Food Recognition and Nutrition Estimation using CNN Model

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***Abstract*—In today's digital age, the overwhelming abundance of online recipes presents a challenge in finding meals that suit individual tastes and dietary needs. To address this, the Food Recognition and Nutrition Estimation platform uses advanced technologies like CNNs to deliver personalized, visually-driven recipe recommendations that simplify meal planning and enhance culinary exploration.**

The objective of the Food Recognition and Nutrition Estimation project is to develop an intelligent platform that enhances how users discover and plan meals through personalized recipe recommendations. By utilizing Convolutional Neural Networks alongside traditional filtering methods, the system analyzes both images and text to deliver accurate, visually appealing, and tailored culinary suggestions.

The methodology of this project centers on the use of Convolutional Neural Networks (CNNs) for automated food classification, enabling the system to extract and interpret complex visual features from raw images. By leveraging convolutional, pooling, and fully connected layers, the CNN model effectively identifies various food types, enhancing applications such as nutritional analysis, diet tracking, and personalized recipe recommendations. Custom Dataset is used that is extracted from Internet Resources.

This code builds a food image classification model using transfer learning with MobileNetV2, leveraging a balanced dataset and Keras' ImageDataGenerator for efficient training, validation, and testing. It evaluates performance using a confusion matrix and classification report, then saves the final trained model as final_cnn.h5.

Future developments of the Recipe Recommendation System will focus on enhancing image recognition, integrating multi-modal data analysis, and incorporating dynamic user feedback to improve personalization and accuracy. Additional advancements will include culturally aware suggestions, ingredient substitutions, smart appliance integration, and community-driven features to create a more diverse, accessible, and engaging culinary platform.

Keywords—CNN, Image Recognition, Nutrients.

I. INTRODUCTION

In the contemporary digital landscape, the abundance of online recipe content presents both opportunities and challenges for culinary enthusiasts. While the internet offers a vast repository of culinary inspiration, navigating through countless recipes to find dishes that align with individual tastes, dietary preferences, and ingredient availability can be daunting. Traditional recommendation systems often fall short in providing personalized and relevant recipe suggestions, lacking the ability to capture the nuanced characteristics of recipes, such as visual appeal and ingredient combinations. To address these challenges, we introduce the Food Recognition and Nutrition Estimation, a novel platform designed to revolutionize recipe discovery and meal planning. Leveraging state-of-the-art technologies such as Convolutional Neural Networks (CNNs) alongside traditional recommendation methodologies, our system aims to provide users with intuitive, personalized, and visually engaging recipe recommendations. By analyzing both image and text data associated with recipes, the system extracts meaningful features to enhance recommendation accuracy. Through a user-friendly interface, users can input their preferences, explore diverse recipe options, and receive tailored suggestions that cater to their culinary needs. This introduction sets the stage for the Food Recognition and Nutrition Estimation, highlighting the significance of personalized recipe recommendations in simplifying the meal planning process and inspiring culinary exploration. Throughout this project, we will delve into the development, implementation, and evaluation of the system, aiming to empower users to discover, explore, and enjoy a wide variety of culinary delights tailored to their tastes and preferences. Convolutional Neural Networks (CNNs) play a vital role in automated food classification by effectively learning and recognizing diverse visual features from recipe images, aiding tasks like nutritional analysis and diet tracking. Through layered processing—including convolutional, pooling, and fully connected layers—CNNs extract and interpret complex patterns, enabling accurate food recognition and enhancing applications in health monitoring and culinary assistance.

II. RELATED WORK

The Food Recognition and Nutrition Estimation is driven by the need to simplify recipe discovery and meal planning in today's digital age. With an abundance of online recipe content, users often struggle to find dishes that match their preferences, dietary needs, and ingredient availability.

