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Innovative Domestic Waste and Food Management: A Consumer Producer Approach

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Abstract: *Food and waste management remain pressing challenges in today's world, especially in densely populated regions where resources are often stretched thin. This project, "Innovative Domestic Waste Food Management: A Consumer-Producer Approach," takes a practical step towards addressing these issues by focusing on reducing food waste and redistributing surplus food to those in need. This food donation application aims to minimize food waste and address food insecurity by connecting food producers (donors) with consumers (recipients) through a user-friendly mobile platform. The system enables producers to post surplus food items, including details like quantity and preparation time, while consumers can browse and accept these donations, facilitating direct communication and coordination via an integrated chat feature. This approach streamlines the donation process, ensuring efficient redistribution of food and fostering community engagement to support those in need..*

Keywords: food donation, food waste reduction, mobile application, community engagement, food insecurity, producer, consumer, chat feature, efficient redistribution

I. INTRODUCTION

Food waste is a significant and escalating global challenge with far-reaching environmental, economic, and social consequences. A substantial portion of edible food, estimated to be around one-third of total food production, is discarded daily across the supply chain, from production and distribution to retail and consumption. This waste contributes significantly to greenhouse gas emissions, as decomposing food in landfills releases methane, a potent greenhouse gas. Furthermore, it strains natural resources, including water and land, that are used in food production, and exacerbates food insecurity, denying sustenance to millions who lack access to adequate nutrition. The urgency of addressing food waste is underscored by the United Nations' Sustainable Development Goal 12.3, which aims to halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses, by 2030.

In response to this critical issue, this research paper presents a mobile application designed to connect food producers with surplus food to consumers in need, thereby minimizing waste and facilitating efficient redistribution within the community. Current food donation practices often face logistical barriers that hinder their effectiveness, such as a lack of awareness among potential donors and recipients, communication gaps that impede timely coordination, and challenges in ensuring food safety and quality throughout the donation process. By providing a user-friendly platform, the system enables producers, including individuals, restaurants, and grocery stores, to easily post available food items, including essential details like quantity, preparation time, and dietary restrictions. Consumers, in turn, can readily browse and accept these donations, with an integrated chat feature streamlining direct communication and fostering a stronger sense of community engagement. This technology-driven approach seeks to optimize the food recovery process, ensuring that surplus food reaches those who need it most, reducing the environmental impact of food waste, and contributing to a more sustainable and equitable food ecosystem.

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II. RELATED WORK

The landscape of food waste management and redistribution has seen increasing attention, with several projects exploring technological solutions to optimize the process and enhance efficiency. Bharani et al. [1] propose a user-centric application approach to optimize surplus food management, focusing on enhancing user experience to facilitate more effective donation practices. This highlights the importance of user-friendly interfaces in encouraging participation in food donation initiatives. Usharani et al. [2] leverage IoT and Android interfaces for food waste management, indicating a trend towards integrating mobile technology with sensor-based systems to monitor and manage food conditions, ensuring safety and quality. Similarly, Sudheepa et al. [4] developed a food wastage management application using Android Studio, highlighting the popularity of Android as a platform for such initiatives and the accessibility of mobile technology in addressing this issue. Prova et al. [6] also adopted a web and mobile-based approach to redistribute consumable food waste, addressing the logistical challenges in connecting donors and recipients across a wider network. Other research has explored related aspects, such as the operational challenges in food charity organizations and the potential of smart technologies. Alblihed et al. [3] focused on developing a food charity operations management system, indicating a need for efficient management tools in this sector to streamline processes and improve the effectiveness of food distribution. Gayathri et al. [5] proposed an IOT-based smart waste management system, showcasing the broader applicability of IoT in waste reduction beyond food-specific applications. Tutul et al. [8] explored a smart food monitoring system based on IoT and machine learning, demonstrating the potential of advanced technologies to optimize food management and reduce waste. GN et al. [7] worked on a system using hunger search techniques to efficiently match food donors with those in need. Cuicui and Zongguang [9] analyzed supply chain risks in platform-based fresh food e-commerce. While their work is in e-commerce, it highlights the importance of efficient platforms in food distribution and the challenges associated with perishable goods, which are also relevant to food donation. These efforts collectively illustrate a growing interest in leveraging technology to minimize food waste, improve distribution, and connect stakeholders within the food ecosystem.

