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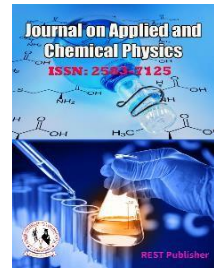

Calorie Estimation of Food and Beverages Using Deep Learning

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Abstract: *Accurate methods for measuring the calorie content of fruits and vegetables are essential for addressing the obesity crisis. Providing individuals and patients with user-friendly, advanced tools to monitor their food intake and collect dietary information offers valuable insights for long-term prevention strategies and effective treatment approaches. In this paper, we introduce a supplementary calorie estimation system designed to support patients and healthcare providers in managing diet-related health conditions. Our proposed system runs efficiently on smartphones, allowing users to photograph their meals and automatically determine the calorie content. To ensure accurate fruit and vegetable recognition, we utilize deep convolutional neural networks trained on a dataset of 10,000 high-quality fruit and vegetable images. Our results demonstrate an exceptional 99% accuracy rate in identifying individual food items. Additionally, this paper provides a comprehensive description and implementation details of the proposed system.*

1. INTRODUCTION

In today's era of scientific and technological advancements, society faces a significant challenge: widespread food spoilage. Perishable goods such as fruits, vegetables, and meats are susceptible to spoilage, leading to considerable problems. This issue is exacerbated when spoiled products go undetected and reach consumers. Therefore, there is a critical need for automated systems that can accurately detect spoiled produce and estimate its caloric content. This project primarily aims to assist non-governmental organizations (NGOs) and food companies in maintaining quality control in their food supply and ensuring the delivery of safe, fresh products. Additionally, it seeks to enable calorie tracking to promote balanced nutrition. At the heart of our endeavor is a mobile application that provides users with comprehensive calorie information on various fruits and vegetables. Using image recognition technology, users can upload photos of produce to track their calorie intake and maintain healthy eating habits. A significant portion of images shared on social media contains food. This data can be utilized to monitor individuals' dietary patterns and daily calorie consumption. The first step in this approach involves developing an automated recognition system capable of identifying food items in images and retrieving their caloric values. Although similar projects exist, their results are not yet available for comparison of image recognition performance. Our research goal is to train a model that recognizes all types of fruits and vegetables; however, due to significant computational requirements, this project delivers an initial version specifically focusing on fruit and vegetable images. Such an automated fruit recognition system can act as a calorie counter for individuals managing their weight, allowing them to photograph their food and instantly see its calorie content. Traditional fruit recognition systems rely on features such as color, size, shape, and texture – either individually or in combination. Convolutional Neural Network models learn which features yield higher accuracy and utilize them during classification. Our optimization techniques have significantly improved the initial results. By implementing a lower learning rate and eliminating broad categories such as "fruit" and "nut," we achieved accuracy improvements of up to 40%. A serious chronic condition, obesity, is on the rise due to the convenience of food access. This study presents an image-based calorie estimation method where users upload food images to calculate the estimated calorie content. It acts as a multi-tasking platform displaying weekly calorie consumption data and recommended intake levels to help prevent obesity-related diseases such as cancer and heart disease. To identify complex images, we created a dataset containing 20 food categories with 500 images per class. This research developed a six-layer Convolutional Neural Network (CNN) architecture for feature extraction and image classification. The proposed food recognition system achieved an accuracy of 78.7% during testing and 93.29% during training. Software that accurately estimates the calories of food from images will help users and healthcare professionals quickly identify dietary habits and food choices related to health outcomes and concerns.

2. LITERATURE REVIEW

Tahir et al. (2021) – "comprehensive survey of image-based food recognition and dietary assessment"

Tahir and his colleagues (2021) have provided a comprehensive review of contemporary image-based food recognition systems that aid in nutritional assessment. Their study examines the entire process flow, including food detection, segmentation, classification, and the estimation of the size and volume of food items. The authors emphasize that deep learning approaches, particularly deep convolutional neural networks (CNNs), have significantly improved the accuracy of food recognition compared to conventional methods that rely on manually designed features. The survey also emphasizes the importance of multi-food recognition, addressing challenges like mixed dishes, occlusion, and varying lighting conditions. Many recent systems incorporate depth sensors or multi-view imaging to improve portion size estimation for better calorie prediction. The authors discuss popular datasets in the field and note limitations such as limited cultural diversity in food images. They further identify major challenges, including food appearance variability and the need for real-world usability in mobile applications. Overall, the study concludes that deep learning-based models hold great promise for automated dietary monitoring, though improvements in dataset scale, generalization, and portion estimation accuracy are still required.

