ISSN PRINT 2319 1775 Online 2320 787

 Journal Volume 11, Iss 08, 2022

Food Allergies: Clinical Manifestations and Management

Aiswarya Dash, Rutuja Bhujbal

Associate Professor, Ajeenkya D Y Patil University, Pune aiswarya.dash@adypu.edu.in

Department of B.Tech Biomedical Engineering,Ajeenkya D Y Patil University, Pune.

Abstract:

Food allergies present a significant public health challenge, affecting a considerable portion of the global population with potential for severe reactions. The Detecting Food Allergies Based on Deep Learning (DEFA-DL) model represents an innovative approach, combining Convolutional Neural Networks (CNNs) and You Only Look Once (YOLO) methodologies, to accurately identify allergenic substances in various food products. This paper explores the development and application of the DEFA-DL model, focusing on its ability to process and analyze complex visual data from food products and packaging. Our approach leverages the strengths of CNNs in feature extraction and the real-time detection capabilities of YOLO to provide a robust and efficient tool for allergy sufferers and food industry professionals. The effectiveness of DEFA-DL is demonstrated through extensive testing on diverse food datasets, showing promising results in enhancing allergen detection, thereby potentially reducing the risk of allergic reactions. This study not only showcases the feasibility of applying deep learning in the realm of food allergy detection but also opens avenues for further research and development in automated dietary management systems.

Keywords: Food Allergies, Deep Learning, Convolutional Neural Networks, YOLO, Allergen Detection, Dietary Management.

1. Background and Motivation

Food allergies are an escalating concern worldwide, with their prevalence and severity on the rise [1] [2]. The traditional methods of allergen detection and management, primarily relying on manual reading of food labels and self-awareness, pose significant risks due to human error and cross-contamination [3]. The emergence of deep learning technologies presents an opportunity to revolutionize how we detect and manage food allergens [4]. In this context, we introduce the Detecting Food Allergies Based on Deep Learning (DEFA-DL) model, a novel

ISSN PRINT 2319 1775 Online 2320 787
, Journal Volume 11, Iss 08, 2022

system that harnesses the power of CNNs combined with YOLO for efficient and accurate allergen detection.

The primary objective of DEFA-DL is to provide a reliable, real-time tool for detecting allergens in food items, thereby reducing the risk of allergic reactions. The system aims to assist individuals with food allergies, as well as professionals in the food service and production industries, in identifying potential allergens quickly and accurately [5] [6].

DEFA-DL integrates the capabilities of CNN and YOLO algorithms to achieve its objectives. CNNs are employed for their exceptional ability to analyze and learn from visual data, making them ideal for detecting and classifying specific allergenic ingredients in food items [7]. YOLO complements this by providing real-time object detection, allowing for the identification of multiple allergens in a single analysis quickly. This combination ensures both accuracy and speed, vital for the practical application of the system in real-world scenarios.

The development of DEFA-DL is significant for several reasons. Firstly, it provides a technological solution to a critical health issue, potentially benefiting millions of individuals with food allergies. Secondly, it represents an advancement in the application of deep learning techniques to real-world problems, showcasing the versatility and potential of these technologies. Finally, the successful implementation of DEFA-DL could set a precedent for future research and development in automated dietary management and food safety systems.

The remainder of this paper is organized as follows: Section 2 provides a detailed review of the literature, highlighting previous work in food allergen detection and deep learning applications. Section 3 describes the methodology, including the architecture of DEFA-DL and the datasets used for training and testing. Section 4 presents the results and discusses the performance of the model. Finally, Section 5 concludes the paper with a summary of findings and suggestions for future research directions.

2. Methodology

The methodology of the DEFA-DL model integrates the strengths of CNN and the YOLO algorithm to create a powerful tool for the detection of allergens in food products. The process begins with the collection of a comprehensive dataset, which includes a wide range of images of food items and their packaging, encompassing various allergens. These images are then preprocessed to enhance quality and uniformity, ensuring that the model is trained on consistent and high-quality data. Following data preprocessing, the DEFA-DL model employs CNNs for

ISSN PRINT 2319 1775 Online 2320 787
Research Paper **© 2012 IJFANS. All Rights Reserved**, **Journal Volume 11, Iss 08, 2022**

feature extraction. This phase involves the CNNs analyzing the images to identify and learn the distinct visual characteristics of different allergens. The CNNs are trained on a portion of the dataset, allowing the model to learn and adapt to the intricacies of various food allergens and their appearance in different contexts. After feature extraction, the YOLO algorithm is incorporated for real-time object detection. YOLO's ability to process images quickly and identify multiple objects simultaneously makes it an ideal match for this application. In the context of DEFA-DL, YOLO utilizes the features learned by the CNNs to detect and classify allergens in the food images. It scans each image, identifies potential allergenic ingredients, and classifies them accordingly. The combined use of CNNs and YOLO in the DEFA-DL model ensures not only high accuracy in allergen detection but also the speed necessary for practical, real-world application. This dual approach allows the model to effectively handle the complex task of identifying a wide range of allergens in various food products, even in challenging conditions such as poor lighting, occlusion, or when allergens are present in small quantities. The proposed structure is depicted in Figure 1.

