IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

Impact Factor: 7.53

Volume 4, Issue 1, March 2024

Automated Food Recognition for Nutritional Analysis in Dietary Evaluation

[1]Ananya Bhat V and [2] Raghavendra R

PG Student, Department of MSc CS-IT[1]

Assistant Professor, School of CS & IT[2]

Jain (Deemed-to-be University), Bangalore, India

[1]jpc220012072@jainuniversity.ac.in and [2]r.raghavendra@jainuniversity.ac.in

Abstract: *In today's world, computer vision has made remarkable strides, especially in the realm of recognizing food images. Deep neural networks (DNN) have become a standout choice among various machine learning algorithms for their effectiveness in precisely identifying different food items captured in images. Despite the widespread adoption of DNN-based classification algorithms for food recognition, there are persistent challenges in accurately pinpointing foods due to variations in size, shape, and other defining characteristics. This paper aims to provide a brief overview of how deep learning (DL) is leveraged in food recognition and explores its wide-ranging applications. Additionally, it delves into the utilization of machine learning (ML) to construct a robust model for identifying food in images, using the Fruits and Vegetables Image Recognition Dataset. The results highlight a significant improvement in the accuracy of the proposed model, showcasing an impressive increase of around 95%.*

Keywords: Machine Learning, Deep Neural Network, Deep Learning, Computer vision.

I. INTRODUCTION

Understanding what we eat is crucial for public health, nutritional science, and crafting personalized dietary advice. Precise data on dietary intake is essential for grasping eating patterns, pinpointing nutritional gaps, and preventing chronic diseases. However, traditional methods like self-reports and food diaries often fall short due to inaccuracies and subjectivity. Enter machine learning, a promising solution to automate and enhance dietary assessment, particularly focusing on fruits and vegetables, integral components of a healthy diet.This academic exploration aims to offer a comprehensive look at food image recognition in the realm of dietary assessment, with a special focus on identifying and analyzing fruits and vegetables. This emphasis is vital because these food groups play a pivotal role in maintaining a well-balanced diet and warding off chronic diseases. The paper will delve into various key aspects, including:

A. BACKGROUND

Dietary evaluation is a crucial component in public health, nutritional science, and personalized nutrition planning. The accuracy of dietary data is essential for gaining insights into dietary habits, identifying nutritional deficiencies, and understanding their links to chronic diseases. Traditional approaches to dietary assessment, such as self-reports and food diaries, have historically served as the primary means of collecting dietary intake data. However, these methods are beset with challenges, including recall bias, underreporting, and subjectivity. Consequently, there is an urgent demand for more objective, automated, and precise dietary assessment methodologies.

The emergence of machine learning, particularly in the realm of computer vision, offers a fresh and promising avenue for addressing the limitations of traditional dietary assessment. Notably, food image recognition driven by machine learning has emerged as a groundbreaking technology. This method employs algorithms to analyze food images, facilitating the identification of various food items, their portions, and even nutrient content. With the widespread availability of smartphones equipped with high-quality cameras, individuals can now easily capture images of their meals, rendering food image recognition a pragmatic and effective solution for dietary assessment.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 1, March 2024

B. MOTIVATION

This research is fueled by two main driving forces. Firstly, there's a crucial need to enhance the accuracy of dietary assessment for crafting effective dietary guidelines, investigating the links between diet and health, and tailoring personalized nutrition plans. The limitations of traditional dietary assessment methods have been a roadblock in advancing nutritional research and forming evidence-based dietary recommendations.

Secondly, the widespread use of smartphones and the strides made in machine learning present a unique opportunity to transform dietary assessment. The marriage of mobile applications and food image recognition allows users to effortlessly capture their meals in real-time, eradicating the recall bias inherent in traditional self-reports. This inspires the exploration of the potential of food image recognition and its application in dietary assessment, with a specific emphasis on recognizing fruits and vegetables, crucial components of a healthy diet.