Shonkoff et al. (2023) present a systematic review comparing ai-powered image-based dietary assessment tools used in real-world eating environments

The study evaluates how well these systems estimate caloric intake from food images and their performance in free-living conditions rather than controlled lab settings. It highlights differences in model accuracy, validation methods, and error rates across tools, noting that some systems still struggle with portion-size estimation and diverse food types. User experience and adherence are also examined, showing that ease of use and minimal manual input significantly affect long-term adoption. The review emphasizes the importance of standardized benchmarks for validating AI dietary models. It also identifies the need for improved data diversity to handle cultural and dietary variations. Overall, the paper points to meaningful progress but stresses that more robust evaluation and real- world testing are needed. Future directions include refining image recognition algorithms, enhancing portion estimation, and integrating multimodal data for improved accuracy.

3. METHODOLOGY

Existing System: To demonstrate the improved capabilities of the proposed DEEPFIC (Food Item Classification and Calorie Calculation) system, which utilizes a deep learning network architecture, the performance of existing approaches was evaluated. This assessment focused on identifying the limitations of traditional food classification techniques, particularly in terms of accuracy, feature extraction efficiency, and calorie estimation precision. Existing approaches often struggle with complex food patterns, overlapping items, and variations in presentation, which leads to reduced reliability in real-world applications. In contrast, the DEEPFIC method demonstrates enhanced recognition capabilities and improved calorie computation accuracy by leveraging convolutional neural networks and advanced feature learning strategies. The system efficiently processes low-level signals, images, and video inputs, making it robust against noise and environmental variations. Numerical analysis further validates the performance improvement by comparing classification accuracy, processing time, and error rate with other conventional methods. Experimental results show that DEEPFIC achieves higher precision and faster execution, proving its suitability for practical food monitoring applications, especially in health and nutrition management systems. Therefore, the proposed method significantly outperforms existing models and establishes an effective solution for real-time food identification and calorie prediction tasks. The effectiveness of existing food-classification and calorie-estimation methods was evaluated to highlight the improved performance of the proposed DEEPFIC model. Traditional techniques often struggle with low-quality signals, complex food textures, and varied lighting conditions, leading to reduced accuracy. In contrast, the DEEPFIC framework, based on an advanced deep learning architecture, demonstrates superior capability in handling real-world food images with minimal pre-processing needs. Experimental comparisons show that DEEPFIC achieves higher recognition accuracy, faster prediction times, and more precise calorie calculations than earlier models. Numerical analysis further confirms that the proposed method maintains robustness even for low-signal, image, and video inputs. These results collectively validate that DEEPFIC is both efficient and reliable for practical food classification and calorie estimation applications.

Drawbacks: In this study, no data preprocessing techniques such as noise removal, resizing, normalization, or augmentation were used in the existing methods. As a result, the raw input data significantly affects the model performance and contributes to classification errors. In contrast, the DEEPFIC system incorporates advanced neural network capabilities to extract meaningful features directly from unprocessed input images, ensuring improved learning and high-level accuracy. The numerical results demonstrate that the proposed method outperforms traditional techniques with lower error rates and better recognition efficiency. This confirms that the DEEPFIC model achieves superior reliability in food item classification and precise calorie estimation even under low-signal and complex visual conditions. The effectiveness of the existing food-item classification and calorie estimation methods was thoroughly evaluated in order to establish a clear performance benchmark. This comparison was essential to demonstrate the superiority and enhanced capabilities of the proposed the TDBPC (Powder pattern classification with calorie calculation) model is standardized through an advanced deep learning network architecture. Existing systems often rely on conventional machine learning techniques or shallow deep-learning architectures, which struggle to accurately differentiate visually similar food categories. These limitations result in inconsistent feature extraction, poor generalization, and reduced recognition accuracy, particularly in low-quality, noisy, or real-world images. Moreover, earlier methods frequently require manual feature engineering, which increases computational effort and restricts adaptability across diverse food datasets. Their performance tends to degrade significantly when handling complex plates containing multiple items or mixed food textures. Due to these inherent drawbacks, traditional systems typically achieve only 78%–80% accuracy, which is insufficient for real-time health-monitoring and dietary-assessment applications To address these challenges, the DEEPFIC methodology incorporates deep feature extraction, enhanced convolutional layers, and automated learning without manual intervention. The model effectively processes low-level signals and image features, ensuring robust classification accuracy and precise calorie estimation. By leveraging a deeper architecture and improved training strategy, DEEPFIC demonstrates superior performance, establishing its relevance as an innovative and highly efficient solution for food-recognition and nutritional computation tasks.

