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A Comprehensive AI Driven Framework for Smart Food Management

[1]Prof.Akshata Kumbhare, [2]Sahil Ambulkar, [3]Vishal Sandalwar

[1,2,3] Department of Computer Engineering, SCET, Nagpur, Maharashtra, India

[1]akshatakumbhare26@gmail.com, [2]shambulkar@gmail.com, [3]sandalwarvishal@gmail.com

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ABSTRACT

The problem of Food wastage is becoming an alarming global concern and vast amounts of good edible food are being thrown away while millions in the world are still suffering from hunger. In this paper, we propose a complete implementation of "Food link 360": an Intelligent Food Donation System that utilizes Artificial Intelligence (AI) and Machine Learning (ML) techniques to create an effective system for connecting Food Donors to Food recipients like NGOs, Orphanages, Food banks, and Charity. The proposed system will allow donors to create an account on the system and upload their surplus food with details and images, and also specify a time for food pick up. The AI models used in the system are; an image classification and spoilage detection model (based on ML) that ensure the quality of food donated, and a smart matching algorithm that uses many parameters like the donors' location, type of food, its quantity and also the urgency for the food, the capacity of the recipient, etc., to assign the most eligible food recipient. Additionally, routing algorithms like Dijkstra and A* are employed in the system for optimal delivery paths to ensure minimizing the transit time and the spoilage rate of the food. The ML based models are also used for predicting food demand across the region to make it easier for charities to make the distribution plan. The implementation is completed with an all-in-one centralized dashboard for real-time monitoring of all donations, user activities, and statistics on food wastage reduction.

1. INTRODUCTION

Food waste and food insecurity are serious global Problems. They affect millions of people, even though there is enough food to go around. A large amount of food produced gets lost or wasted during production, distribution, and consumption, while many people still struggle with hunger and malnutrition. This issue shows the need for a smart system that can manage food resources and ensure fair distribution. Traditional food management and donation systems often face challenges. They are limited by manual processes, poor coordination, and ineffective resource allocation. These systems usually depend on basic communication and do not use real-time data, predictive analysis, or intelligent decision-making. As a result, they struggle with timely distribution, food quality, demand-supply mismatch, and logistical problems. Thanks to the rapid growth of Artificial Intelligence (AI) and Machine Learning (ML), there is now an opportunity to improve food management systems. AI technologies can automate food quality checks, predict demand, intelligently connect donors and recipients, and plan deliveries more effectively. By using deep learning models, data analytics, and real-time processing, we can create a smart and scalable system that greatly improves the efficiency and reliability of food redistribution

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2. LITERATURE REVIEW

The rising concern about food waste and poor distribution systems has sparked significant research in smart food management. By integrating artificial intelligence (AI), machine learning (ML), the Internet of Things (IoT), and cloud computing, several new frameworks aim to tackle issues related to managing surplus food, predicting demand, and ensuring efficient

allocation. Early research mainly focused on online and mobile food donation platforms. These platforms connected donors, non-governmental organizations (NGOs), and recipients. They improved accessibility and coordination, but they relied heavily on manual inputs and did not support smart decision-making. As more and more attention was paid to AI and ML, scientists incorporated various forecasting and analytics methods into food management processes. Regression analysis, decision trees, and neural networks are examples of machine learning methods that have been applied to assess past food intake trends and predict future demand for food. This ensures that there is less misbalance between supply and demand in food resources. The role of deep learning algorithms is also significant when considering food quality analysis techniques. CNN and object detection algorithms like YOLO have been extensively used to analyze food images, detect their freshness status, and classify different types of food objects.

Table 1:-Literature Review

Author(s)	Title	Merits	Demerits
Kruthika et al. (2024)	Integrated Approach for Food Donation System Using ML	Combines donation tracking, demand forecasting, and global analysis	Requires robust datasets and real-time deployment for effectiveness
Mathur, M., Srivastava, I., Rai, V. (2021)	Aahar - Food Donation App	Encourages community-driven food donation	Limited scalability and absence of admin-level data tracking
Chapell, B. (2020)	Coronavirus: U.S. Urges Americans to Home-School	Highlights public health communication during crisis	Not directly related to food donation or waste management
Karthikeyan, D., Shah, S., Varde, A., Alo, C. (2020)	Interactive Visualization and App Development for Precipitation Data in Sub-Saharan Africa	Demonstrates data visualization for climate-related insights	Application scope limited to environmental data, not food systems
Oktaviana, R. S., Febriani, D. A., Yoshana, I., Payanta, L. R. (2020)	FoodX: A System to Reduce Food Waste	Implements structured food waste categorization	Requires further validation in diverse geographic regions
Sammer (2024)	AI-FEED: Prototyping an AI-Powered Platform for Food Charity Ecosystem	Combines AI and blockchain for efficient resource allocation	Focused on platform design; real-world deployment not yet reported

