AI-RATIONMITRA: SMART PUBLIC DISTRIBUTION THROUGH AI AND IOT

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ABSTRACT

Though vital to food security, India's Public Distribution System (PDS) still suffers from severe challenges like ration leakage, identity fraud, manual inefficiencies, and poor accessibility, particularly in rural and underserved areas. These systemic weaknesses frequently lead to the deprivation of the entitled food grains to the intended beneficiaries, impacting millions who rely on government subsidies for their sustenance.

To resolve these challenges, this paper presents AI-RationMitra — a smart ration dispensing system that is intelligent, voice-controlled, and IoT-enabled. The system employs an auger-based mechanical design augmented by solenoid valves and food-grade stainless steel chambers to accurately dispense vital commodities such as rice, wheat, sugar, oil, and pulses. It utilizes a multi-layered authentication mechanism comprising fingerprint scanning, RFID, and facial recognition to authenticate legitimate beneficiaries. A multilingual voice assistant driven by AI allows users to easily communicate in their language, review quota balances, and submit ration requests without the need for literacy or manual intervention.

The system includes weight sensors to verify real-time dispensing and synchronize data to the cloud for real-time logging and inventory reconciliation. Usage patterns are analyzed using AI algorithms that predict demand and identify anomalies. With its scope of integration at local Kirana shops and FPS centers, AI-RationMitra is a vision of an open, citizen-centric, and tamper-proof ration distribution system that guarantees timely delivery, equal access, and operational transparency for urban and rural India.

Keyword: - *AI-RationMitra, Smart Ration Dispensing, IoT-Based PDS, Biometric Authentication, Voice Assistant, Load Cell Feedback, Multilingual AI Chatbot, Automated Food Distribution*

1. INTRODUCTION

India’s Public Distribution System (PDS) plays a vital role in ensuring food security for millions of citizens. Despite several reforms, the system continues to face challenges such as manual processing errors, leakage of food grains, identity fraud, delays in delivery, and limited accessibility, especially in rural and underserved regions. Traditional

ration shops rely heavily on manual verification and paper-based record-keeping, making them vulnerable to inefficiencies and corruption.

To address these issues, there is a pressing need for a smart, automated, and inclusive system that ensures accurate, timely, and transparent distribution of subsidized food commodities. The convergence of Internet of Things (IoT) technologies with Artificial Intelligence (AI) presents a promising solution. AI-Ration Mitraa is an innovative approach that combines biometric authentication, intelligent dispensing hardware, and voice-enabled multilingual AI assistance into one integrated platform.

The system facilitates the distribution of essential commodities such as rice, wheat, sugar, dal, and oil through a fully automated auger-based dispensing mechanism. It employs secure user authentication using fingerprint sensors, RFID cards, and facial recognition, thereby eliminating the scope for fraudulent beneficiaries. Additionally, users can interact with the system using voice commands in their preferred language to check their quotas, place ration requests, and receive assistance.

This paper discusses the architecture, implementation, and societal benefits of AI-Ration Mitraa. With its emphasis on automation, real-time monitoring, and multilingual accessibility, the system aims to modernize the PDS infrastructure, particularly benefiting remote and economically weaker regions of India.

2. Objective

- To automate and digitize the public distribution system with the help of AI and IoT.
- To provide equitable, secure, and 24*7 access to ration commodities through biometric and voice interaction.
- To eliminate corruption, leakage, and manual errors from the rationing process.

2.1 Problem Statement

The Public Distribution System (PDS) in India faces issues like corruption, identity fraud, and exclusion errors due to manual processes. AI-Ration Mitra addresses these challenges using an AI-powered vending machine with biometric and smart authentication. It ensures transparent, efficient, and accurate ration distribution with minimal human intervention.

2.2 Existing System

The conventional PDS is highly dependent on manual processes using ration cards, handwritten registers, and paper-based records. Such systems are susceptible to duplication, abuse, and human error. Even newer digitizations in a few locations continue to rely on human-run shops, constraining automation and 24/7 access.

2.3 Scope

- Automation of ration distribution through AI-enabled IoT devices.
- Multilingual AI interface to support users of different linguistic backgrounds.
- Fingerprint, RFID, and facial recognition-based secure access.
- Government database and Kirana store integration.

