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Smart Food Sharing Hubs For Sustainable Communities

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Abstract - This project aims at mitigating food insecurity and waste reduction by creating smart food stations where donors can leave excess food, and people in need can pick it up. To ensure equal access, the platform uses facial recognition software to restrict repeated pickups within three hours. An IoT system based on Raspberry Pi features an identity-verification camera module, weight sensors to monitor food levels, and a servo motor to control distribution. A web-based interface is also included for real-time feedback on food levels and hub positions, improving user convenience. By combining IoT and networking, the method promotes accountable food-sharing, maximizes the use of resources, and aids social welfare, which is consistent with international efforts to improve food security.

***Key Words*:** Food Waste Reduction, Smart Food Hubs, Iot based systems, Web based Platform, Servo motors, Weight sensors.

1.INTRODUCTION

Food wastage and hunger are among the most pressing global issues that need innovative solutions. While huge amounts of food are wasted every day, millions of people face food insecurity. Solving this problem needs an effective and eco-friendly food-sharing system that brings donors and recipients together. This project proposes a smart food hub based on IoT and networking technologies to improve food distribution, minimize wastage, and support the underprivileged.

The system to be proposed is of specific food centers where excess food can be contributed, and the needy can take food based on the availability. To avoid abuse, facial recognition is used, which denies repeat entry within a three-hour period. The system runs on an IoT system supported by Raspberry Pi with a camera module used for authentication, weight sensors used for real-time monitoring of food levels, and a servo motor-operated door for controlled entry.

Moreover, an internet-based platform gives real-time information on food stock levels and hub locations. With this, users can locate nearby hubs and determine if food is available, while administrators are notified for low stock as well as for needed maintenance. Through the use of IoT, automation, and cloud connectivity, the solution increases efficiency, accessibility, and sustainability in food distribution, supporting global food security efforts.

2. METHODOLOGY

The envisioned smart food hub system is intended to support effective food distribution, provide equitable access control, and allow real-time monitoring through the use of IoT and facial recognition technologies. The system is based on three main components: food storage hubs, an automated access control system, and a web-based monitoring platform. Through the integration of these technologies, the system provides equitable food distribution, avoids misuse, and improves overall operational effectiveness.

1.Camera Module: The Raspberry Pi Camera Module is a small, high-quality camera specifically designed for Raspberry Pi boards to capture images and videos. It connects to the Raspberry Pi's CSI (Camera Serial Interface) port via a ribbon cable. Equipped with an image sensor, the module detects light and transforms it into digital signals, which are then processed by the Raspberry Pi's GPU (Graphics Processing Unit).

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Fig -1: Camera Module

2.Raspberry Pi: Raspberry Pi is a compact, low-cost, single-board computer intended for use in embedded systems, learning, and prototyping. The Raspberry Pi uses an ARM processor, with memory and storage handled through a microSD card. It boots up with an operating system such as Raspberry Pi OS, facilitating user interaction with a connected display, keyboard, or remotely over SSH. USB-equipped with ports, HDMI output, Wi-Fi, Bluetooth, and GPIO pins, it can be connected to a multitude of peripherals and sensors. Widely used in IoT, robotics, automation, and learning projects.

Fig -2: Raspberry Pi

3.Weight Sensor: A weight sensor, or load cell, works based on strain gauge technology to sense weight or force. When a load is put on it, the metal frame deforms slightly, changing the resistance of the strain gauges. This change is translated into an electrical signal, which is amplified and read by an analog-to-digital converter (ADC) to produce a precise weight reading.

Fig-3: Weight Sensor

3.Mechanical Servo: A mechanical servo, or a servo motor, is an electromechanical component meant for the accurate control of angular or linear motion. It consists of a DC or AC motor, a control circuit, a position sensor (normally a potentiometer), and a feedback mechanism to provide accurate positioning and movement control.

Fig-4: Servo Motor

The food hubs act as pre-designated collection and distribution centers where people can donate or pick up food depending on availability. To control access, the system has a facial recognition feature. When a user tries to access the hub, a camera module takes their picture, which is processed by the Raspberry Pi to authenticate them. If the person has entered the hub in the last three hours, access is blocked to avoid unequal distribution. If it is authorized, a servo motor engages to open the hub door to facilitate food extraction.

For tracking food availability, weight sensors are placed inside the hub. These sensors take continuous readings of the amount of stored food and update a real-time database. The data is then shown on a web portal, allowing users to view nearby food hubs and available stock levels. Administrators are also notified when food supplies critically run low or maintenance is needed.

