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TRANSFORMING WELL-BEING: IMAGE-DIRECTED MEAL CHOICES WITH TEXT-TO-SPEECH INTEGRATION

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Abstract—**The research aims to enhance the home cooking experience through a sophisticated recipe recommendation system. Prompted by the increased trend towards home-cooked meals during the COVID-19 pandemic, this research addresses the lack of effective and healthy recipe platforms. By utilizing Convolutional Neural Networks (CNNs) with the MobileNetV2 model, the system accurately identifies ingredients from user-provided pictures, eliminating the requirement for manual ingredient filling and ensuring precise recipe suggestions. The integration of text-to-speech technology provides hands-free recipe instructions, particularly benefiting users with visual impairments and enhancing overall accessibility. The project involves curating an in-depth collection of ingredient photos and healthy recipes, integrating TTS for directions, and developing a user-friendly mobile app using Flutter**

Index Terms—**Convolutional Neural Networks (CNNs), Flutter, MobileNetV2, Text-to-speech.**

I. INTRODUCTION

The COVID-19 pandemic has resulted in a substantial lifestyle change, especially in eating habits, as more people are considering preparing their food at home. This change has brought to light the shortcomings of current recipe platforms, which frequently fall short of providing users with effective and precise recipe recommendations based on the ingredients they own priorly. Meal cooking can become less efficient and hectic due to the laborious and tedious process.

This paper presents an innovative solution to address these issues: a recipe suggester system powered by advanced image recognition and Text-to-Speech (TTS) technologies. By employing the Convolutional Neural Networks (CNNs) and the MobileNetV2 model, the system can identify ingredients from user-submitted images, thereby reducing the requirement for manual entry. Additionally, it provides hands-free, audio based recipe instructions, making the cooking process more accessible and convenient, especially for users with visual impairment.

The development of this system is fueled by the need to simplify meal planning and enhance the home cooking experience. It aims to promote nutritional and healthy eating habits by making it easier for users to find suitable recipes using the ingredients they currently have on hand. This paper outlines the methodology, design, and implementation of the system, providing a comprehensive overview of its potential to revolutionize home cooking.

A. Objective

The research study aims to provide a list of recipes that relate to ingredients identified from user-provided images. The objectives are to gather and sort datasets for ingredient pictures and healthy recipes, incorporate TTS conversion functionalities for recipe instructions and develop a mobile app to put into practice the proposed system.

B. Scope

The "RecoRec: A Recipe Suggester" system encompasses the development of an innovative mobile application that lever ages machine learning to enhance the culinary experience for users. This involves the collection and filtering of a comprehensive dataset of images of ingredients

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and nutritious recipes, ensuring diversity and accuracy for effective model training. Some of the ingredient images are illustrated in "Fig. 1". The study also includes the incorporation of TTS features to provide accessible, auditory recipe instructions, thereby improving usability for people with visual inconveniences and those who prefer voiceover guidance. Additionally, the scope includes the usage of the Flutter framework to design and develop a user-friendly, responsive mobile application. This application will enable users to identify ingredients through image recognition and receive personalized recipe recommendations, promoting healthier eating habits and making the cooking process more enjoyable and accessible.

Fig. 1. Sample Ingredients (Tomato, Onion, Millet, Green Gram)

II. RELATED WORKS

The development of culinary recommendation systems has been an area of significant research interest, with various approaches explored to enhance accuracy and user experience.

Seda Kul et al. [5] leveraged Java, Jsoup, and RabbitMQ for dataset creation and employed TensorFlow Lite for material classification, enabling efficient recipe retrieval by matching ingredient lists to APIs. Gim et al. [6] extended the Reciptor system to include 507,834 recipes from Recipe1M, enhanced by 630 cooking tags, directions, and ingredients, utilizing Tf Idf scores for target ingredient selection.

Anitha et al. [7] utilized a Kaggle dataset with 15,000 images, enhancing input image quality through preprocessing modules in TensorFlow. They also integrated a TTS module using Google TTS API, providing audible recipe instructions. Mingsheng Fu et al. [1] introduced a collaborative filtering model based on deep reinforcement learning, installation of multiview neural networks and pre-trained representations to improve recommendation accuracy and personalize user experiences.