Traditional recommendation systems fall short in capturing the nuanced aspects of recipes, such as visual appeal and ingredient combinations. By integrating Convolutional Neural Networks (CNNs) with conventional techniques, our system aims to address these challenges. CNNs analyze both image and text data, allowing for a comprehensive understanding of recipe content. This approach enables the system to recommend visually appealing dishes and recognize key ingredients and cooking techniques. Ultimately, our goal is to empower users to explore new culinary horizons, discover diverse recipes, and simplify their cooking experience in a digital world.

Traditional recipe recommendation methods typically rely on collaborative filtering and content-based filtering techniques. Collaborative filtering analyzes user interactions and preferences to generate recommendations based on similarities between users or items. Content-based filtering, on the other hand, recommends items similar to those previously liked by the user, focusing on item attributes such as ingredients, cuisine type, or cooking methods.

Literature Survey

[1] Seda Kul & Ahmet Sayar , “A Smart Recipe Recommendation System Based on Image Processing and Deep Learning”, Kocaeli University, Baki Komsuoğlu bulvarı No:515, Umuttepe, 41001, Kocaeli, Turkey, 2021.

While technology facilitates our lives, it also allows us to lead a quality, efficient energy and to do more productive work in less time. One of our basic needs that takes our time is to eat. One of the problems people face is, ‘‘What can I cook today?’’ It is the question. The Smart Recipe Suggestion System (SRSS) is a system that can make food recommendations to the person with the materials available. This system is designed as a mobile application, including the deep learning method, to answer people’s questions during the day. This paper proposes an approach that recognizes the person’s materials with image processing technology and presents the most suitable meal suggestions to be made with those materials. Recipes are collected from web sites through RabbitMQ. Food items are captured from images by using object detection processes through deep learning. Available food items are modeled as NoSQL and stored to MongoDB document based databases. For the real-world application Firebase mobile cloud platform is used.

The scope of the Food Recognition and Nutrition Estimation project encompasses several crucial aspects aimed at developing an efficient and user-centric platform.

[2] M. Gim, D. Park, M. Spranger, K. Maruyama and J. Kang, "RecipeBowl: A Cooking Recommender for Ingredients and Recipes Using Set Transformer," in IEEE Access, vol. 9, pp. 143623-143633, 2021.

Countless possibilities of recipe combinations challenge us to determine which additional ingredient goes well with others. In this work, we propose RecipeBowl which is a cooking recommendation system that takes a set of ingredients and cooking tags as input and suggests possible ingredient and recipe choices. We formulate a recipe completion task to train RecipeBowl on our constructed dataset where the model predicts a target ingredient previously eliminated from the original recipe. The RecipeBowl consists of a set encoder
and a 2-way decoder for prediction. For the set encoder, we utilize the Set Transformer that builds meaningful set representations. Overall, our model builds a set representation of an leave-one-out recipe and maps it to the ingredient and recipe embedding space. Experimental results demonstrate the effectiveness of our approach. Furthermore, analysis on model predictions and interpretations show interesting insights related to cooking knowledge.

This includes collecting and preprocessing a diverse dataset of recipe images and text descriptions to ensure data quality.

[3] Devis Bianchini, Valeria De Antonellis, Nicola De Franceschi, Michele Melchiori, “PREFer: A prescription-based food recommender system” University of Brescia, Department of Information Engineering, via Branze 38, 25123 Brescia, Italy, 2017.

In the literature, several researches on food recommendation and automatic menu generation have been proposed, taking into account different aspects, such as personal and cultural preferences, health and religion constraints, menu composition and recipe co-occurrence. However, recommending recipes and menus, which not only meet the user's preferences, but are also compliant with best food habits, is still an open issue. This paper presents the PREFer food recommender system, apt to provide users with personalized and healthy menus, taking into account both user's short/long-term preferences and medical prescriptions.

The project involves designing and training Convolutional Neural Network models to extract relevant features from recipe images and text, thereby facilitating accurate recommendations.