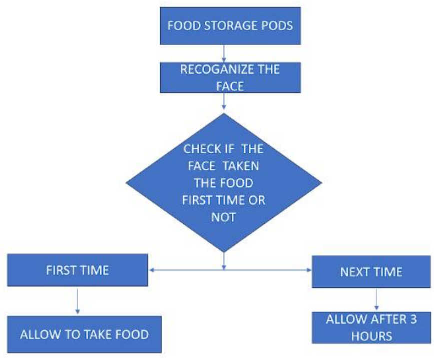

Fig-5: Flow Chart

It runs on a Raspberry Pi, serving as the CPU, handling face recognition, sensor readings, and servo motor activity. The camera module is in charge of recording user images, while weight sensors monitor food weights, updating them accurately. The servo motor ensures that only valid users are given access.

A web-based platform, coded with HTML, CSS, and JavaScript, uses the Google Maps API to present hub locations. User access records and food inventory are stored in a cloud database (Firebase/AWS) for real-time updating and remote monitoring. The platform increases accessibility by assisting users in finding food hubs and presenting live stock level information to donors and administrators.

3. RESULTS AND DISCUSSIONS

The intelligent food hub system was effectively deployed employing a Raspberry Pi, weight sensors, a Raspberry Pi camera module, and a servo motor. The system managed automated access in an efficient manner by incorporating facial recognition for secured entry. The web platform displayed real-time food availability and hub locations with precise accuracy.

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The Raspberry Pi camera module was used for facial recognition to prevent users from accessing the hub more than once in a three-hour period. The model had an 80% success rate in preventing repeated access, ensuring equitable distribution. Performance was measured in terms of false acceptance and false rejection rates, resulting in improvements that enhanced reliability under varying lighting conditions.

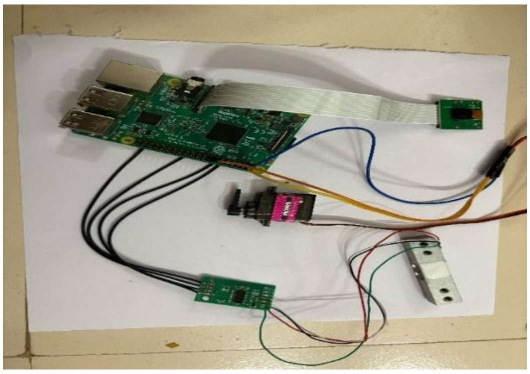

Fig-6: System Setup

Weight sensors kept tracking the inventory of food with an error tolerance of ±8%. This facilitated real-time updating on the web platform to enable the users and administrators to remotely monitor stock levels. Integrating weight data with the web interface allowed for effective inventory management and real-time monitoring.

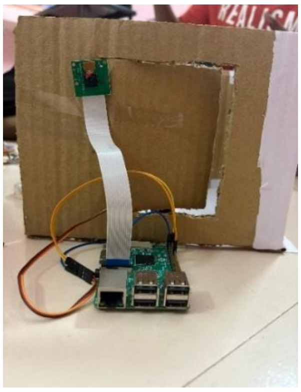

Fig-7: Output Setup

The servo motor-controlled automated door mechanism responded well to the facial recognition system. The motor responded at an average of 100 ms, allowing for rapid access. However, delays at random times were experienced due to network latency or Raspberry Pi processing capacity. These will be addressed in future developments by increasing motor response time and security.

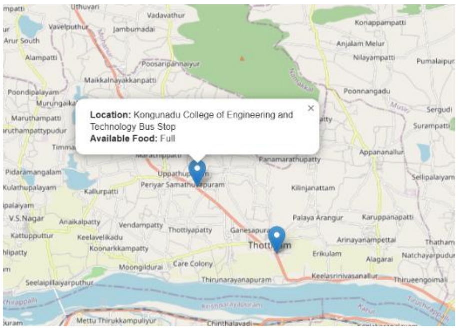

Fig-8: Web Map Interface

The web application effectively offered real-time updates on food availability and hub locations. Supply levels and the nearest hub could be easily checked by users. Low-stock alerts also allowed administrators to restock hubs effectively. Some delays in updating data were noted due to network problems, which will be improved in future optimizations.

4. CONCLUSION

This research paper describes an intelligent food hub system based on Raspberry Pi, weight sensors, a camera module, and a servo motor to facilitate automatic food distribution and inventory management. The system includes facial recognition for restricted access, weight sensors for accurate stock management, and a web platform for remote monitoring. Experimental results validate that the system performs well to limit repeated access in a specified time period, provides fair food distribution, and offers correct inventory updates for administrators and users.