3. PROBLEM STATEMENT

Despite the availability of new technologies, food waste and poor food distribution remain significant global problems. Large amounts of edible food are wasted each day in homes, restaurants, supply chains, and events, while many people continue to struggle with food insecurity and malnutrition. This imbalance mainly stems from the lack of a unified system that can manage food resources effectively. Current food management systems are often disjointed and focus on separate tasks such as donation platforms, storage monitoring, or logistics management. These systems generally depend on manual processes or basic digital tools, which do not provide real-time data, predictive features, or smart decision-making. Because of this, they cannot effectively address important issues like mismatched supply and demand, delays in food distribution, poor allocation, and food spoilage during transport. Another major issue is the lack of automated food quality checks. Without proper evaluation methods, there is a risk of distributing unsafe or expired food, which can create health risks and lessen trust in the system. Furthermore, current systems do not effectively use data-driven techniques to forecast food demand, resulting in either excessive waste or not enough supply in certain areas

4. OBJECTIVE

Advanced Food Quality Detection and Classification: The system must accurately detect and classify food items using advanced AI models such as Convolutional Neural Networks (CNNs) or YOLO, ensuring reliable identification of food type and quality (fresh, consumable, or spoiled) in real-time.

Intelligent Demand Prediction using Machine Learning: The system should incorporate predictive models to analyse historical and real-time data for forecasting food demand across different locations, enabling proactive and data-driven food distribution.

Optimized Donor–Recipient Matching and Allocation: The system must implement intelligent allocation mechanisms that consider multiple parameters such as location, quantity, urgency, and demand predictions to ensure efficient and balanced food distribution.

Logistics Optimization and Real-Time Tracking: The system should provide optimized delivery routes using algorithmic approaches and enable real-time tracking of food transportation to reduce delays, minimize losses, and improve operational efficiency.

Scalable and Integrated System Architecture: The system must be designed as a comprehensive and scalable framework integrating AI models, cloud-based data

management, and user interfaces to support large-scale deployment and real-time decision-making.

5. METHODOLOGY

The methodology of the proposed comprehensive smart food management system using AI is an integrated approach using data driven methods, state-of-the-art ML models and system-level optimization techniques. The system is designed as an end-to-end system composed of several modules that are designed to work together in an integrated manner.

Data Collection and Integration: The proposed system collects food and recipient related data from sources like food donors (households, restaurants, parties and events), NGOs and recipients through web based interface and mobile applications. The collected data includes food type, quantity, location, time of availability, images of food etc. Historical data is also collected to assist demand prediction.

Data Preprocessing and Feature Engineering: The data collected is processed including cleansing, normalization, transformation and feature engineering is done to develop the features for the ML models. In order to identify the quality of food and categorize food, the food images are pre-processed (resized, augmentation etc) and then processed by the DL model, while structured data is pre-processed through extraction, and encoding.

Food Quality Detection Using Deep Learning: A Deep learning model, like CNN or YOLO, can be deployed to analyse the images and detect the food quality based on type and freshness. Only the safe to eat food items will be used for allocation.

Food Demand Prediction Using ML Models: Different models based on regression algorithms, time-series analysis and neural networks can be used to forecast food demand in various areas so that the demand and supply can be balanced.

Intelligent Matching and Allocation Mechanism: The developed system utilizes optimization algorithms and AI-based decision-making methods to match the available food from donors with the potential recipients by taking in to account factors like proximity, quantity, demand and urgency of food.

Logistics Optimization and Route Planning: Route optimization algorithms can be deployed to find the most optimal delivery routes between the donors and the recipients. It will help in minimizing time, resources, and transportation cost and making sure the timely delivery of the food to recipients.

6. CLASSIFICATION

System has some components that are as listed below:

Dashboard: - It includes the detailed analysis of the donation and gives us insights into the model .It enables us to track progress of our website.

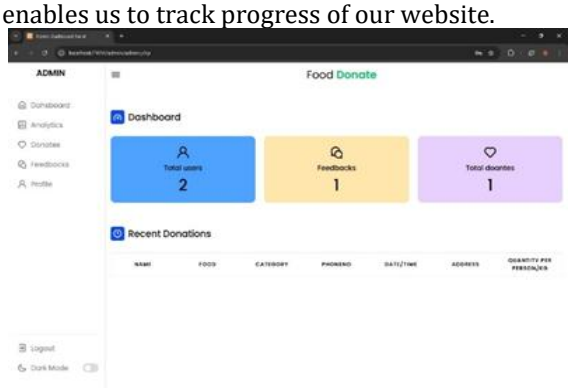

Figure 1: Dashboard

Analytics:-It involves the donation table and demand of the product by analytics bar graph as mentioned below in figure.