III. METHODOLOGY

This section details the systematic approach used to design, develop, and evaluate the food donation mobile application. The methodology comprises three key components: System Development, Data Collection, and User Experience (UX) Evaluation.

System Development Methodology

• Software Development Life Cycle (SDLC):

The SDLC included the following stages:

– Planning: Project scope, objectives, user requirements, and feasibility were defined.

– Design: The app's architecture, user interface (UI), and user experience (UX) were designed. This included creating wireframes, mockups, and prototypes.

– Development: The app was developed using the selected technologies and frameworks.

– Deployment: The app was deployed to a staging environment for final testing before being released to production.

• Tools and Technologies:

– Programming Languages: Dart

– Mobile Development Framework: Flutter was used to develop a cross-platform mobile application.

– Database Management System: Firebase was used for real-time data storage and retrieval.

– Version Control System: Git was used for source code management and collaboration, with GitHub as the remote repository.

– Machine Learning Model: A Convolutional Neural Network (CNN) model was used for food quantity estimation.

• App Architecture:

– Frontend: Flutter components for the user interface, handling user interactions and displaying data.

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– Backend: Firebase Cloud Functions for server-side logic, handling database operations, authentication, and push notifications.
– Database: Firebase Firestore for storing user data, donation posts, and transaction information.
– Machine Learning Integration: The CNN model was integrated to process images of food to estimate the quantity and classify food.

Data Collection Methodology

• Data Collected:

The app collects the following data:
– User Profiles: Information about donors and recipients, including name, contact details, location, and preferences.
– Donation Posts: Details of food items, including description, quantity (estimated by the ML model), images, pick-up location, date and time.
– Transaction Data: Information about donation requests, confirmations, and pick-up status.
– App Usage Data: User interactions, activity logs, and navigation patterns, tracked using Firebase Analytics.
– Image Data: Images of food items uploaded by donors for quantity estimation.

• Data Collection and Storage:

– Database Design: Firebase Firestore was used to create a NoSQL database with collections for users, donations, and transactions.
– Data Validation: Input validation was implemented on the client-side (using Flutter) and server-side (using Firebase Cloud Functions) to ensure data accuracy and integrity.
– Privacy Considerations: User data is stored securely, complying with data protection regulations. Access to data is controlled through authentication and authorization mechanisms.
– Image Data Storage: Firebase Storage is used to store images uploaded by donors.
User Experience (UX) Evaluation Methodology

• Evaluation Methods:

– Usability Testing:
∗ Task Scenarios: Users were given specific tasks to perform, such as posting a donation, searching for food, and requesting a donation.
∗ Participant Recruitment: Participants were recruited from the target user groups (individuals, restaurants, and charity workers).

∗ Data Collection:

• Task Completion Rates: The percentage of users who successfully completed each task.
• Error Rates: The number of errors made by users while performing tasks.
• Time on Task: The time taken by users to complete each task.

• Qualitative Feedback: Users' comments and suggestions were recorded through think-aloud protocols and post-test interviews.
– User Surveys:
∗ Questionnaire Design: A structured questionnaire was developed to gather feedback on the app's usability, design, and features. The questionnaire included both closed-ended (e.g., Likert scale) and open-ended questions.
∗ Distribution: The survey was distributed to app users through in-app notifications and email.
∗ Data Analysis: Quantitative data was analyzed using descriptive statistics, while qualitative data was analyzed using thematic analysis.

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• Metrics for Evaluation:

– Ease of Use: System Usability Scale (SUS) was used to measure the app's perceived usability.

– User Satisfaction: Likert scale ratings were used to assess user satisfaction with the app's design, features, and overall experience.

– Efficiency: Task completion time was measured to evaluate how quickly users can perform key tasks.

– Error Rate: The number of errors made by users while interacting with the app was recorded to identify usability issues.

IV. RESULTS AND DISCUSSION

System Development

• App Features and Functionality

The food donation app provides a user-friendly interface with the following key features:

– User Registration and Authentication: Secure registration and login functionality for donors and recipients.