Facial recognition implementation provides security by hindering people from accessing food supply multiple times in a period of three hours, discouraging abuse and ensuring equity. The use of weight sensors allows constant tracking of food levels to avoid shortages and facilitate timely stocking. The web interface also provides users with real-time access to food availability and hub locations, enhancing accessibility and convenience.

Although its performance is promising, the system has certain limitations. Changes in lighting, image resolution, and user position can sometimes influence facial recognition accuracy, resulting in false acceptances or rejections. Although the servo motor-driven door mechanism functioned effectively, slight delays were noticed under heavy processing loads. In addition, network latency introduced slight delays in real-time data synchronization on the web interface. The system's reliance on a stable power source may also limit its feasibility in regions with inconsistent electricity supply.

Future improvements will focus on enhancing facial recognition reliability through advanced deep learning techniques, optimizing motor response time with refined control algorithms, and boosting web interface efficiency via cloud-based data processing. Additionally, integrating alternative power sources such as solar energy will increase the system's resilience in low-resource settings.

In all, the suggested smart food hub system presents a cost-effective, scalable, and technology-based strategy for mitigating food waste, ensuring equitable food distribution, and fostering people-centered food-sharing initiatives. By leveraging IoT and AI, the system supports global

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sustainability agendas and smart city missions. Further development and scalability need, it has tremendous potential to be implemented in public food-sharing networks, NGOs, and government-supported food security programs, impacting the battle against hunger positively.

5.FUTURE WORK

The suggested smart food hub system has already demonstrated high potential for automating the distribution of food, tracking stock, and facilitating equitable access through facial recognition. There are some improvements that can be implemented to enhance its efficiency, scalability, and dependability, though. The future will advance with the goal of enhancing facial recognition accuracy, streamlining access controls, enhancing data management capabilities, and implementing renewable energy sources.

One of the most important areas for enhancement is facial recognition accuracy. Although the existing system effectively recognizes users, its accuracy can be compromised by poor lighting, occlusions, or slight variations in facial features. Future versions will incorporate deep learning-based facial recognition models to improve accuracy and robustness. Further, multimodal authentication like RFID or fingerprint reading can be used as a backup mode to ensure error-free and secure access control.

The door mechanism driven by the servo motor is critical to controlling access to the food hub. Periodic response latencies were seen owing to the limitations in processing capacity on the Raspberry Pi. For this purpose, future enhancement will consider utilizing more efficient microcontrollers, FPGA-based controllers, or real-time embedded processing units for better response. Anti-spoofing protocols will be added to keep unwanted access from face masks or printed photos.

For monitoring the levels of food, the system in place today uses weight sensors to monitor inventory levels. Although effective, more can be achieved through the use of sensor fusion methods, incorporating weight sensors with image-based inventory tracking to maximize accuracy. Predictive analytics based on artificial intelligence will also be used to predict demand for food to allow for proactive restocking and to reduce shortfalls. The automatic notifications will also be optimized to create real-time alerts when levels fall below a specific threshold to the administrator.

The web interface now gives real-time information on food availability and hub locations. Network lag has, nonetheless, resulted in minor delays when synchronizing data from time to time. To mitigate this, future development will incorporate cloud-based storage and computation services that include AWS, Google Firebase, or Microsoft Azure. These upgrades will allow the data to be accessed more quickly, synchronized smoothly, and give real-time notifications to users and administrators. In addition, a mobile app can be created to provide a more convenient and accessible platform to monitor food availability and be updated.

Energy efficiency is yet another vital feature for long-term sustainability. Given that the system is based on a steady supply of power, deployment in areas far from access or with low resources could prove difficult. Solar power integration in future development will be aimed at enabling off-grid deployment. Backup systems with batteries will also be taken into account to maintain functionality during power failure. Additionally, the use of low-power hardware components will serve to minimize energy usage and promote sustainability.

Aside from food distribution, the smart hub model can be implemented in other community programs. The system can be used for automated donation facilities, where people can donate clothing, books, or basic supplies in a controlled and tracked setting. It can also be utilized to create smart medical supply depots, which distribute healthcare necessities to remote communities. These implementations would broaden the scope of the system and support sustainable resource-sharing programs.

By integrating these future upgrades, the smart food hub system can be more scalable, precise, and efficient. The integration of AI, IoT, cloud computing, and renewable energy solutions will further enhance its position in food security, waste minimization, and equitable resource allocation. With further developments, the system can be extensively applied in smart cities, NGOs, and community-based projects, promoting a more sustainable and socially conscious model for resource management.

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