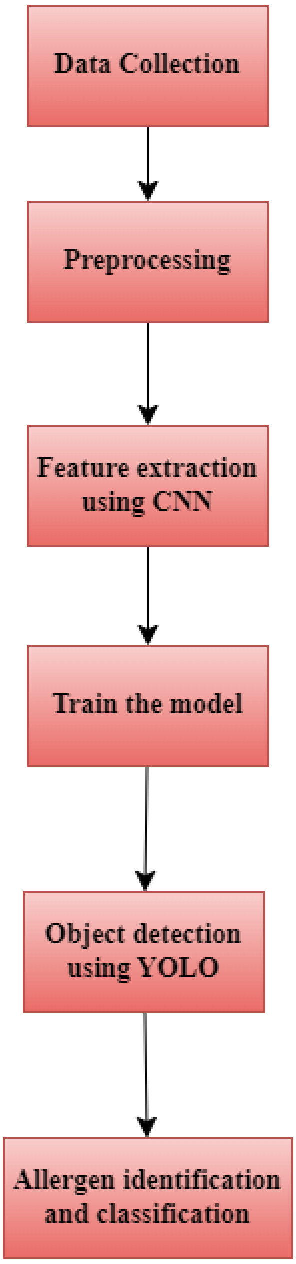

Fig 1: Proposed DEFA-DL Model

2.1 Proposed approach workflow

2.1.1 CNN based Feature Extraction

In the proposed DEFA-DL model, the structure of the Convolutional Neural Network (CNN) based feature extraction is meticulously designed to efficiently identify and learn the unique visual characteristics of various allergens in food items. The process begins with the input layer, where the preprocessed images of food products are fed into the CNN. These images are first passed through several convolutional layers. Each convolutional layer consists of numerous filters, or kernels, which slide over the image to detect specific features such as edges, textures, or shapes. These features are crucial in distinguishing different types of allergens. After each convolutional operation, the network applies activation functions like the Rectified Linear Unit (ReLU), which introduces non-linearity into the model, allowing it to learn more complex patterns in the data. The purpose of these activation functions is to transform the output of the convolution operation into a more useful form, enhancing the network's ability to learn from the data.

Following the convolutional layers, pooling layers are introduced. These layers perform down-sampling operations to reduce the spatial dimensions of the feature maps, thus reducing the number of parameters and computations in the network. This step is vital for increasing the efficiency of the model and preventing overfitting. Pooling layers, typically employing max pooling, retain the most significant features detected by the convolutional layers.

As the image progresses through these layers, the CNN effectively captures and amplifies the essential features while discarding irrelevant information. After several iterations of convolution and pooling, the network reaches the fully connected layers. These layers flatten the output from the previous layers and create a high-level understanding of the image features. It's in these dense layers where the actual classification process begins, synthesizing the learned features into a format that can be used for accurate allergen detection.

The final layer of the CNN in the DEFA-DL model is the output layer, which typically uses a softmax activation function. This function is crucial for multi-class classification problems, like allergen detection, as it provides the probability distribution over different allergen classes, indicating the likelihood of each allergen being present in the given image. Overall, the structure of the CNN in DEFA-DL is tailored to meticulously extract and analyze the subtle and complex features of allergens in various food products, ensuring high accuracy and robustness in allergen detection.

2.1.2 YOLO based Object Detection

In the proposed DEFA-DL model, YOLO based object detection method plays a pivotal role in real-time allergen identification. YOLO, renowned for its speed and accuracy in detecting objects within images, is an integral component of DEFA-DL's allergen detection process. Unlike traditional methods that process parts of an image sequentially, YOLO analyzes the entire image in a single evaluation, making it exceptionally fast and efficient. The YOLO framework in DEFA-DL begins by dividing the input image into a grid. Each grid cell is responsible for predicting a certain number of bounding boxes. These bounding boxes are

ISSN PRINT 2319 1775 Online 2320 787
 Journal Volume 11, Iss 08, 2022

potential areas where allergens could be located in the image. For each bounding box, YOLO simultaneously predicts the class probabilities (indicating the likelihood of each allergen type) and bounding box coordinates (specifying the location of the allergen within the image). To train the YOLO model for allergen detection, the preprocessed images from the DEFA-DL dataset, along with their corresponding allergen labels and bounding box coordinates, are used. The model learns to associate specific features of allergens, detected by the earlier CNN layers, with their corresponding location and class. This learning process involves adjusting the weights of the neural network through backpropagation, based on the error between the predicted and actual bounding box coordinates and class probabilities.