[4] W. Min, S. Jiang and R. Jain, "Food Recommendation: Framework, Existing Solutions, and Challenges," in IEEE Transactions on Multimedia, vol. 22, no. 10, pp. 2659-2671, Oct. 2020.

A growing proportion of the global population is becoming overweight or obese, leading to various diseases (e.g., diabetes, ischemic heart disease and even cancer) due to unhealthy eating patterns, such as increased intake of food with high energy and high fat. Food
recommendation is of paramount importance to alleviate this problem. Unfortunately, modern multimedia research has enhanced the performance and experience of multimedia recommendation in many fields such as movies and POI, yet largely lags in the food domain.
This article proposes a unified framework for food recommendation, and identifies main issues affecting food recommendation including incorporating various context and domain knowledge, building the personal model, and analyzing unique food characteristics. We then

review existing solutions for these issues, and finally elaborate research challenges and future directions in this field. To our knowledge, this is the first survey that targets the study of food recommendation in the multimedia field and offers a collection of research studies and technologies to benefit researchers in this field.

Integration with traditional recommendation techniques like collaborative filtering and content-based filtering expands the system's capability to provide personalized recipe suggestions.

[5] Mayumi Ueda, Mari Takahata, and Shinsuke Nakajima, “User’s Food Preference Extraction for Personalized Cooking Recipe Recommendation” Kyoto University Yoshida Nihonmatsu-cho, Sakyo-ku, Kyoto, Kyoto 606–8501, Japan, 2018.

There are many websites and researches that involve cooking recipe recommendation. However, these websites present cooking recipes on the basis of entry date, access frequency, or the recipe’s user ratings. They do not reflect the user’s personal preferences. We have
proposed a personalized recipe recommendation method that is based on the user’s food preferences. For extracting the user’s food preferences, we use his/her recipe browsing and cooking history. In this paper, we present a method for extracting the user’s preferences. In the experimental results, extracting the user’s favorite ingredients were detected with a 60 to 83% of precision. And extracting the unfavorite ingredients were detected with 14.7% of precision, and 58% of recall. Furthermore, the F-measure value for
extraction of favorite ingredients was 60.8% when we focused on the top 20 ingredients.s

Additionally, user interface design is pivotal, ensuring intuitive interaction for inputting preferences, viewing recommendations, and offering feedback.

[6] Food Recognition and Nutrition Estimation using MobileNetV2 CNN architecture and Transfer Learning, 2023

A food detection and nutritional analysis project is a cutting-edge tool that allows users to easily identify the nutritional information of different types of food by simply taking a photo of the food item. This paper leverages state-of-the-art image recognition technology to analyze the image and extract crucial information such as calorie count, protein content, and other relevant nutritional facts. To accomplish this, a Convolutional Neural Network (CNN) model based on the MobileNetV2 architecture has been trained, and it can successfully identify 190 different food categories, including a wide range of cuisines, both Western and local. Transfer Learning has been employed to achieve accurate and robust food detection across an extensive array of food categories. Furthermore, a mobile app has been developed to facilitate food identification and provide a wide range of nutritional information to users based on the use of the Edamam food API.

Evaluation using standard metrics such as accuracy and precision, alongside iterative refinement based on user feedback, ensures the system's continual improvement.

[7] Recognition of food type and calorie estimation using neural network, 2021

Across the globe, health cognizant among the people is increasing and everyone wants to maintain a healthy and normal life. But due to the fast moving world, obesity and other related issue becomes the major health problem among the human beings. According to medical experts, a person is defined as obese when their BMI is greater than 30 kg/m^2. Obesity leads to many diseases like high cholesterol, liver failure, breathing issues, heart problems, diabetes and sometimes cancer. By eating healthy foods with high nutrition and low calorie values, we can control the obesity among the people. Human cannot control their appetite and have the nature of eating food which they like the most which leads to obesity. Many people have the difficulty in choosing the food items that have good nutrient and low calorific values. If a system can help the people and give them suggestions about the food and its calorific values, we can find a solution for this obesity problem. In this paper, identifying the food type and its calorific value estimation is done using multilayer perceptron model and the results are discussed. From the mixed food items, region of interest is selected from which the features are extracted. Extracted features are fed as the input to the MLP. Based on the food volume, the calories present in the food are calculated. Implementation of the algorithm is done in MATLAB environment for fruits and food items. The results showed that the level of detection of food item and accuracy of estimation of calorific level was acceptable.