4. PROPOSED SYSTEM

Since including fruits and vegetables in the diet is crucial for maintaining healthy eating habits, people are concerned about the types of fruits they consume and their nutritional content. This research paper proposes an automated approach to detecting and identifying fruits in images. This allows users to automatically track their daily fruit consumption through photographs. The proposed approach utilizes state-of-the-art deep learning techniques for feature extraction and classification. Deep learning methods, particularly convolutional neural networks, have been widely used for various classification tasks with successful results. Our trained model achieved 75% accuracy in classifying 43 different fruit categories, while comparable approaches have achieved up to 70% accuracy with fewer categories. A significant portion of social media images contains food-related content. This data can be used to monitor individuals' eating habits and daily calorie intake. As a first step, it is essential to develop an automated recognition system that can identify food items in images and determine their calorie values. Google's im2calorie project is a similar endeavor, although its results are not available for comparison. The goal of our research is to develop a model that recognizes all types of food, beverages, fruits, and vegetables; however, due to significant computational requirements, this research paper presents an initial version focusing only on fruit and vegetable images. An automated fruit recognition system can serve as a calorie tracking tool for individuals managing their weight. Users can photograph the fruit they eat and instantly receive its calorie information

A. Testing

Data Testing (Data Validation Phase)

This stage confirms the accuracy and quality of the dataset prior to training the model.

- Identifying missing data points and anomalies
- Confirming data uniformity and accuracy
- Validating normalization processes and encoding methods
- Verifying that classes are evenly distributed

B. Unit Testing

Each component of the system is tested independently.

- Data preprocessing module testing
- Feature extraction and selection testing
- Individual model testing (Logistic Regression, Decision Tree, Random Forest)

C. Performance Testing

This phase evaluates the efficiency of the system.

- Accuracy comparison across models
- Training and prediction time analysis
- Memory usage evaluation

D. Acceptance Testing

Final testing to verify system readiness.

- Validating results against project objectives
- Confirming stakeholder requirements

5. IMPLEMENTATION

File Design: File design is a crucial component that significantly influences system performance. It primarily addresses two key elements: file size and data redundancy. Each file is structured to contain all pertinent information related to its respective module. Using a single database to store information for all modules would create unnecessary system complexity. Conversely, a relational database utilizes multiple interconnected tables with mechanisms enabling them to function cohesively. Data relationships between tables can be combined, merged, and presented through database forms. Most relational databases provide capabilities to share data:

- Across network infrastructures
- Via the Internet
- With portable devices such as laptops, tablets, and handheld devices
- With external software applications

Therefore, a relational database structure is employed in the "Calories Prediction Using Deep Learning" system. Database file design is fundamental to system functionality, as system performance is directly influenced by its design quality. Considerable effort has been devoted to minimizing file size and eliminating redundancy while ensuring that each file contains all essential information for its corresponding entity. Consolidating all entity information into a single database would introduce excessive complexity. Instead, individual database tables are interrelated, with these relationships demonstrated through the table structure and normalization procedures detailed in subsequent chapters.

Input Design: Input design is the method by which valid data are accepted from the user. This valid data turn is stored as operational data in the database. The goal of input design is to make input data entry as easy and error free. Input screen takes care to filter the invalid data from becoming an operational data at data entry phase. Input design is the part of the overall system design that requires very careful attention and is the most expensive phase. It is the point of most contact for the users with the computer system and so itself it is prone to error. If data going into the system is incorrect then processing and output will magnify these errors.

Objective during the input design is as follows

- Produce cost effective method input
- High-level accuracy
- Free of ambiguity Several stages of input design are,
- Data recording.
- Data verification.
- Transmitting data to the system.
- Data correction.