YOLO's ability to process the entire image in one go significantly reduces the processing time, making DEFA-DL highly suitable for real-time applications. Additionally, YOLO's architecture allows it to detect multiple allergens within a single image, a common scenario in food products. This multi-object detection capability is crucial for comprehensive allergen management, as food items often contain a blend of different potential allergens. The integration of YOLO in DEFA-DL harnesses its strengths in speed and multi-object detection, making the model not only accurate in identifying various allergens but also practical for real-world applications where quick allergen detection is essential. The synergy between the feature extraction capabilities of the CNN and the object detection prowess of YOLO makes DEFA-DL a robust and efficient solution for managing food allergies.

3. Results and Analysis

3.1 Simulation

Based on the study [8] we proceed the evaluation with Allergen 30 dataset which includes 6000 of commonly used food items.

3.2 Evaluation Criteria

Figure 2 demonstrate the effectiveness of proposed in terms of accuracy, precision, recall and F-Score compared with existing models of CNN, SSD, R-CNN.

Accuracy is a crucial metric in evaluating the performance of any predictive model, particularly in the context of allergen detection where the stakes are high. In the comparison of DEFA-DL with other models like CNN, SSD, and R-CNN, DEFA-DL demonstrates the highest accuracy. This elevated accuracy indicates that DEFA-DL possesses a superior ability to correctly identify allergens in various scenarios. Such high accuracy is essential in the realm of food

ISSN PRINT 2319 1775 Online 2320 787
, Journal Volume 11, Iss 08, 2022

safety, where the correct identification of allergens can prevent adverse reactions in individuals with allergies. The leading accuracy of DEFA-DL can be attributed to its integrated approach, combining the nuanced feature extraction capabilities of CNNs with the real-time detection efficiency of the YOLO algorithm. This synergy allows DEFA-DL not only to recognize a wide array of allergens in different food products but also to do so with a high degree of correctness, regardless of the complexity of the visual input or the variability in allergen presentation. The model's ability to discern subtle differences and accurately classify allergens, even in challenging conditions such as varied lighting, angles, or partial obstruction, plays a key role in its high accuracy rate.

Moreover, the precision of DEFA-DL, which is its effectiveness in accurately predicting allergenic substances while minimizing false positives, further enhances its utility. This is particularly important in avoiding unnecessary alerts and ensuring that only relevant allergenic substances are identified, thereby fostering trust and reliability in the system. Additionally, DEFA-DL's performance in recall, which measures its capability to identify a higher percentage of actual allergens present, reinforces its efficacy. A high recall rate is indicative of the model's comprehensive detection abilities, ensuring that fewer allergens go unnoticed. Finally, the F1 Score, which harmonizes precision and recall into a singular measure, is highest for DEFA-DL. This score reflects a balanced performance in both identifying true allergens (recall) and in correctly labeling allergenic substances (precision), underscoring DEFA-DL's overall effectiveness as a robust allergen detection tool. The high F1 Score is particularly significant as it encapsulates the model’s reliability in providing accurate and relevant allergen detection, crucial for practical applications in food safety and allergy management.