Vivek, M.B. et al. [2] investigated user- and item-based recommendation strategies using Pearson Correlation, Tanimoto Coefficient, Euclidean Distance, and Log-Likelihood Similarity, along with evaluation metrics like RMSE, AAD, and Recall on a range of datasets. To increase the system's resilience, Ilya Shchuka et al. [4] gathered 40,000 recipes via ChefNet, used scale augmentation, and showed deep learning frameworks for ingredient retrieval. Bushra et al. [3] broke down ingredient components and converted them to lowercase during preprocessing to enable precise recipe identification from images using the Recipe 1M dataset as training data for an artificial neural network.

The progress in culinary recommendation systems is demonstrated by these studies as a whole, with special attention to the incorporation of preprocessing methods, machine learning models, and user-focused features like TTS. Nevertheless, there is still a lack of attention to detail when it comes to catering to particular cultural contexts, like Indian food, and utilizing cutting-edge technologies like thorough TTS integration to improve user experience. By adapting suggestions to Indian recipes, utilizing TTS for accessibility, and encouraging health-conscious food choices while taking local ingredient availability into account, this study seeks to close these disparities.

III. METHODOLOGY

To develop any software system successfully, the design and implementation phases are essential. These phases encompass the detailed planning, architectural decisions, and actual coding required to bring the study to fruition as shown in "Fig. 2". For this study, which involves creating a recipe recommendation system with integrated TTS technology, the design and implementation processes are intertwined to ensure that each design decision is effectively realized in the final product.

A. Dataset Preparation

To compile a solid and varied dataset that is necessary for teaching the machine learning model, the design phase starts with a thorough data-gathering effort. This dataset consists of a sizable number of ingredient photos that were clicked in several lighting and environmental settings to replicate actual situations. This guarantees that the model will correctly identify ingredients even in cases where users of the mobile app encounter disparities in image quality. Additionally, a dataset of healthful recipes was compiled, primarily sourced from homemakers familiar with traditional cooking practices. This grassroots approach ensured the inclusion of culturally relevant and health-focused recipes.

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B. Preprocessing
Data preprocessing was a critical step, involving error correction, standardization of ingredient names, and organization for database storage. The recipes were initially provided in the Kannada language and translated into standard English using both automated tools and manual verification to maintain authenticity and cultural nuances. Each recipe was tagged with relevant metadata such as primary ingredients, preparation time, and serving capacity to facilitate efficient querying and fetching by the recommendation engine.

C. Model Configuration
The core component of the system is the MobileNetV2 model, selected for its balance between accuracy and efficiency, making it suitable for mobile deployment. The model was trained on a dataset of over 5000 images spanning 24 classes of ingredients. Data augmentation functionality, including random crops and horizontal flips, was employed during training to enhance the model's generalization capabilities.
The MobileNetV2 model was optimized using TensorFlow Lite to ensure it remained lightweight and efficient for real time processing on mobile devices. This optimization was crucial for maintaining the application's performance without compromising on battery life or computational resources.

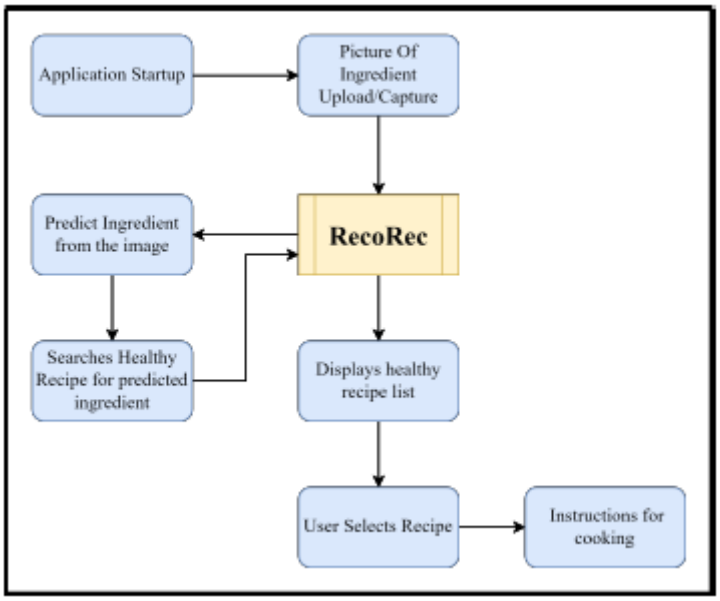

Fig. 2. RecoRec Recipe Recommendation System

D. Mobile Interface
Frontend designing focused on developing an intuitive and user-friendly interface using the Flutter framework. Flutter was chosen for its high outcome on Android platforms and its capability to create expressive and interactive user interfaces. TTS integration was incorporated to enhance accessibility, allowing users, especially those with visual impairments, to receive auditory instructions for recipes, improving the overall user experience.