Deployment options, either standalone or integration into existing platforms, guarantee accessibility to a broad user base.

[8] Food Recognition and Nutrition Estimation Using Deep Learning, 2023

Studies on weight reduction therapies have shown that an accurate assessment of the patient’s diet is crucial. However, the majority of existing techniques of nutritional evaluation rely on recall. With the availability of powerful mobile devices and extensive cloud services, it is now feasible to create a sophisticated computer-based food identification system for trustworthy food assessment. Helping computers recognize what’s being shown in food photographs has been a persistent issue for some time. The task is difficult because of the wide range of food items available, their low inter- and large intra-class differences, and the lack of detail in a single image. To boost recognition and classification skills based on attributes collected from different deep models, the authors propose the global application of several fusion-trained classifiers. In this chapter, they examine the efficiency of three distinct food-recognition methods based on a number of criteria. The findings of their research show that deep learning is superior to other approaches, such as manual different classifiers, conventional machine learning algorithms, and deep learning itself, when it comes to ensuring the safety of food during inspections. Food recognition, machine learning, deep learning, categorizing,

clustering, and picking features are all relevant concepts to consider.

While the project emphasizes system functionality, it does not extend to content creation or implementing advanced features beyond the scope of CNNs for recipe analysis.

[9] Food Recognition and Calorie Measurement Using Machine Learning, 2024

This study is one of many that investigate the relationship between determining the nutritional ingredients in food and calculating the calories using data analysis utilizing machine learning techniques. Due to the availability of multifood photos, which must be cropped before processing, the Indian food recipes database is used for the research. The study uses a large dataset of various food photos to train state-of-the-art deep convolutional neural networks (CNNs) to recognize and categorize distinct food items with an amazing 99.89% accuracy. This study's applicability spans several sectors in addition to food recognition, including calorie measurement, meal planning services, and nutritional monitoring systems. The solution is widely available to a wide range of users thanks to a user-friendly web interface. The system's 99.89% accuracy in food detection and calorie measurement demonstrates its dependability and distinguishes it from competing options. Its ability to improve individual health, fight obesity, and encourage healthy eating habits makes it a vital tool in today's health-conscious culture.

The scope of the Food Recognition and Nutrition Estimation project encompasses several crucial aspects aimed at developing an efficient and user-centric platform.

[10] Calorie Measurement and Food Recognition Using Machine Learning, 2024

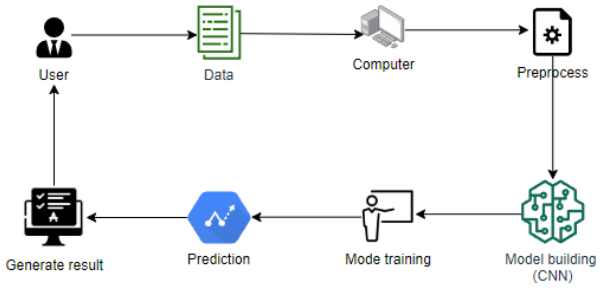
This paper proposes a novel approach leveraging machine learning for accurate calorie estimation and food recognition. The system employs computer vision techniques to identify and classify food items from images, utilizing convolutional neural networks (CNNs) trained on diverse food datasets. Subsequently, it integrates this recognition with nutritional databases to estimate calorie content based on portion sizes and ingredients. K Nearest Neighbour, VGG16 Model, and image processing are used to enhance accuracy in recognizing various food items and their nutritional composition. The system aims to provide a user-friendly interface for individuals to track dietary intake, promote healthier eating habits, and facilitate more precise nutritional analysis. Experimental results demonstrate the efficacy of the proposed method in accurately identifying and quantifying food items, enabling more efficient and reliable calorie measurement for dietary management and health monitoring.