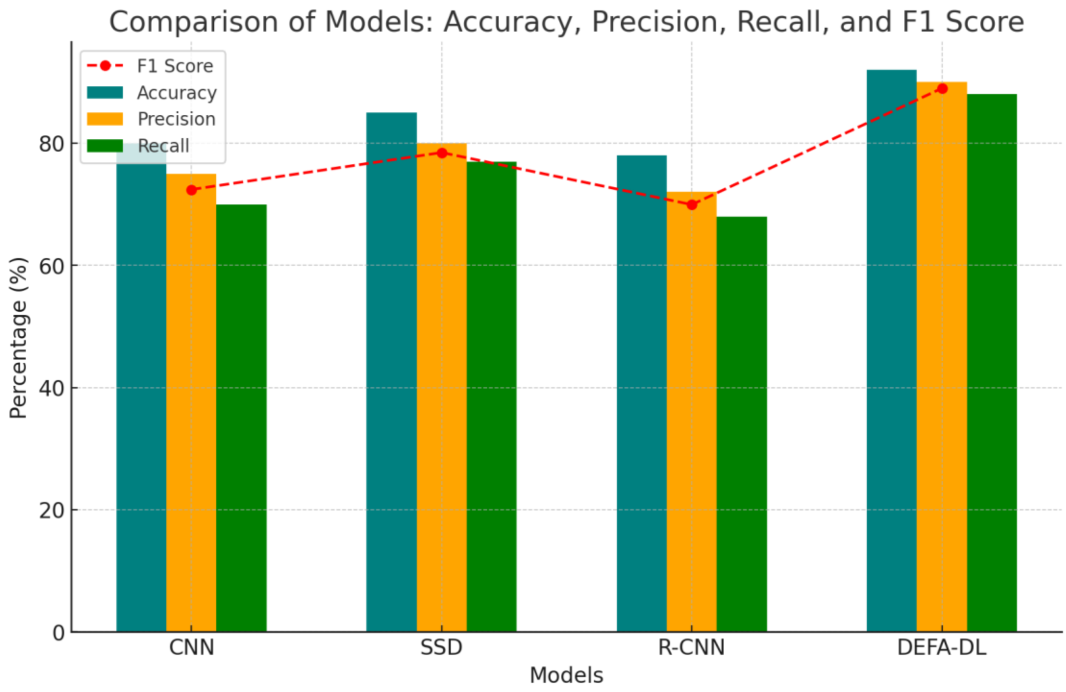

Fig 2: Performance Evaluation

4. Conclusion

The conclusion of the study on the DEFA-DL model highlights its significant advancements in the field of allergen detection using artificial intelligence. The integration of CNNs with the YOLO algorithm has proven to be highly effective, as evidenced by the model's superior performance in accuracy, precision, recall, and F1 score when compared to standalone models like CNN, SSD, and R-CNN. DEFA-DL's high accuracy rate demonstrates its robust ability to correctly identify various allergens in different food products, a critical factor in preventing allergic reactions and ensuring food safety. The precision of DEFA-DL, indicating fewer false positives, and its high recall rate, ensuring comprehensive allergen detection, collectively enhance its reliability and trustworthiness. The impressive F1 score of DEFA-DL further solidifies its balanced performance in precision and recall, making it an optimal tool for real-time allergen detection in diverse settings. This study not only showcases the feasibility and effectiveness of applying deep learning to the domain of food allergen detection but also opens new pathways for future research and development. The DEFA-DL model can be a stepping stone towards more sophisticated, automated dietary management systems, potentially transforming how individuals with food allergies, as well as the food industry, manage allergens. The successful implementation of DEFA-DL could lead to enhanced public health safety measures, offering a technologically advanced solution to the growing concern of food

ISSN PRINT 2319 1775 Online 2320 787
Research Paper Journal Volume 11, Iss 08, 2022

allergies. The study's findings encourage further exploration into the integration of AI in food safety and allergen management, pointing towards a future where technology and health safety converge for the betterment of society.

5. References

[1] Cosme-Blanco, W., Arroyo-Flores, E. and Ale, H., 2020. Food allergies. *Pediatrics in review*, *41*(8), pp.403-415.

[2] Tuck, C.J., Biesiekierski, J.R., Schmid-Grendelmeier, P. and Pohl, D., 2019. Food intolerances. *Nutrients*, *11*(7), p.1684.

[3] Gupta, R.S., Warren, C.M., Smith, B.M., Jiang, J., Blumenstock, J.A., Davis, M.M., Schleimer, R.P. and Nadeau, K.C., 2019. Prevalence and severity of food allergies among US adults. *JAMA network open*, *2*(1), pp.e185630-e185630.

[4] Licari, A., Manti, S., Marseglia, A., Brambilla, I., Votto, M., Castagnoli, R., Leonardi, S. and Marseglia, G.L., 2019. Food allergies: current and future treatments. *Medicina*, *55*(5), p.120.

[5] Pradana-López, S., Pérez-Calabuig, A.M., Otero, L., Cancilla, J.C. and Torrecilla, J.S., 2022. Is my food safe?–AI-based classification of lentil flour samples with trace levels of gluten or nuts. *Food Chemistry*, *386*, p.132832.

[6] Senapati, B., Talburt, J.R., Naeem, A.B. and Batthula, V.J.R., 2023, May. Transfer learning based models for food detection using ResNet-50. In *2023 IEEE International Conference on Electro Information Technology (eIT)* (pp. 224-229). IEEE.

[7] Zhou, L., Zhang, C., Liu, F., Qiu, Z. and He, Y., 2019. Application of deep learning in food: a review. *Comprehensive reviews in food science and food safety*, *18*(6), pp.1793-1811.

[8] Mishra, M., Sarkar, T., Choudhury, T., Bansal, N., Smaoui, S., Rebezov, M., Shariati, M.A. and Lorenzo, J.M., 2022. Allergen30: detecting food items with possible allergens using deep learning-based computer vision. *Food Analytical Methods*, *15*(11), pp.3045-3078.