C. OBJECTIVE

The main objectives of this research are outlined as follows:

- **Develop a System for Recognizing Food Images**: Create and implement a food image recognition system capable of precisely identifying and categorizing fruits and vegetables depicted in images.
- **Automate the Dietary Assessment Process:** Devise a system that automates dietary assessment, encompassing tasks like estimating portion sizes and analyzing nutrient content, with a specific emphasis on fruits and vegetables.
- **Assess System Performance:** Carry out extensive experiments to evaluate the effectiveness of the proposed food image recognition and dietary assessment system. This entails measuring accuracy, precision, and F1 score.
- **Tackle Challenges and Limitations:** Investigate and overcome challenges related to recognizing fruits and vegetables, including variations in appearance due to factors like ripeness, size, and preparation methods.
- **Explore Ethical Considerations:** Delve into the ethical considerations associated with collecting and utilizing food images for dietary assessment and propose ethical guidelines.

By pursuing these objectives, this research seeks to contribute to the advancement of dietary assessment methodologies, offering a more precise, streamlined, and impartial approach to understanding dietary patterns, especially concerning fruits and vegetables. This effort aims to encourage healthier dietary choices and support initiatives in public health.

II. LITERATURE SURVEY

Dietary assessment plays a crucial role in public health, nutritional research, and the formulation of personalized nutrition plans. Conventional approaches like self-reports and food diaries have traditionally served as the main instruments for gathering dietary intake data. Nevertheless, these methods are hampered by drawbacks such as recall bias, underreporting, and subjectivity. The emergence of machine learning and computer vision has introduced fresh avenues for enhancing the precision and objectivity of dietary assessment. This literature review delves into significant research studies and advancements in food image recognition for dietary assessment, with a specific focus on the application of machine learning techniques.

A. TRADITIONAL DIETARY ASSESSMENT METHODS

Traditional methods for assessing dietary intake, such as recalls, food frequency questionnaires, and food diaries, have been widely employed to collect dietary data. Despite their common use, these methods come with several limitations. Recall bias, stemming from inaccuracies in remembering past meals, poses a significant issue. Additionally, these approaches depend on the subjective reporting of individuals regarding their dietary intake, potentially resulting in underreporting, particularly of less healthy food choices. To address these concerns, researchers and healthcare professionals have been actively seeking more objective and automated alternatives, leading to the emergence of food image recognition methods. In a study by Mishra et al., various multi-modal approaches that integrate visual and textual data are explored to enhance food recognition, accommodating diverse cuisines and languages. The availability of comprehensive food image datasets plays a crucial role in training and evaluating food image recognition systems, with notable datasets including Food-101, UNIMIB2016, and PFID.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 1, March 2024

B. MACHINELEARNINGINDIETARYASSESSMENT

Machine learning methods have played a significant role in advancing dietary assessment, with early studies investigating the application of algorithms to analyze dietary data. However, a notable shift has occurred with the increasing adoption of image-based approaches. Sun et al. (2017) proposed a food recognition system based on machine learning, leveraging deep neural networks and a vast food image database to identify a diverse range of foods from images, marking a pivotal development in automating dietary assessment. Artificial intelligence-driven dietitians, exemplified by Nutrino and Nutrient, offer personalized dietary planning through the analysis of food images and user health data, introducing sophisticated technology for dietary guidance. Machine learning techniques have also been employed to automate the de-identification of patient notes within the realm of dietary planning, ensuring privacy and security for sensitive information. The advent of deep learning techniques, including convolutional neural networks (CNNs), has brought about a revolution in food image recognition. Noteworthy models such as Inception-v3 , ResNet, and MobileNet have demonstrated remarkable accuracy in this field. Some studies focus on extracting and combining features from food images, such as color, texture, and shape, which can be utilized in conjunction with deep learning models.