This includes collecting and preprocessing a diverse dataset of recipe images and text descriptions to ensure data quality.

III. PROPOSED METHODOLOGY

The proposed Food Recognition and Nutrition Estimation aims to overcome the limitations of existing methods by integrating advanced technologies such as Convolutional Neural Networks (CNNs) with traditional recommendation methodologies. The system will analyze both image and text data associated with recipes to provide personalized, visually engaging, and contextually relevant recommendations.

The objective of the Food Recognition and Nutrition Estimation project is to develop an innovative platform that transforms the way users discover and plan meals. Leveraging Convolutional Neural Networks (CNNs), the system aims to analyze recipe images and text data, extracting meaningful features to enhance recommendation accuracy. By integrating CNNs with traditional recommendation methodologies, such as collaborative and content based filtering, the system strives to provide personalized recipe suggestions tailored to individual tastes and dietary needs. Emphasis is placed on recognizing visually appealing dishes, identifying key ingredients, and considering cooking techniques to improve recommendation relevance. Through user-friendly interfaces and iterative refinement based on performance metrics and user feedback, the system aims to empower users to explore diverse culinary options effortlessly. Ultimately, the project seeks to simplify meal planning, inspire culinary creativity, and enrich the overall cooking experience for users.



1.1 Dataset:

In this module, the dataset containing images for recipie prediction is divided into two subsets - the training dataset and the testing dataset. This split is typically done with a test size of around 20-30%. The training dataset is used to teach the model, while the testing dataset is used to evaluate its performance.

1.2 Data Pre-Processing:

Data preprocessing is a data mining technique which is used to transform the raw data in a useful and efficient format.

(a). Missing Data:

This situation arises when some data is missing in the data. It can be handled in various ways.

(b). Noisy Data:

Noisy data is a meaningless data that can't be interpreted by machines. It can be generated due to faulty data collection, data entry errors etc.

3.3 Algorithm:

Convolutional Neural Networks (CNNs) have indeed transformed many areas of computer vision, including the specific domain of food classification. In this context, CNNs are particularly effective because they can directly learn to recognize and differentiate among various types of foods from images, which is crucial for tasks like nutritional analysis, diet tracking, and automated cooking assistance. In a food classification task, the convolutional layers of a CNN play a critical role. These layers apply numerous filters to the input images to capture and encode different visual features, such as textures of a grilled surface, shapes of different fruits, or colors typical of certain foods. For instance, the early layers might detect edges and colors, while deeper layers could identify more complex patterns like the flakiness of a pastry or the glossiness of fresh vegetables. Pooling layers further support this process by downsampling the feature maps generated by the convolutional layers, reducing the spatial dimensions of the data. This not only diminishes the computational load and memory usage but also makes the model more robust to variations in the position and size of food items within images. For example, pooling can help the model recognize a pizza whether it's centered in the image or partially cut off at the edge. Finally, the fully connected layers aggregate all the learned features into a holistic representation, which is used to classify the type of food. In this stage, the CNN might discern whether an image depicts a bowl of pasta or a plate of sushi, based on the learned features. Furthermore, advances in CNN architectures, such as introducing deeper layers or employing techniques like batch normalization and dropout, have improved their performance and generalization in food classification tasks. Models can be trained on large datasets of food images to achieve high accuracy, making them invaluable for apps and services aimed at food recognition. Overall, CNNs offer a powerful tool for automated food classification, leveraging their hierarchical learning structure to interpret complex and varied visual data directly from raw pixels, significantly benefiting areas like health monitoring, culinary exploration, and automated food processing.

IV. RESULT

The code performs image classification on a food dataset using a Convolutional Neural Network (CNN) with transfer learning (MobileNetV2).

