verification

The system utilizes a **locally stored database** for beneficiary details and biometric data, enabling faster verification and uninterrupted ration distribution in remote rural areas.

6.4 Cost-Effective Embedded System Design

The proposed solution integrates **low-cost hardware components** such as Arduino and a camera module, making it affordable and suitable for large-scale rural deployment.

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6.5 Improved Reliability in Rural Environments

By functioning without internet access, the system ensures **consistent and reliable service** even in regions affected by poor connectivity, power fluctuations, or server downtime.

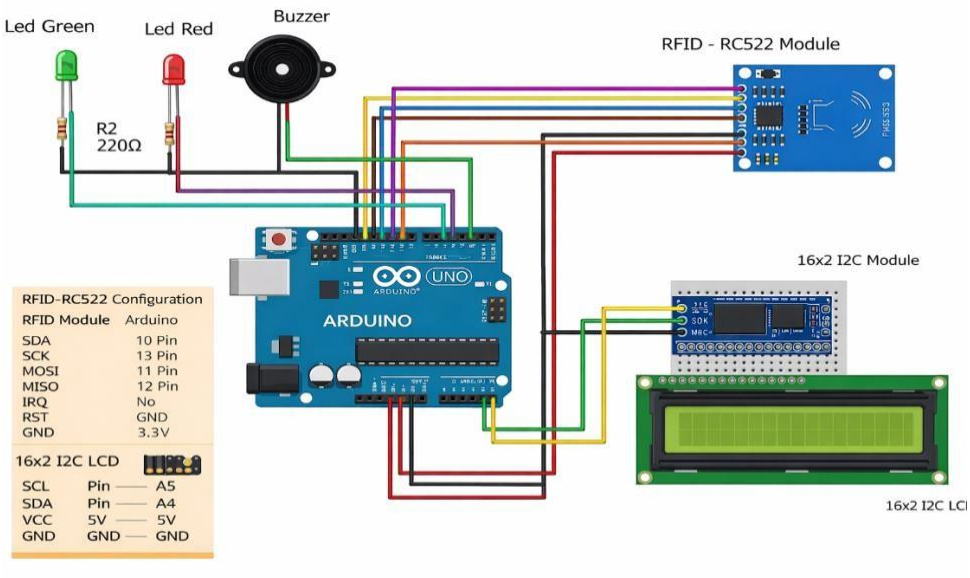
6.6 Fraud Reduction in Public Distribution System

The proposed model significantly minimizes **duplicate entries, unauthorized access, and ration leakage**, thereby improving transparency and trust in the Public Distribution System.

7. METHODOLOGY

The proposed methodology employs an offline multimodal authentication system combining RFID and face recognition. Beneficiary data is stored locally, and authentication is performed without internet dependency using embedded hardware and image processing techniques, ensuring secure and reliable ration distribution in rural areas.

8. SYSTEM ARCHITECTURE



9. SOFTWARE REQUIREMENT DEVELOPMENT

The proposed system requires a combination of embedded programming software, computer vision libraries, database tools, and development environments to support offline biometric authentication and system control.

9.1. Operating System

- **Windows 10 / Windows 11 (64-bit)**
  Used for running the Python-based face recognition module, database management, and serial communication with Arduino.

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9. 2. Programming Languages

- **Embedded C / Arduino C**
  Used to program the Arduino UNO for controlling RFID reader, LCD display, buzzer, keypad, and serial communication.
- **Python 3.x**
  Used for facial recognition processing, database handling, and communication with Arduino through serial interface.

9. 3. Development Environments

- **Arduino IDE (Version 1.8.x or above)**
  Used to write, compile, and upload code to the Arduino UNO board.
- **Python IDE / Editor**
  - VS Code / PyCharm / IDLE
    Used to develop and execute the face recognition and backend logic.

9.4. Libraries and Frameworks

- **Arduino Libraries**
  - MFRC522 (RFID communication)
  - LiquidCrystal / LiquidCrystal_I2C (LCD interface)
  - Keypad Library (for keypad input)
  - SoftwareSerial / Serial (communication)
- **Python Libraries**
  - OpenCV (cv2) – Face detection and image processing
  - face_recognition (Dlib-based) – Facial feature extraction and matching
  - NumPy – Numerical operations
  - PySerial – Serial communication with Arduino
  - OS / Time libraries – File handling and timestamps

9. 5. Database Software

- **SQLite / MySQL (Local Database)**
  Used to store:
  - RFID tag UID
  - User identity details
  - Facial embeddings
  - Transaction and authentication logs
    Ensures complete offline operation without internet dependency.

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9. 6. Communication Software

- **Serial Communication (USB / UART)**
  Enables real-time data exchange between Arduino UNO and Python application for authentication decisions.

9. 7. Additional Software Tools

- **DFPlayer Mini Library (Optional)**
  Used for voice playback alerts when ration limits are reached.
- **Device Drivers**
  - USB-to-Serial drivers (CH340 / ATmega drivers if required)
  - Webcam drivers for face capture

9. 8. Security Software Features

- Local data encryption (AES – optional)
- Admin-protected enrollment interface
- Offline storage without cloud dependence.

10. BENEFITS

10.1 Prevents Ration Fraud

Biometric authentication ensures that only authorized and genuine beneficiaries receive ration supplies, eliminating duplicate records and fake identities.

10.2. Offline Operation

The system works without internet connectivity, making it highly suitable for rural and remote areas where network access is poor or unavailable.

10.3. Improved Transparency

All ration distribution transactions are recorded locally, enabling clear verification and increasing trust between beneficiaries

10.4. Accurate Beneficiary Identification

The combination of biometric authentication and RFID ensures precise identification of beneficiaries, providing higher accuracy than traditional manual verification methods.

10.5. Reduction of Human Error

Automated authentication reduces errors caused by manual data entry and human involvement during the ration distribution process.

10.6. Faster Distribution Process

Quick authentication and verification help reduce waiting time, minimizing long queues and improving overall efficiency.

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11. CONCLUSION

The proposed Offline Biometric Authentication System for Rural Area Ration Shops provides a secure and efficient solution to overcome the challenges of traditional ration distribution systems. By integrating biometric authentication with RFID technology, the system ensures accurate identification of beneficiaries and prevents fraudulent practices such as duplicate and fake entries. The offline functionality makes the system highly suitable for rural and remote areas where internet connectivity is unreliable. Automated verification reduces human errors, speeds up the distribution process, and improves transparency by maintaining accurate transaction records. Additionally, the use of low-cost hardware components and open-source software makes the system economically feasible and easy to maintain. Overall, the proposed system enhances trust, accountability, and efficiency in public distribution systems and can be effectively implemented to improve food security and service delivery in rural communities.

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