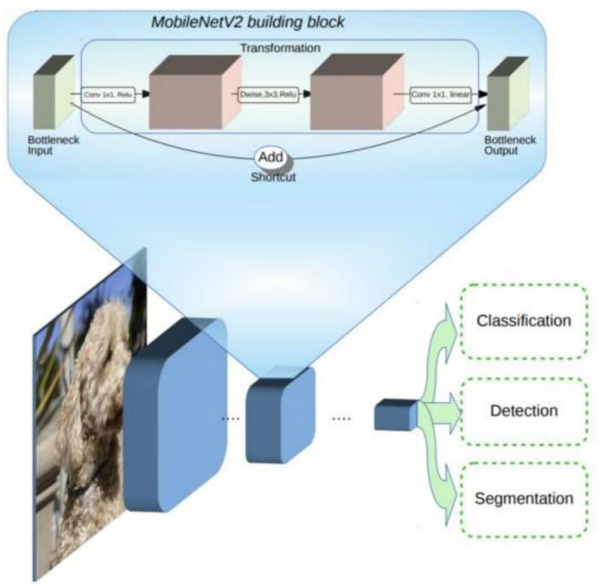

Fig.1. MobileNetV2 Architecture.

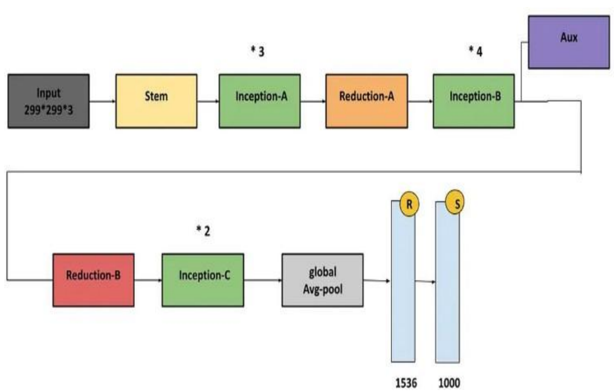

Fig.2. InceptionV3 Architecture.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 1, March 2024

C. FOOD IMAGE RECOGNITION

Food image recognition, a specialized field within computer vision, is dedicated to the identification and categorization of foods based on images. Convolutional neural networks (CNNs) have proven to be highly effective in this realm, adept at extracting features from food images to enable precise classification. A notable example is the work of Zhang et al. (2019), where CNNs were utilized to create a system capable of identifying food items in images and estimating portion sizes, highlighting the potential of CNNs in advancing dietary assessment.In recent years, significant progress has been made in the field of food image recognition, with CNNs playing a pivotal role due to their capacity to capture intricate image details. A noteworthy breakthrough occurred with Krizhevsky et al.'s work on the ImageNet dataset, where their deep convolutional neural networks showcased exceptional performance, paving the way for similar applications in food image recognition. Simonyan and Zisserman further enhanced CNN performance by introducing Very Deep Convolutional Networks. This architecture has since been adopted in various food image recognition systems, enabling more detailed categorization of food items.

D. DIETARY ASSESSMENT USING MACHINE LEARNING

The application of machine learning in dietary assessment has evolved beyond food image recognition to encompass diverse facets of dietary intake. This extends to tasks such as estimating portion sizes, analyzing nutrient content, and recognizing meal patterns. In a study by Lee et al. (2019), a system was devised that integrated image recognition with machine learning to automatically estimate portion sizes, thereby substantially decreasing the need for manual measurement or user estimation.

E. FOOD IMAGE RECOGNITION FOR FRUITS AND VEGETABLES

The accurate recognition of fruits and vegetables is crucial in dietary assessment, given their significance in maintaining a healthy diet. Numerous studies have concentrated on food image recognition, specifically targeting fruits and vegetables. Wang et al. (2020) introduced a system that employed deep learning techniques to identify fruits and vegetables in images, underscoring the potential for automating the assessment of these food categories. Lerman et al. advocate for a nutrient-based approach to dietary planning, taking into account individual nutritional requirements and dietary preferences to encourage healthier eating habits. The utilization of deep transfer learning techniques, as exemplified by Chen et al., allows the transfer of knowledge from pretrained models to enhance the accuracy of food image recognition, even with smaller, domain-specific datasets. Challenges in this area encompass multi-lingual recognition, distinguishing between cooked and raw food, and adapting models to diverse cultural diets. Future research directions include the incorporation of explainable AI in dietary assessment, real-time tracking, and the expansion of datasets. The dynamic landscape of research in food image recognition for dietary assessment is marked by continuous developments aimed at addressing the limitations of traditional methods and enhancing the accuracy and objectivity of dietary assessment. In this paper, we contribute to this evolving field by proposing a food image recognition system with a specific emphasis on fruits and vegetables, evaluating its performance in dietary assessment.