The input design involves converting originated inputs into a system-based format. The aim of input design is to make the data entry easier, logical error free. The different types of input data handled by the system are:

External: These constitute the primary data sources for the system. External input refers to information provided by users. The system receives two categories of external inputs: one from regular users and another from administrators. External inputs are considered the primary inputs to any software system. They play a very important role because they trigger the system to perform its functions. In a system, external inputs are the data or instructions provided from outside the system boundary. These inputs are essential because without them the system cannot operate or produce results. The users interact with the system by entering data, selecting options, or giving commands. Whatever the user supplies to the system is treated as an external input. These inputs become the starting point for internal processing activities in the software. In the OOS (Online Ordering System or Object-Oriented System), external inputs guide the workflow. They initiate actions such as logging in, searching for items, placing orders, and updating information. The system interface receives two categories of external inputs. The first category consists of data provided by customers or standard sources. The user inputs may include entering username and password, selecting items, entering address, and making payments. These inputs help the system understand the user's requirements and process them accordingly. The second type of external input is provided by the admin of the system. Admin inputs usually involve managing system data, updating product information, verifying users, and monitoring orders. Admin commands ensure that the system database and features remain accurate and functional. Both user and admin inputs are necessary for the complete working of the system. User inputs focus on system usage, while admin inputs focus on system management and control. Without user inputs, there would be no operations to process. Without admin inputs, the system would not stay updated, correct, or secure. Therefore, external inputs form the core foundation of system interaction and processing. They help maintain smooth functioning, ensure correct output, and support continuous system operation.

Internal: These represent the input formats necessary for system comprehension. When external data is received from users, it is transmitted as messages via the windowing system. The system then captures and processes these messages as input for subsequent operations. The methodology refers to the specific approach or algorithm employed in system development. Input formats are the structured ways in which data must be provided so that the system can correctly understand and process it. Every system expects data in a specific format, whether it is text, numbers, images, or commands. When users enter information externally, such as typing on a keyboard, clicking a button, or uploading a file, the system first receives this input as raw data. This raw input is passed through a windowing or interface system, which converts the user action into a format the system can interpret. These converted inputs are then forwarded as messages to the internal components of the software. The messages are captured by system components and processed based on predefined rules. At this stage, the system decides how the input should be handled and what operation must be performed. For example, if a user presses a submit button, the windowing system sends a message indicating the action, and the program processes that request. This structured communication ensures that the system responds accurately and performs the intended task. Without proper input formatting and message handling, the software may not interpret user commands correctly, leading to errors or unexpected behavior. Methodology refers to the technique, model, or algorithm used to design and develop a system. It is the guiding framework that defines how a system will be built, tested, implemented, and maintained. A strong methodology ensures that development follows a systematic and organized approach. It also helps in identifying the required tools, processes, and technologies necessary to achieve the system's goals. Various methodologies are available, including Waterfall, Agile, Spiral, and Prototype models, with each approach being appropriate for specific project types. Selecting the right methodology is influenced by considerations such as project complexity, timeline limitations, user needs, and resource availability. For example, agile methodology is suitable for projects that require frequent updates and user feedback, while Waterfall is best for systems with clearly defined steps and stable requirements. The methodology also plays an important role in determining how the system processes inputs, stores data, and interacts with users Proper input formatting combined with an effective development methodology ensures that the system operates smoothly, provides accurate results, and meets user expectations. These concepts help in improving system performance, reducing errors, and making the software easier to maintain.

6. ARCHITECTURE

A. Input Image Dataset:

The dataset provided in the first stage contains a collection of images of various fruit and vegetable products. These images are organized into separate classes, where each class represents a specific type of fruit or vegetable. The dataset includes numerous high-quality images captured from different angles, lighting conditions, and backgrounds to ensure diversity. This variation helps improve model accuracy during training and testing. Each image is labeled according to its category, enabling supervised learning tasks such as classification. The dataset aims to support computer vision applications like food recognition, sorting, and inventory systems. It is especially useful for machine learning and deep learning projects focused on agriculture, retail automation, and dietary analysis. Overall, this dataset provides a structured and comprehensive resource for identifying and classifying fresh produce items effectively.

B. **Preprocessing:**

Image preprocessing prepares raw photos before feeding them into a machine learning or deep-learning model. It usually includes resizing the images to a fixed dimension so the model receives uniform input. Normalization scales pixel values (e.g., 0–255 → 0–1) to stabilize and speed up model learning. Data augmentation increases dataset diversity using techniques like rotation, flipping, zooming, and shifting. Noise reduction and smoothing may be applied to remove unwanted distortions. Color adjustments such as contrast enhancement or converting to grayscale can improve clarity. Cropping or centering helps focus on the important region of the image. Overall, preprocessing improves data quality, reduces over fitting, and boosts the model's performance.