E. Evaluation
Testing involved conducting thorough assessments to ensure the accuracy of ingredient recognition, the relevance of recipe recommendations, and the smooth functioning of the TTS feature, using both automated tests and user feedback to identify and resolve any issues.

IV. RESULT AND DISCUSSION

The proposed machine learning model was successfully implemented and evaluated using the testing dataset. The model achieved an accuracy of 92%, outperforming. Additionally, a mobile application was designed to provide an intuitive user interface for real-time predictions. Screenshot samples of the Flutter mobile application, as shown in "Fig. 3" and "Fig. 4", demonstrate a user-friendly layout that allows users to input data easily and view results instantaneously. This seamless integration between the model and the application ensures accessibility and practical usability for end-users.
The results and discussion sections highlight the effectiveness and performance of the proposed system in revolutionizing healthy cooking. The model achieved an impressive overall accuracy of 90.28%, with an F1 score of 0.876. The model's accuracy in categorizing ingredients is

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validated by the high F1 score, which displays a composed performance between precision and recall across multiple ingredient categories. Furthermore, the per-class accuracy graph "Fig. 5" demonstrates near-perfect accuracy for most ingredient classes, often reaching 100%, with few exclusions that showed slightly lower accuracy. The confusion matrix shows where the model needs to be improved and highlights its strong performance by giving more information about the mix of correct and incorrect predictions made for each class.

The discussion underscores the successful incorporation of the TTS feature, enhancing accessibility for users with optical impairment and meeting the goals of the study. The RecoRec mobile application, leveraging the MobileNetV2 model and a user-friendly Flutter interface, achieved real-time ingredient recognition and recipe recommendations, directly addressing the objectives of the study. The system's performance, validated by high accuracy metrics and a seamless user experience, confirms its effectiveness in promoting healthier eating practices.

V. CONCLUSION

This research has successfully developed a cutting-edge recipe suggestion system that leverages advanced image classification and TTS technologies to enhance the home cooking experience. By utilizing CNN and the MobileNetV2 model, the system effectively identifies ingredients from user uploaded images, getting rid of the requirement for manual input. The integration of TTS technology provides hands-free, audio-based recipe instructions, improving accessibility for optically hampered users and enhancing overall user convenience. The system's performance, validated through rigorous testing and high accuracy metrics, confirms its potential to revolutionize healthy cooking practices. The mobile application, developed using the Flutter framework, offers a user-friendly interface that supports real-time ingredient recognition and recipe recommendations. By addressing the shortcomings of existing recipe platforms and promoting healthier eating habits, this research has achieved its objectives and demon strated the significant potential of combining machine learning and TTS technologies in culinary applications. Future work could explore the expansion of the ingredient and recipe database to include a broader range of cuisines and dietary preferences. Additionally, incorporating feedback mechanisms to refine recipe suggestions based on user preferences and experiences could further enhance the system's effectiveness and user satisfaction.