Key Steps & Workflow

1. **Importing Libraries**
   - Libraries such as NumPy, Pandas, TensorFlow, Keras, and others for image processing, model building, and visualization.

2. **Loading & Preprocessing Data**
   - Image file paths are collected using glob.
   - Class labels are extracted from the directory structure.
   - A DataFrame is created combining file paths and labels.
   - A balanced dataset is sampled with 130 images per class.
   - Data is shuffled and split into training (70%) and test (30%) sets.

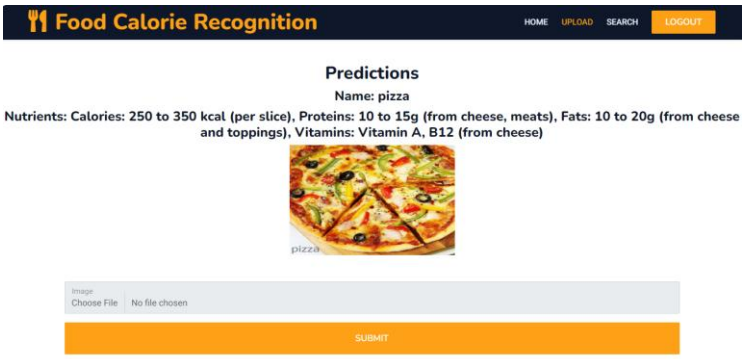
3. **Image Generators**
   - ImageDataGenerator is used for training, validation, and test sets.
   - Images are resized to 224x224 to match MobileNetV2 input.
   - Data is split into training and validation using the validation_split=0.2.

4. **Model Building**
   - MobileNetV2 (pretrained on ImageNet) is used for feature extraction.
   - The top classification layer is replaced with custom dense layers:
   - Two hidden dense layers with 128 neurons and ReLU activation.
   - Output layer has 20 neurons (one per class) with Softmax activation.
   - The base MobileNetV2 model is frozen (trainable=False).

5. **Model Compilation & Training**
   - Compiled with Adam optimizer and categorical_crossentropy loss.
   - Trained for 10 epochs with early stopping (patience=3).
   - Accuracy improves with more epochs (up to ~77.46% with 100 epochs).

6. **Evaluation & Results**
   - Model is evaluated on the test set.
   - Confusion matrix and classification report are generated.
   - Predictions are visualized using a heatmap.
   - Final model is saved as final_cnn.h5.

7. **Outputs**
   - Test Accuracy is printed.
   - Confusion Matrix and Classification Report display detailed performance.
   - Final model is saved for future inference.



Upload Image and Result Page

V. CONCLUSION

In conclusion, the Recipe Recommendation System represents a significant advancement in the field of culinary

exploration and meal planning. By integrating Convolutional Neural Networks (CNNs) with traditional recommendation methodologies, the system offers a comprehensive and personalized approach to recipe discovery. Through the analysis of both image and text data associated with recipes, the system provides users with visually engaging, contextually relevant, and highly accurate recipe recommendations tailored to their individual preferences and dietary requirements. The proposed system addresses the limitations of existing methods by leveraging advanced technologies to capture the complex and nuanced characteristics of recipes. By considering visual elements such as presentation and aesthetic appeal, as well as textual attributes like ingredients and cooking techniques, the system offers a holistic understanding of recipe content, leading to more satisfying and enjoyable culinary experiences for users. Moving forward, further research and development efforts will focus on refining the recommendation algorithms, enhancing user interaction interfaces, and continuously evaluating the system's performance to ensure its effectiveness and adaptability in meeting the evolving needs of users. Ultimately, the Recipe Recommendation System aims to inspire culinary exploration, foster creativity in the kitchen, and enrich the overall cooking experience for users worldwide.

VI. REFERENCES

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[9] Food Recognition and Calorie Measurement Using Machine Learning, 2024.

[10] Calorie Measurement and Food Recognition Using Machine Learning, 2024.