3. Literature Survey

[1] Anil Kadu, Sumaiyya Nadaf, Medhavi Pajgade, Mrunal Narwane, Anjali Nile, "Design and Development of Low-Cost Automated Ration System Using IoT," International Journal for Research in Applied Science and Engineering Technology (IJRASET), 2023. DOI: 10.22214/ijraset.2023.56417.

Summary: This research presents an Automated Ration Distribution System (ARDS) that combines artificial intelligence, machine learning, and data analytics to improve the effectiveness and transparency of ration distribution. The system uses biometric identification and smart inventory management to promote fair access to basic food items. Through automated distribution, the ARDS intends to minimize mistakes, identify and eliminate fraud, and streamline resource allocation.[6]

[2] Sunil M, Ravi Rayappa, Ravi Kumar K I, "Automatic Ration Dispenser," Journal of Electronics Design and Technology, 2024.

Summary: The writers suggest an automatic ration dispenser system using biometric authentication and smart card

identification to provide reliable and efficient distribution of rationed goods. The system dispenses the rations automatically, reduces human interaction to a bare minimum, and stores transactions centrally for monitoring and auditing. The aim is to eliminate irregularities, mismanagement, and corruption in Public Distribution Systems (PDS).[7]

[3] S Varsha, P Divya, R Jhansi, Y Pradeep, "Smart Ration Distribution System Using RFID or Biometric," International Journal for Research in Applied Science and Engineering Technology (IJRASET), 2022. DOI: 10.22214/ijraset.2022.45321.

Summary: This research offers an intelligent ration distribution system that substitutes manual systems with automated systems employing RFID or biometric identification. A consumer is offered an RFID card or employs fingerprint scanning for identification purposes. The system intends to manage malpractices in the shops by providing accurate measurements and restricting unauthorized utilization of consumer materials.[8]

[4] Shilpa K. Rudrawar, Kuldeepak Phad, Prajwal Durugkar, "IoT Enabled Secured Card Less Ration Distribution System," Techno-Societal 2020, Springer, 2021. DOI: 10.1007/978-3-030-69921-5_48.

Summary: This paper describes an IoT-based, card-free system for the distribution of rations that employs biometric authentication and cloud storage technology. The above system is like an Automated Teller Machine (ATM) and saves customer information in the cloud via platforms such as Google Firebase. The transactions are made secure via One-Time Passwords (OTP) sent via email or SMS, keeping everything transparent and curbing malpractices such as smuggling and corruption during the ration distribution system.[9]

[5] Jinali Goradia, Sarthak Doshi, "Automated Ration Distribution System," Procedia Computer Science, 2015. DOI: 10.1016/j.procs.2015.03.096.

Summary: This paper suggests an Automated Ration Distribution System utilizing embedded systems in order to automate the process of distributing key commodities. The system is composed of a microcontroller, keypad, and peripheral circuits to control the dispensing process. Automating the ration distribution should decrease the chances of manual errors, illegal smuggling of goods, and improve the overall efficiency of the Public Distribution System.[10]

4. Methodology

The AI- RationMitra system involves several stages, as shown in Figure 1:

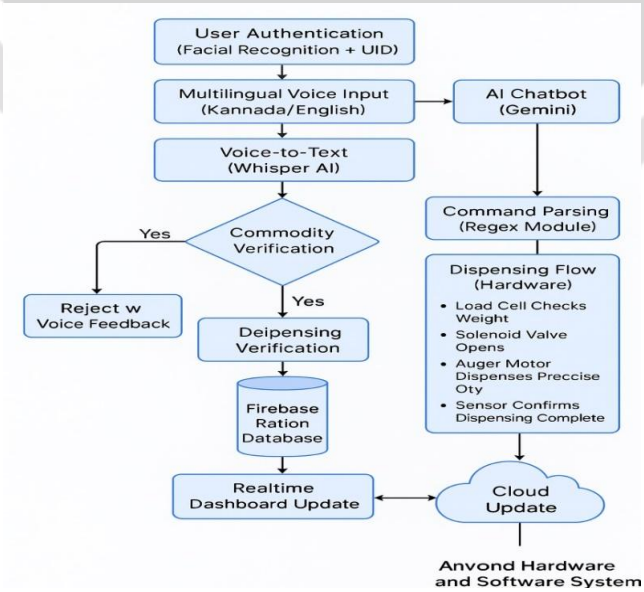

Fig -1: Methodology of AI- RationMitra System

The AI-RationMitra system works based on a cloud-based infrastructure that hosts the user data, biometric credentials, ration allowance, and stock status. Through secure APIs, each dispensing unit communicates in real time with the central database. Users are authenticated by fingerprint, RFID, or face recognition modules. They are then taken through their allotted ration quota and current government schemes by a multilingual AI voice assistant once verified. Voice interaction provides ease of access, particularly in rural and semi-urban regions.