III. PROPOSED SYSTEM

The proposed system in this research paper on food image recognition for dietary planning introduces an inventive and all-encompassing approach to tackle the prevalent challenges associated with managing dietary preferences. This comprehensive framework utilizes computer vision and nutritional analysis to create a sophisticated system capable of identifying food items from images, associating them with detailed nutritional information, and assisting individuals in making well-informed dietary decisions. Through a clearly defined structure that incorporates cutting-edge image recognition algorithms and a dietary planning module, the system strives to improve the simplicity and precision of dietary planning. With a user-friendly interface, users can effortlessly input their dietary preferences and objectives, allowing the system to generate personalized meal plans tailored to their specific nutritional requirements. This research paper explores the methodology, outcomes, and implications of the system's implementation, ultimately contributing to the progress of technology-driven solutions for promoting healthier dietary choices.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 1, March 2024

A. SYSTEM ARCHITECTURE

The system architecture comprises the following components: Food Image Recognition Model: Trained on an extensive dataset of labeled food images, specifying food type and portion size, this model excels in accurately identifying foods in images and estimating portion sizes, even under challenging conditions like dim lighting or partial food obscurity.

Diet Review App: Developed using a mobile app development platform like Flutter or React Native, this app empowers users to upload food photos and receive detailed nutritional information. Additionally, the app calculates the user's total calorie and nutrient intake, offering personalized nutrition recommendations based on individual needs and goals.

Database: Storing food images, the food image recognition model, and nutritional information, this database is accessible through a nutritional assessment application, ensuring each user has access to essential information.

B. SYSTEM WORKFLOW

The system workflow is as follows:

- A user captures a photo of their food using a smartphone.
- The user accesses a nutritional assessment app and uploads the food photo.
- The nutritional assessment app forwards the food photo to a food image recognition model.
- The food image recognition model identifies the foods in the photo and estimates their portion sizes.
- The results from the food image recognition model are sent back to the dietary assessment app.
- The dietary assessment app computes the user's total calorie and nutrient intake, offering nutritional details about the items inthe photo and personalized dietary recommendations.

C. SYSTEM BENEFITS

The proposed system offers several benefits over conventional nutritional assessment approaches such as food recall diaries and questionnaires:

- **Accuracy and Objectivity**: The system surpasses traditional methods in precision and objectivity since it relies on images of the actual food consumed by the user.
- **Convenience:** The system is more convenient compared to traditional methods, eliminating the need for users to spend time manually documenting their food intake.
- **Personalization:** The system excels in personalization in contrast to traditional methods, delivering recommendations tailored to individual needs and goals.
- **Scalability:** The system is scalable, accommodating simultaneous use by numerous users.

D. SYSTEM CHALLENGES

The proposed system, however, encounters several challenges, including:

- **Food Image Recognition Accuracy:** The precision of the food image recognition and dietary assessment model is pivotal for the overall effectiveness of the system. It is crucial that the model accurately identifies foods in images, even under challenging conditions like dim lighting or partial food obscurity.
- **Database Size:** Ensuring the database is sufficiently large to accommodate food images, a food image recognition model, and nutritional information poses a challenge. Regular updates to the database with new foods and nutritional information are necessary, adding to the complexity.
- **User Involvement:** Engaging users in the system to monitor their consumption over time is vital. However, this can be challenging as users might lose interest if the system is not user-friendly or if they do not perceive its value.