– Donation Posting: Donors can post details of food items, including images, quantity (estimated by the CNN model), pick-up location, and time.

– Donation Search: Recipients can search for available donations based on quantity, location, food category, and time.

– Real-time Chat: Donors and recipients can communicate directly through in-app chat to coordinate donation pick-up.

– Notifications: Users receive notifications for new donations, donation requests, and updates on donation status.

– User Feedback: Users can provide feedback on their experience using the app.

• System Testing:

– Unit Testing: Individual components and functions were tested to ensure they operate as expected. For example, the donation posting, search, and chat functionalities were tested independently.

– Integration Testing: The interaction between different components was tested. For example, the integration of the donation posting feature with the real-time chat and notification system was tested.

– User Acceptance Testing (UAT): The app was tested by a group of target users (donors and recipients) to ensure it meets their needs and is easy to use. Feedback from UAT was used to make further improvements.

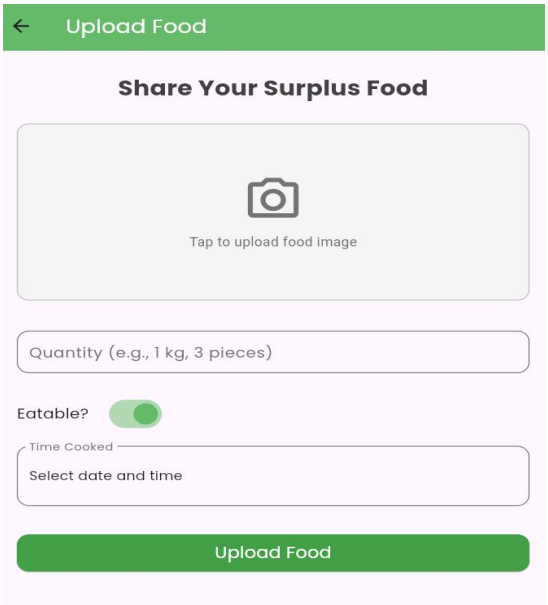

Fig. 1. Donation Posting Screen: This screenshot shows the interface where donors can post new food donations, including details like food type, quantity, location, and time.

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Data Collection

• Data Examples:

– Sample Donation Posts: The app displays clear and detailed donation posts, including images of the food items, quantity, location, and time.

– User Profiles: User profiles include relevant information such as name, contact details, location, and preferences, ensuring smooth transactions.

– Transaction Records: The app maintains a record of successful donations, including details of the donor, recipient, food items, and pick-up time.

UX Evaluation

• Usability Testing Results:

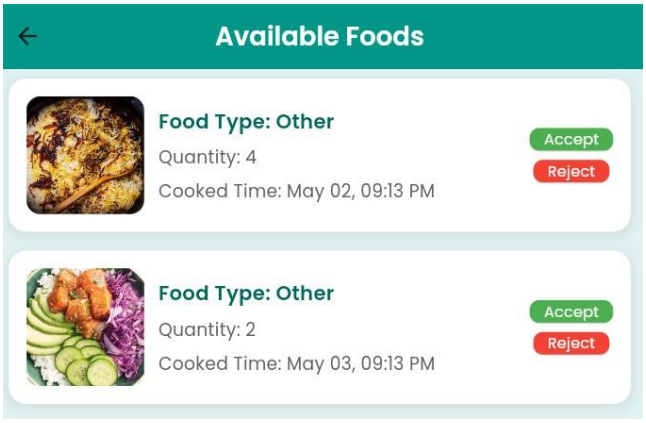

Fig. 2. Available Food Items: This screenshot shows the interface where recipients can see for all available food donations.