An auger system controlled by an AI releases the chosen commodity according to real-time weight sensor output. Solenoid valves handle flow control, minimizing wastage, ensuring accuracy, and maintaining hygiene. The transactions are recorded and associated with the user for audit and transparency.

Administrators and government authorities have access to a real-time dashboard displaying inventory levels, usage history, and demand patterns. Low stock or unusual usage triggers alerts, and predictive analytics ensure optimal future stock allocation.

In the event of connectivity or power loss, offline activities are recorded and synchronized once the system is restored, providing uninterrupted data flow and service.

4. PROPOSED SYSTEM

The envisioned AI-RationMitra is an IoT-based smart ration dispensing system that provides secure, transparent, and efficient The envisioned AI-RationMitra is an IoT-based smart ration dispensing system that provides secure, transparent, and efficient distribution of subsidized commodities.

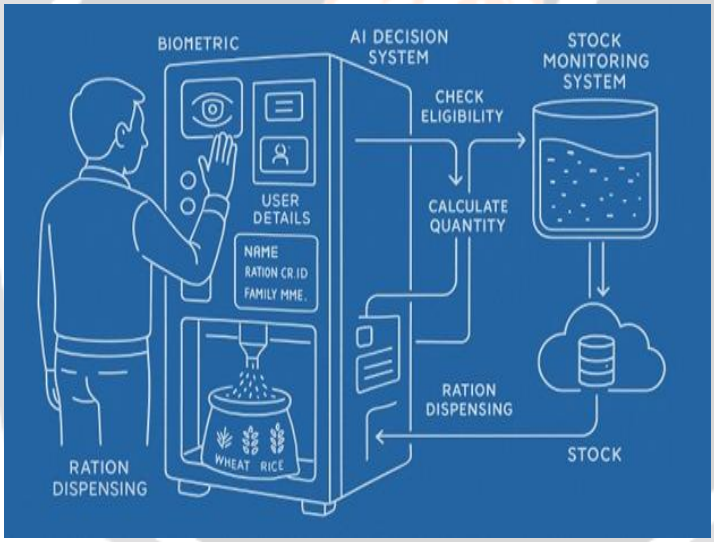

Fig -2: Workflow of AI- RationMitra System

Authentication is done through fingerprint, RFID, or face recognition, followed by interaction with a multilingual voice-based AI assistant. The dispensing unit, which is a food-grade auger motor and solenoid valve enabled, dispenses rice, wheat, dal, sugar, and oil according to real-time quota validation. All stock levels and transactions are synced to the cloud, allowing live monitoring and analytics via an admin dashboard. AI-integrated modules analyze usage patterns, flag anomalies, and aid in proactive stock management, cutting out fraud, manual errors, and middleman dependency.

5. Implementation

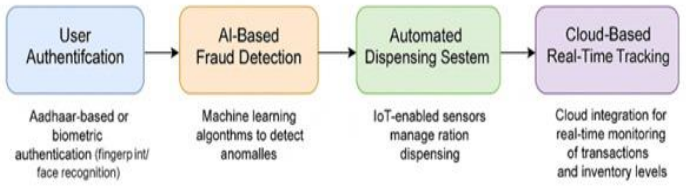

Fig - 3 : Implementation of AI- RationMitra System

Implementation of AI-RationMitra is achieved through a sequence of highly orchestrated software and hardware phases aimed at providing secure, automated, and intelligent ration dispensation. Every aspect is rural-deployment optimized to provide reliability, precision, and accessibility.