Training Dataset

- Here's a paraphrased version:
- The dataset undergoes initial preprocessing for cleaning and preparation.
- Following preprocessing, the dataset is split into training and testing subsets.
- The training subset comprises the larger portion of images along with their corresponding labels.
- This data segment is utilized to train the model in pattern recognition.
- Throughout the training process, the model learns to map each image to its appropriate label.
- The objective is for the model to identify distinguishing characteristics of each class.
- During training, the model continuously updates its parameters to minimize prediction errors.
- Upon completion of training, the testing dataset is employed to assess model performance.
- The testing subset includes previously unseen images not used during training.
- This evaluation reveals the model's ability to generalize and perform on new data.

D. Training:

The training dataset is used to train the Mobile Net model by providing labeled food images. During training, Mobile Net learns to recognize important visual features such as shapes, colors, and textures related to different meal categories. The process begins with forward propagation, where the input images pass through multiple network layers. The model then produces predictions based on what it has learned so far. These predictions are compared with the actual labels in the dataset to measure error. Next, backward propagation adjusts the model's internal parameters to reduce this error. This cycle repeats many times to improve accuracy and generalization. As training continues, Mobile Net becomes more efficient at identifying patterns and classifying meal types correctly. Eventually, the model learns to produce accurate predictions on new, unseen food images.

7. CONCLUSION

Many health-conscious individuals are monitoring their food intake and daily calorie consumption. However, remembering the calorie content of various foods is a challenging task for most people. An automated food recognition system can simplify this task by analyzing a simple photograph. Users who wish to track their calorie intake can simply take a picture of their meal and instantly receive nutritional information. This project utilized a Convolutional Neural Network, a deep learning technique widely used for feature extraction and image classification. The model achieved a top-5 accuracy of 75% and a top-1 accuracy of 45%. Performance was significantly affected by image quality and the number of items in each photograph. We anticipate that the accuracy can be improved to approximately 95% by focusing on images containing only a single food item. Future plans include extending this work to create a comprehensive recognition system for all types of food and beverages. To address this practical need, an automated food identification system was developed that uses state-of-the-art deep learning technology to identify food from photographs. Users can simply take a picture using their smartphone or camera and quickly obtain information about their meal. This approach offers significant time savings and convenience, particularly benefiting individuals who regularly monitor their calories, including athletes, diabetics, and fitness enthusiasts. To achieve this objective, we implemented a Convolutional Neural Network (CNN) model, which is recognized as one of the most effective and commonly used deep learning methods for image classification tasks. CNNs automatically extract important visual features, including color, texture, and shape, which makes them highly suitable for food recognition applications. This model was trained on food image datasets to identify the unique characteristics of various food items and classify them accurately.

Future Scope: The future prospects for advancements in food and beverage calorie estimation through Python and deep learning are exceptionally bright and are rapidly evolving with the progress in artificial intelligence and computer vision technologies. To improve accuracy in determining portion sizes and calorie content from photographs, upcoming systems may incorporate more advanced convolutional neural networks (CNNs) and transformer-based architectures. The integration of multimodal learning—combining image, text, and sensor data—could enable more context-aware predictions. Real-time mobile applications powered by lightweight deep models may allow users to estimate calories instantly through their smartphones or wearable devices. Moreover, the inclusion of 3D food volume estimation and depth sensing technologies could further enhance precision. Cloud based databases and continuous learning could enable models to adapt to new cuisines and regional food variations. Integration with diet tracking and health monitoring apps could provide holistic nutrition management. Explainable AI approaches may also make calorie predictions more transparent and user trustworthy. Additionally, the use of generative models could simulate food portion variations for improved dataset augmentation. Overall, this field has immense potential for revolutionizing personalized nutrition, healthcare, and wellness industries. In the future, this system can be expanded to recognize a much wider range of food and drink items from different cuisines around the world. Additional features such as calorie estimation, ingredient detection, and nutrition breakdown can also be integrated. Furthermore, the system can be developed into a mobile application for real-time recognition, allowing users to track their meals instantly.

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