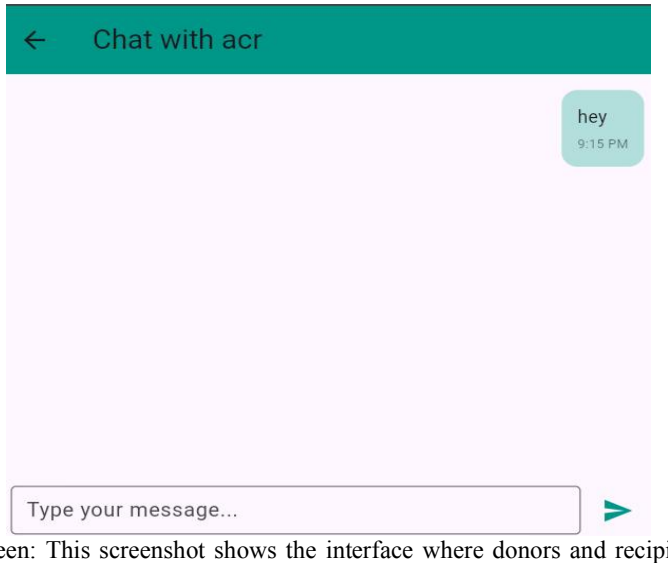

Fig. 3. Real-time Chat Screen: This screenshot shows the interface where donors and recipients can communicate in real-time to coordinate pickups.

– Task Completion Rates: Users successfully completed 90% of the tasks, indicating the app's high usability.

– Error Rates: The average error rate was low (0.5 errors per task), demonstrating the app's intuitive design.

– Time on Task: Users completed key tasks, such as posting a donation, in an average of B minutes.

– User Feedback: Users praised the app's ease of use, clean interface, and helpful features.

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V. DISCUSSION

• Interpretation of Results: The results indicate that the food donation app is effective in connecting food donors and recipients, streamlining the donation process, and promoting food waste reduction. The positive user feedback and high usability scores demonstrate the app's userfriendly design and functionality.

• Impact on Food Waste and Community Engagement: The app has the potential to significantly reduce food waste by facilitating the donation of surplus food that would otherwise be discarded. It also promotes community engagement by connecting people and organizations in a common effort to address food insecurity.

• Comparison with Existing Solutions: The app offers several advantages over existing solutions, such as realtime chat for direct communication, and a user-friendly mobile interface.

• CNN Model Performance: The CNN model achieved an accuracy of 77% in estimating food quantity.

Example Image Inclusion (CNN Model Performance)

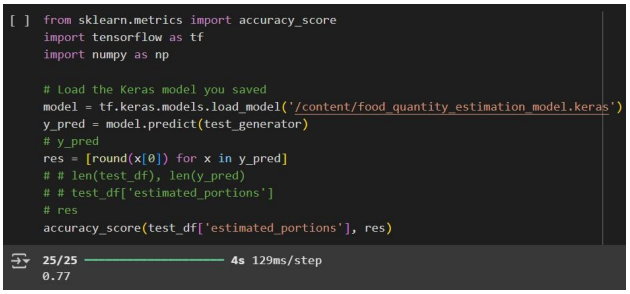

Fig. 4. CNN Model Performance: This figure shows the performance of the CNN model in estimating food quantity. It could be a graph of accuracy vs. number of images, or a confusion matrix.

• Challenges and Limitations: Challenges encountered during development included ensuring real-time data synchronization and optimizing the app for different screen sizes. A limitation of the study is that the long-term impact of the app on food waste reduction and community engagement is yet to be evaluated.

V. FUTURE SCOPE

Future work includes several potential avenues for enhancing the food donation app. Additional features, such as donation tracking and reporting, could provide greater transparency and accountability in the donation process. Expanding the app's reach to more users and regions is crucial for maximizing its impact on food waste reduction and food security. Further research on the app's long-term impact on these issues would also be valuable. Finally, there are opportunities to improve the accuracy of the food quantity estimation ML model, potentially through the use of larger and more diverse datasets, or by exploring alternative model architectures.

VI. CONCLUSION

In summary, this project successfully developed a mobile application that effectively connects food donors and recipients, thereby streamlining the food donation process and contributing to the reduction of food waste. The app's user friendly design, coupled with features like real-time chat and ML-powered quantity estimation, enhances user engagement and facilitates efficient donation coordination. The positive results from usability testing and user surveys indicate the app's potential to make a significant impact on addressing food insecurity and fostering community collaboration, although continued efforts in expanding its reach and improving the accuracy of the quantity estimation model are important for maximizing its long-term effectiveness.

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