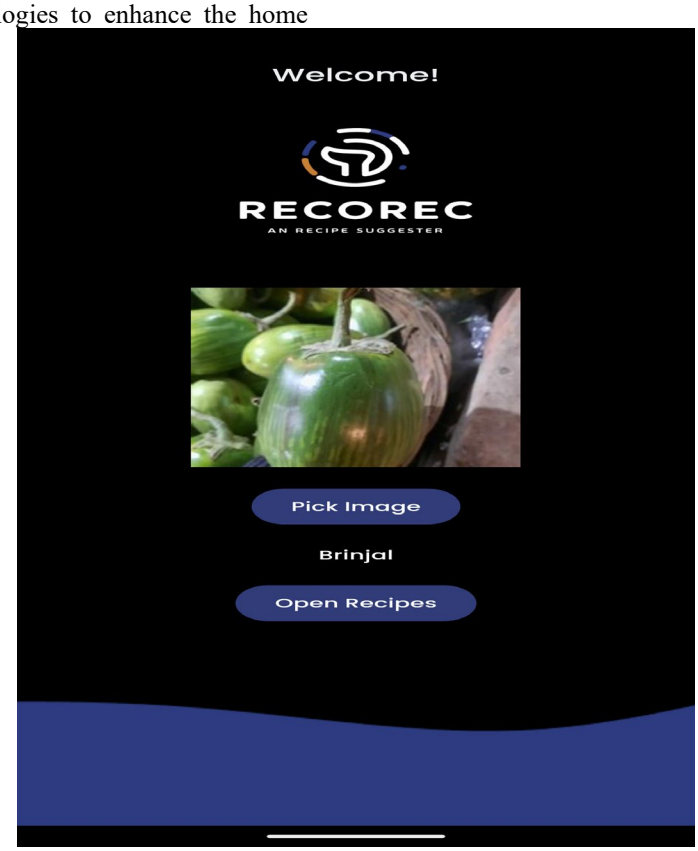

Fig. 3. Image Input User Interface RecoRec

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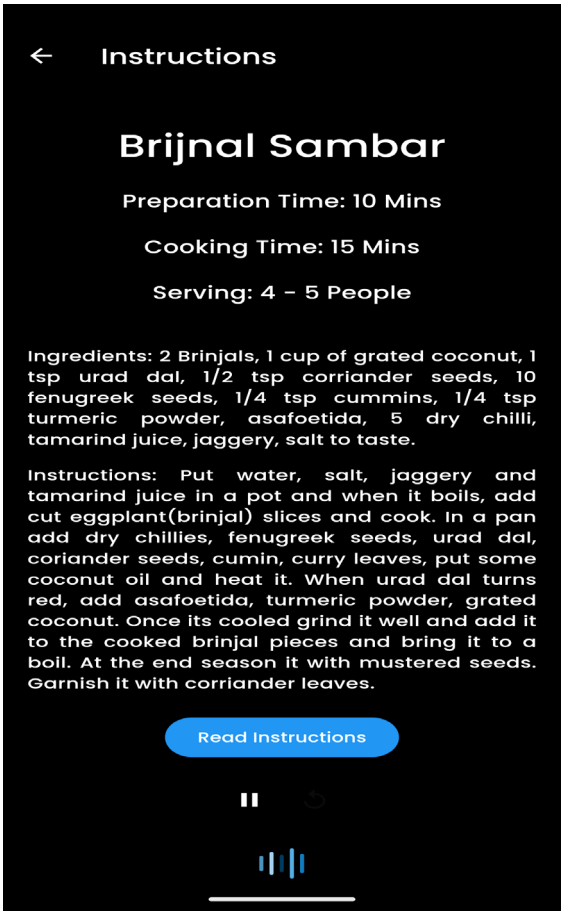

Fig. 4. Recipe Instructions and Text-to-Speech RecoRec

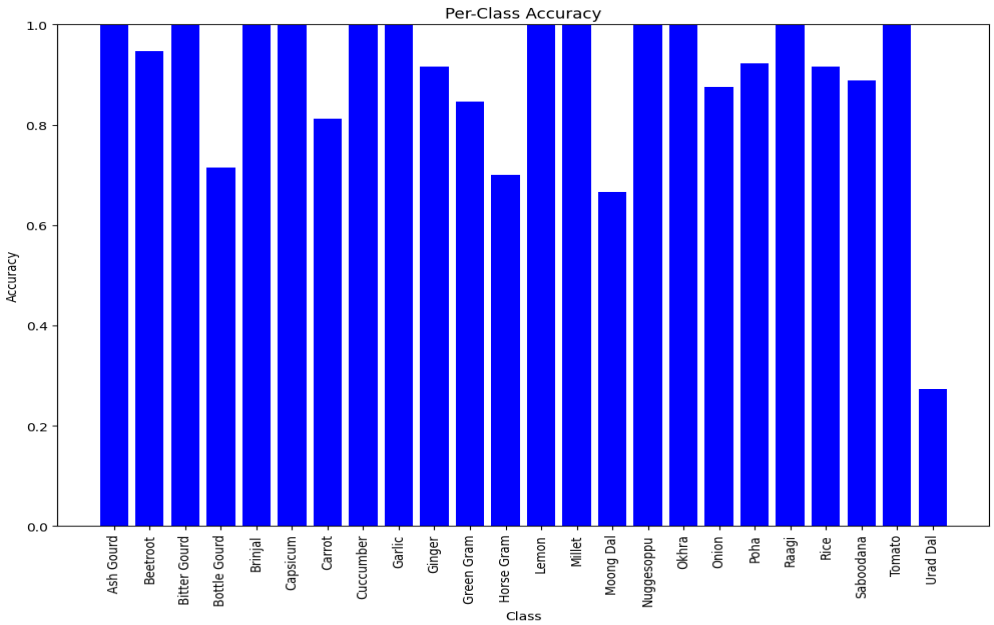

Fig. 5. Model Performance for Selected Ingredients

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