5.1 User Authentication

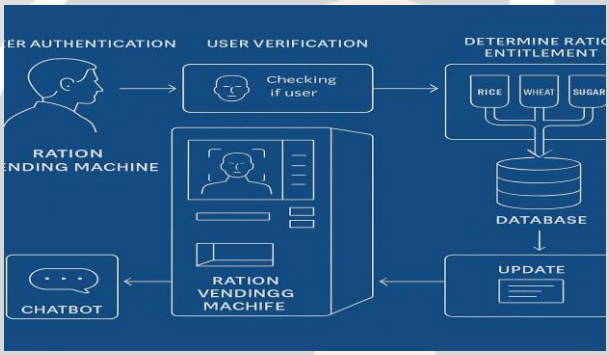

Fig - 4 : User Authentication in AI- RationMitra System

The system starts with a multi-modal biometric authentication module where users can authenticate themselves with the help of fingerprint sensors, RFID cards, or facial recognition. Facial authentication is driven by OpenCV coupled with trained machine learning models* that allow real-time detection and matching even when the light conditions are dim, as is common in rural environments. The user's biometric or ID input is subsequently verified against a cloud-based *Firebase database holding demographic data, eligibility category (APL/BPL), and existing monthly quota data. This is done to ensure that only authenticated beneficiaries can advance, and impersonation or forgery is averted at the beginning.

5.2 Voice-Enabled AI Chatbot Interface

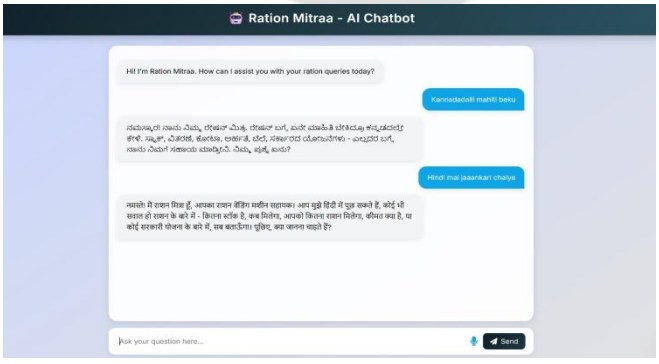

Fig - 5 : Voice-Enabled Chatbot Interface in AI- RationMitra System

When logged in, users interact with a voice-first AI chatbot interface that can work in multiple regional languages. It is driven by Google Speech Recognition, which translates the spoken requests of the user into text. The text is then scanned by Gemini 1.5 Pro, a fast, large language model, through the backend to deduce the intent and provide a correct, personal response. The answer is then spoken through Google Text-to-Speech (gTTS) so that the user gets immediate feedback in his or her desired language. The multilingual voice loop provides a human-like, personalized experience, which is very effective for illiterate or semi-literate consumers who live far from cities.

5.3 Commodity Selection and Quota Verification

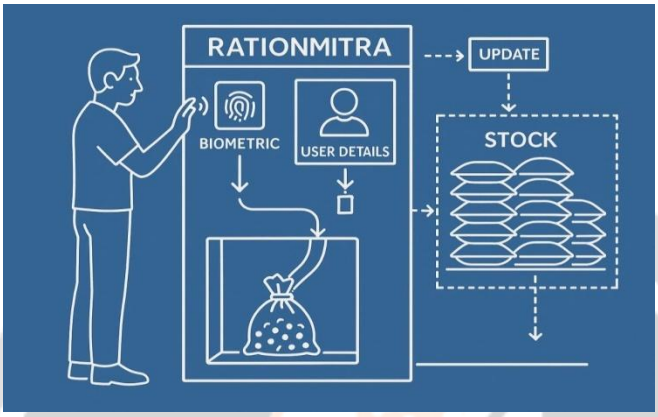

Fig - 5 : Commodity selection Interface in AI-RationMitra System

The AI system understands commodity requests such as "I want 2 kg of rice" and cross-checks the same with the remaining monthly quota and current government entitlements retrieved from the database. It applies natural language parsing to understand quantities, units, and product types. If the request is within the allowed limits, it is sent to the dispensing module. Otherwise, a contextual voice message is played, stating the reason, e.g., "You have already taken 3 kg of rice this month; your balance is 2 kg." This validation layer guarantees scheme rule compliance and over-allocation prevention.

5.4 Dispensing Control through Microcontrollers

The validated dispense request is transmitted as a command from the backend to microcontrollers like Arduino or Raspberry Pi through Flask-based RESTful APIs. Every grain chamber (e.g., rice, wheat, dal, sugar, oil) has auger motors or solenoid valves controlling the flow by commodity type. The motors are activated for a calibrated time, established through previous testing, to dispense precise amounts. All hardware functions are coordinated with real-time sensor feedback loops to ensure operational integrity and avoid mechanical faults.