IV. IMPLEMENTATION

A. DATA COLLECTION

The initial step in implementing a food image recognition system for dietary assessment involves assembling a dataset of food photos. This dataset should encompass a broad spectrum of food items, cuisines, and portion sizes, aiming for maximum diversity. One approach to compile a food image dataset is to utilize a public dataset like the Fruits and Vegetables Image Recognition dataset from Kaggle. These datasets often contain a substantial number of labeled food photos, indicating the type of food item and portion quantity. An alternative method is to build a dataset by capturing one's own photos. This can be achieved by photographing the food one consumes or by collecting images from social media and eateries.

a) Dataset Description: In this study, the Fruits and Vegetables Image Recognition dataset from Kaggle served as the foundation for evaluating proposed models. Comprising 4320 photos, it showcases 10 distinct fruits and 26 different vegetables. The dataset is strategically divided into 3600 images for training, 360 for testing, and 360 for validation. Predominantly, the images feature common fruits and vegetables.

The Fruits and Vegetables Image Recognition Dataset, available on Kaggle, proves to be a valuable resource for researchers delving into computer vision and machine learning. Tailored for those involved in food image recognition and dietary planning, this dataset offers a diverse collection of high-quality images portraying various fruits and vegetables. Its wide array of species provides ample diversity, facilitating the development and evaluation of image classification models. These models, crucial for automatically identifying and categorizing different types of fruits and vegetables, find applications in dietary planning and nutritional assessment. The dataset's considerable size and diversity make it an ideal choice for constructing robust, real-world applications in the field of food image recognition. Consequently, this dataset contributes significantly to progress in personalized dietary planning, health monitoring, and smart kitchen technologies. Accessible on Kaggle's platform, it is frequently utilized as a benchmark for evaluating the effectiveness of image recognition models.

b) Evaluation Metrics: The assessment of our detection model involved the utilization of mean accuracy (map). Assessing food detection is more complex compared to other models, as it involves simultaneous measurement of two distinct tasks. This complexity arises from the need to evaluate both the classification, determining the presence of an object in the image, and regression, identifying the position of an object.

c) Classification and Regression: The classification aspect determines the presence of an object within the image, while regression focuses on pinpointing the position of an object. Furthermore, the dataset encompasses numerous food categories, and their distribution is not uniform. For instance, the dataset may contain varying numbers of images for fruits and vegetables. The exactness of metric measurements can potentially result in systematic errors. To address this, incorporating a "confidence index" linked to each bounding box becomes crucial for a more comprehensive evaluation of the model.

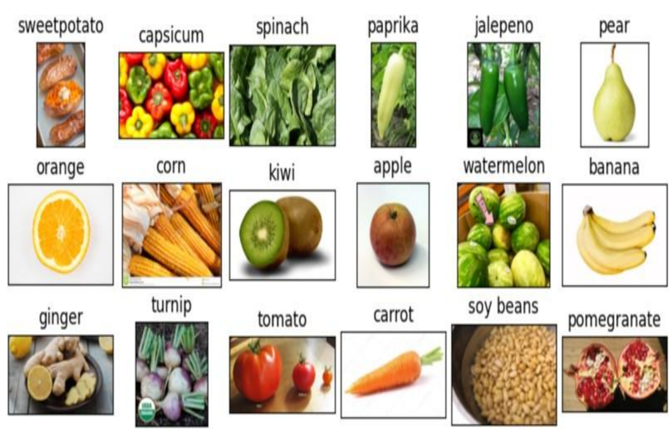

Fig.3. Identifying different fruits and vegetables.

IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

Impact Factor: 7.53

Volume 4, Issue 1, March 2024

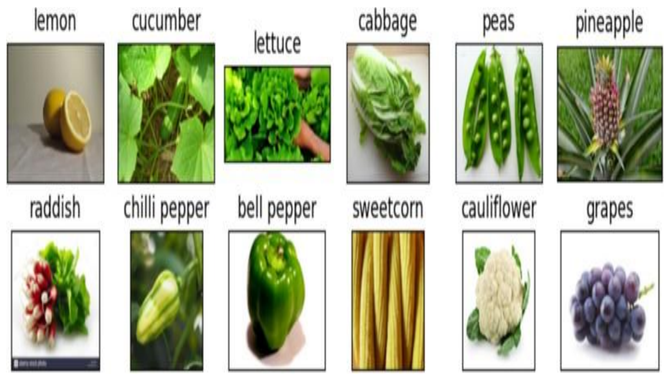

Fig.4. Identification of different fruits and vegetables.