Figure 2: Analytics

7. RESULTS AND DISCUSSIONS

Performance Evaluation of the Comprehensive AI-based Smart Food Management System. The overall performance of the integrated AI-powered system for managing food quality assessment and logistics was evaluated based on the efficiency and effectiveness of various integrated components including food quality assessment, predicting demand, allocating orders, and logistics optimization. In order to evaluate the overall efficiency of the comprehensive system, simulated and live inputs were utilized during performance testing

Table 2:-Summary Table

Module Component	Technique Used	Implementation Status	Observed Outcomes
Intelligent Allocation System	Optimization Algorithms, AI-based Decision Models	Fully Implemented	Efficient and balanced distribution based on multiple parameters
Logistics & Route Optimization	Shortest Path Algorithms (Dijkstra/Genetic Algorithm)	Fully Implemented	Reduced delivery time and transportation cost

Real-Time Tracking	GPS Integration, Cloud APIs	Fully Implemented	Enhanced transparency and monitoring of food delivery process
Backend Processing	Flask/Django (Python-based APIs)	Fully Implemented	Fast and reliable processing of requests and AI model integration

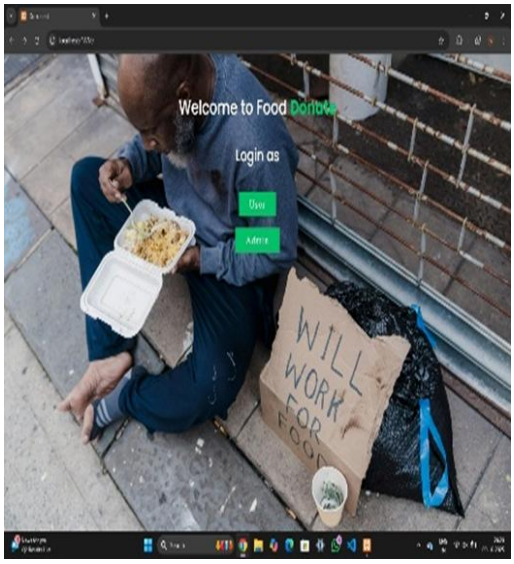

Figure 3: Home Page

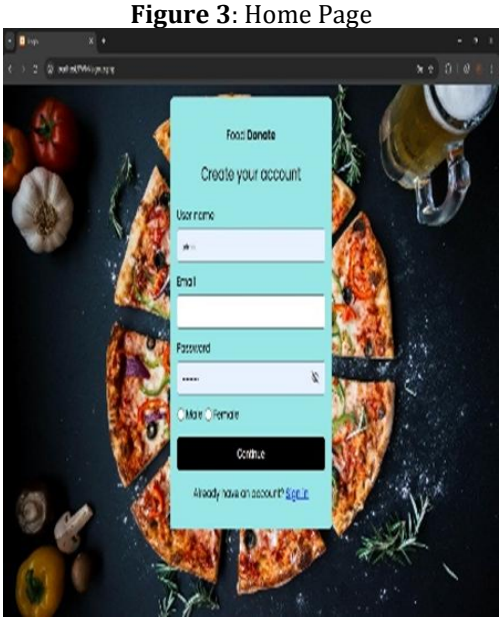

Figure 4: Login Page

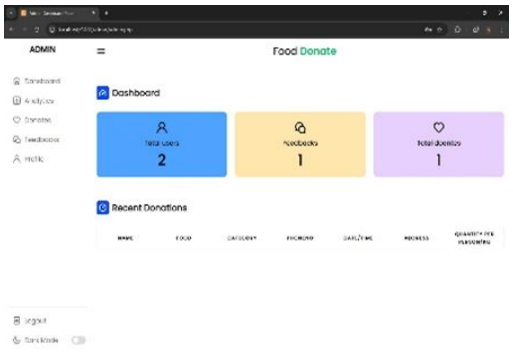

Figure 5: Admin Panel

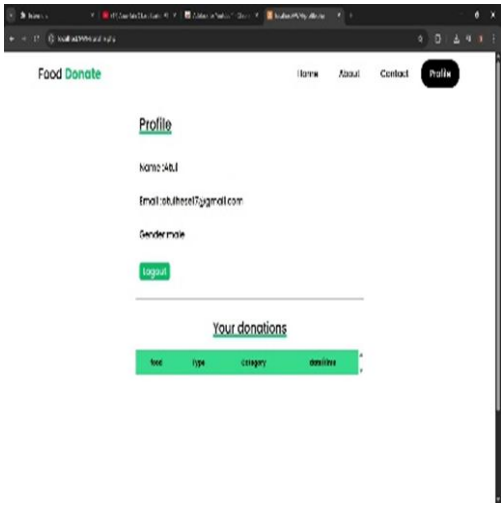

Figure 6: User Profile Page

CONCLUSION

This paper has presented a holistic AI-based framework for a smart food management system designed to tackle two major issues in food: waste and ineffective distribution. The integrated system combines deep learning, for detection of food quality, and machine learning for demand forecasting, a smart allocation system and a logistics optimization model. This combination can provide scalable integration to provide a full solution. A complete application of this system shows how artificial intelligence can be integrated to streamline each stage of the food management system starting from data collection and analysis, to evaluation of food quality and forecast of demand and finally, to food allocation and transportation. Through the use of tracking real-time data and integration through cloud facilities the system ensures transparency, efficiency and proper timing of the distribution of the food resources and enables decision making that reduces the mismatch between supply and demand. The outcome of this whole framework has showed improvements in terms of reductions of food waste, usage of resources, and efficiency in coordination of multiple organizations such as donors, NGOs and recipients. The system offers an end-to-end solution unlike the present systems

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