5.5 Weight Verification and Error Handling

A load cell sensor placed under the dispensing tray confirms the precise amount of the dispensed product. The expected and actual weight values are compared in real time. In case of differences beyond a set tolerance (±5g for grains, ±10ml for oil), the system retries the operation, corrects the remaining amount, or stops the process and informs the user through a voice message. This feedback mechanism minimizes human intervention and provides zero wastage, **accurate fulfillment, and **error resilience.

5.6 Dynamic Stock Monitoring

After each successful dispense, the system updates the central stock database by reducing the amount dispensed from current stock levels. Every commodity has a predetermined minimum threshold, and upon dipping below it, an **automated restock alert is triggered to the admin dashboard or the concerned supply authority. This way, there is timely replenishment and the ability to catch early signs of supply chain disruptions, particularly in remote or underserved locations.

5.7 Multilingual Support and Accessibility

From authentication to confirmation, the system is functional in several Indian languages, such as **Kannada, Hindi, and English. All questions, queries, and instructions are provided in the user's chosen language, closing the digital divide. This is especially effective in rural regions where literacy levels are low. The **voice-first design

allows the system to be used without assistance by elderly citizens, visually impaired people, and those who are not familiar with smartphones or computers.

5.8 Admin Dashboard Operations

The system features a Flask-based admin dashboard with complete control and monitoring of users, inventory, transactions, and hardware status. Admins can add or block users, track live dispense logs, set up quotas, and be alerted to health issues from hardware sensors (e.g., motor faults or jammed valves).

6. RESULTS AND CONCLUSIONS

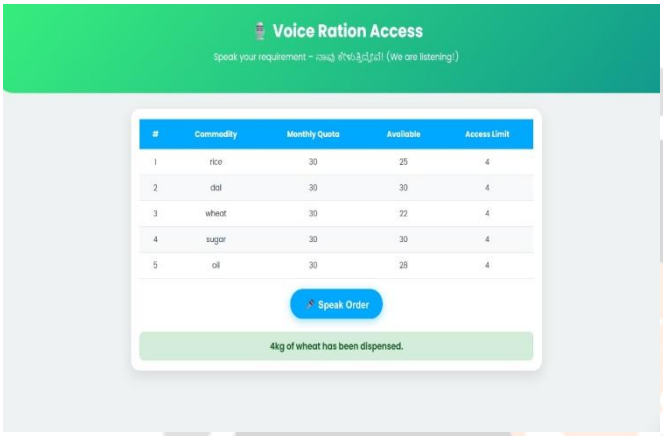

Fig – 6 : Voice-Assisted Ration Access

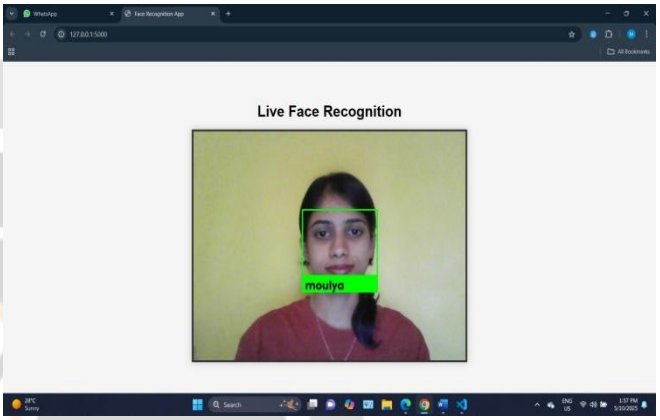

Fig – 7 : Live Facial Recognition System

The AI-RationMitra system effectively combines IoT hardware and AI-powered software to provide a strong, transparent, and user-centric ration dispensing solution. It supports biometric and multilingual voice interaction, secure identification proof, real-time cloud synchronization, and intelligent commodity management, making it suitable for rural and urban deployment. With precise dispensing, dynamic quota verification, and scheme-specific recommendation, the system can transform India's public distribution system (PDS). The real-time admin dashboard equips government agencies with data-driven decision-making and alertness. The innovation is a step towards intelligent governance, better ration delivery, and inclusive public service.

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