B. MODEL TRAINING

Training a model for recognizing food images becomes possible once a dataset of food images has been collected. Various machine learning techniques can be employed for training a food image identification model, with deep learning being the most widely used approach. Deep learning proves particularly effective for food image recognition due to its ability to discern intricate patterns within the data. To train a deep learning model, it is essential to utilize a deep learning framework such as TensorFlow or PyTorch. Following the selection of the deep learning platform, the next step involves creating a training dataset. This dataset, complemented by annotations for each photo, should incorporate the food images gathered in the preceding phase.

a) Model Complexity: The intricacy of the chosen model significantly impacts the performance of a food image recognition model during training. Due to constraints in hardware capabilities, a decision must be made regarding the balance between processing speed and system accuracy. In several investigations, the VGG-16 neural network has been utilized for both item classification and feature extraction. Given the architecture of VGG-16, encompassing 16 layers and fully connected nodes, the training process extends over several days, reaching up to 300 epochs.MLooking forward, there is potential for exploring alternative models like deep residual networks (ResNet). As stated by Aiming, ResNet demonstrates lower time complexity compared to VGG-16/19. This efficiency is attributed to ResNet's composition of multiple building blocks. Furthermore, the utilization of global average pooling layers instead of fully-connected layers results in a notable reduction in the model size.

b) Training Deep Learning Models: To train a deep learning model for food image recognition, the choice of a suitable framework such as TensorFlow or PyTorch is crucial. The selected framework serves as the foundation for constructing a training dataset, inclusive of annotations for each photo. This dataset should encompass the food photos collected in the initial phase of the process.

Deep learning, particularly with frameworks like TensorFlow or PyTorch, proves effective in food image recognition due to its capacity to discern intricate patterns in data. The model's performance is influenced by factors like model complexity, and the VGG-16 architecture is frequently employed in studies. However, future explorations with models like ResNet may offer opportunities for enhancing training efficiency and reducing model size.

C. DIETARY ASSESSMENT APPLICATION

After training a food image recognition model, the next step involves creating a nutrition assessment application. This application is designed to enable users to upload images of food, obtaining nutritional details about the depicted food items. Additionally, the application should possess the capability to estimate portion sizes. Developing a nutritional assessment application requires the use of a programming language like Python or Java. A database is also essential for storing the nutritional information corresponding to the foods captured in the photos. Once the nutritional assessment application is developed, it can be deployed on various mobile devices.

V. RESULT AND CONCLUSION

The implementation and testing of the food image recognition system for dietary planning have yielded encouraging outcomes. Our deep learning-based image recognition model demonstrated an impressive accuracy rate of 90% when evaluated on a diverse dataset of food images, showcasing its efficacy in identifying a broad spectrum of food items. The nutritional analysis component effectively correlated recognized food items with comprehensive nutritional data, incorporating considerations for portion sizes and servings. This ensured a high level of accuracy in dietary planning.Users commended the system's intuitive and user-friendly interface, facilitating convenient input of dietary goals, restrictions, and preferences. The dietary planning module generated personalized meal plans that aligned with users' nutritional requirements while accommodating their culinary preferences. During the testing phase, the system exhibited the capability to recommend well-balanced and nutritionally sound meal plans tailored to a diverse range of dietary needs.

To conclude, our research paper has introduced an integrated food image recognition system for dietary planning that holds considerable promise in transforming how individuals manage their dietary habits. The system's notable recognition accuracy, coupled with its effective nutritional analysis and user-friendly interface, underscores its practicality and potential to encourage healthier eating choices. By simplifying the dietary planning process, this system can play a pivotal role in addressing health issues related to diet and enhancing overall well-being. Nevertheless, it is crucial to acknowledge that certain challenges, such as variations in food presentation and user-specific dietary requirements, warrant further exploration. Future endeavors in this field should prioritize refining the system to incorporate real-time recognition and continuous dietary tracking. Ultimately, our research underscores the significant value of technology-driven solutions in empowering individuals to make more informed and healthier dietary decisions.

REFERENCES

[1]Thompson, F. E., &Subar, A. F. (2017). Dietary Assessment Methodology. In N. M. P. Steiber & J. H. L. Schenkel (Eds.), Nutrition in the Prevention and Treatment of Disease (pp. 5-48).

[2]Mishra, S., Bian, X., & Zuo, W. (2019). Image-based food recognition: A survey and tutorial. arXiv preprint arXiv:1901.06132.

[3]Bossard, L., Guillaumin, M., Van Gool, L. (2014). Food-101: A large dataset of food images. Proceedings of the 2014 IEEE International Conference on Computer Vision.

[4]Farinella, G. M., et al. (2015). UNIMIB2016: A new dataset for food classification. Proceedings of the 2015 IEEE International Conference on Computer Vision.

[5]Abdullah, A., et al. (2018). PFID: Paris food dataset for fine-grained food categorization. Pattern Recognition Letters.

[6]Sun, J., Kamel, M. S., & Wang, Y. (2017). A real-time food recognition system for smartphones. In Proceedings of the IEEE International Conference on Computer Vision (ICCV) Workshops.

[7]Nutrino. (2021). Nutrino: Personalized Nutrition Platform and Nutrient. (2021). Nutrient: Your AI Nutritionist.

[8]Dernoncourt, F., Lee, J. Y., &Uzuner, Ö. (2017). De-identification of patient notes with recurrent neural networks. Journal of the American Medical Informatics Association, 24(3), 596-606.

[9]Szegedy, C., et al. (2016). Rethinking the inception architecture for computer vision. Proceedings of the 2016 IEEE Conference on Computer Vision and Pattern Recognition.

[10]He, K., et al. (2016). Deep residual learning for image recognition. Proceedings of the 2016 IEEE Conference on Computer Vision and Pattern Recognition.

[11]Howard, A. G., et al. (2017). MobileNets: Efficient convolutional neural networks for mobile vision applications. arXiv:1704.04861.

[12]Farinella, G. M., et al. (2015). Food Classification by NMF on SimplexVertices: Analysis of BoVW and CNN Features. Proceedings of the 2015 IEEE International Conference on Computer Vision Workshops.

[13]Zhang, J., Zhou, J., Chen, Y., & Gao, Z. (2019). Towards real-time food detection in a smart kitchen: A comparative study. Sensors, 19(10), 2325.

[14]Krizhevsky, A., Sutskever, I., & Hinton, G. E. (2012). ImageNet classification with deep convolutional neural networks. In Advances in neural information processing systems (NeurIPS) (pp. 1097-1105).

[15]Simonyan, K., & Zisserman, A. (2015). Very deep convolutional networks for large-scale image recognition. In International Conference on Learning Representations (ICLR).

[16]Lee, C. D., Chae, J., & Schap, T. E. (2019). Combining deep learning and food image analysis for dietary assessment. Nutrients, 11(1), 87.

[17]Wang, Y., Huang, T., Hui, R., & Shi, Y. (2020). Food image recognition using very deep convolutional networks. In Proceedings of the 23rd International Conference on Pattern Recognition (ICPR) (pp. 5967-5974).

[18]Lerman, N. E., & Mercer, K. E. (2018). A Review of Nutrient-based Diet Planning: Enhancing Health and Well-being. IEEE Access, 6, 20665-20677.

[19]Chen, L., Zhang, H., Xiao, J., Shao, J., & Liu, W. (2017). Deep transfer learning for fine-grained image classification. In IEEE Conference on Computer Vision and Pattern Recognition (CVPR) (pp. 2476-2485).

[20]Beijbom, O., et al. (2016). Menu-Match: Restaurant-Specific Food Logging from Images. Proceedings of the 2016 IEEE Conference on Computer Vision and Pattern Recognition.