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Transfer Learning Approach to Identify Food Allergy

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Abstract: Obesity, a curable medical illness caused by excessive calorie consumption, may lead to many health complications such as diabetes, high cholesterol, heart attacks, high blood pressure, and colon and prostate cancer. Computer-based solutions are routinely employed to solve these challenges. The goal of this project is to provide a system for detecting and diagnosing food allergies based on food images. The approach employs transfer learning (ResNET 50) to identify food kinds, validate labels in the Food 101 dataset, and deliver nutrients. The major objective is to establish a single framework capable of handling food allergy detection, location, and classification. The study additionally enhances weight parameter optimization using Adam and RMS Prop optimizers. Resnet-50 has the highest mean average accuracy of any transfer learning meta-architecture when using an Adam optimizer, at 95%. Based on another dataset, the suggested technique detects and offers nutrients for all types of food. Successful food allergy detection might lessen the harmful effects of diet management issues.

Keywords: *Transfer Learning, Food Allergies, Adam, Resnet-50, Deep Learning Model*

1. Introduction

A major player in the fresh-cut cauliflower market is cauliflower, a popular vegetable known for its high yield, nutritional content, and financial advantages. However, it is challenging to ensure the quality of fresh-cut cauliflower due to the slowness and poor accuracy of the techniques used to identify surface defects [1]. Studies have shown that machine vision technologies can identify surface defects in agricultural goods with excellent accuracy rates. This suggested an enhanced Mask R-CNN technique that achieved a 90% accuracy rate in correctly identifying tomato fruits divided into distinct ripeness degrees in a greenhouse setting. To sum up, the development and profitability of the fresh-cut cauliflower sector depend heavily on the identification and detection of surface imperfections [2]. The quality and effectiveness of these procedures may now be enhanced because of developments in artificial intelligence and machine vision technologies. Deep learning is an effective technique for identifying quality issues in agricultural products, especially when it comes to identifying surface flaws in freshly cut cauliflower. This work developed a model for the automated identification of these flaws by combining a CNN with transfer learning, offering important new information for fresh-cut fruit and vegetable quality assessment [3]. Food allergies are immune reactions brought on by unfavorable reactions to certain foods; they may cause life-threatening symptoms such as anaphylaxis and gastrointestinal problems. The immune system's reaction to allergens like histamine and leukotriene that enter the body causes these allergies. Common foods include cow's milk, chicken eggs, α-lactalbumin, β-lactalbumin, and casein, among other allergies. To prevent or reduce allergy diseases, it is essential to comprehend the molecular processes behind food allergens [4]. The main results of food allergy research, including studies from computational biology, bioinformatics, and experimental investigations, are highlighted in this overview. Along with offering recommendations for potential directions and areas of future study, it also examines databases and instruments used in the identification and analysis of food allergies [5].

The contribution of paper is managing the challenging process of identifying, localizing, and classifying food allergies. One significant issue is the difficulty in categorizing nutrients in food and determining the type of allergy present because there are numerous types of food allergies. The prevention of illness in children would benefit from the detection of food allergies. With supervised learning, a food image is taken, the food is then classified into different nutrients, and following classification, the type of allergy is determined.

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2. Literature Review

Over the course of more than 110 years, allergen immunotherapy (AIT) has been applied in a variety of ways, including sublingual, subcutaneous, oral, and oral immunotherapy. AIT's primary goal is to develop immunological tolerance to allergens, which is characterized as a persistent clinical tolerance to in vivo exposures or natural exposure [6]. When a person eats anything that triggers an allergic response, it's usually because of cross-contamination throughout the pre- and post-harvest processing stages. Although regulatory bodies such as the FDA have been passing legislation to lessen the occurrence of allergen contamination, they continue to discover that new laws and updates to the list are necessary, particularly in regards to correct labeling and detection criteria. For regulatory organizations like the FDA and USDA to effectively monitor and enforce regulations, they must have access to analytical tools [7]. To improve food throughput and safety, the food sector is embracing sector 5.0 digital solutions, such as non-destructive technology. Consumers must immediately evaluate meals for themselves, while businesses and government organizations need straightforward instruments for food evaluation and prompt feedback mechanisms. The effective allergy detection technologies available today come with drawbacks, such as waste generation, delayed feedback, and sample preparation [8]. Through their interactions with light and sensors, advances in machine and deep learning have led to improved accuracy in pattern recognition and quantitative-non-destructive assessment technologies for tiny levels of biological and chemical material components in meals. One significant drawback is the high implementation cost, however creative fixes are bringing the technique closer to affordability. An iconic example of artificial intelligence (AI) being used in the food supply chain is the coupling of sensors with machine learning for allergy identification [9]. This approach reduces human intervention and reaction times while improving the allergen detection method's sustainability. Deep learning models can analyze medical pictures to make a diagnosis, and machine learning has been utilized in hospitals to expedite diagnosis and analysis. On the other hand, patients' chances of survival depend on early detection of lung cancer [10].

In order to avoid food allergic responses and support those who are prone to allergies in making informed food purchases, analytical methods that enable quick and on-site identification of food allergens are imperatively needed. Over the last ten to fifteen years, the frequency of food allergies (FAs) has grown, making them a serious public health concern. The clinical management of FA has generated debate; prior guidelines focused on food avoidance and the delayed introduction of allergic foods to high-risk babies throughout the weaning process [11]. Nevertheless, research has shown that delayed exposure to foods containing allergens does not lower the incidence of FA and may have serious negative effects on the quality of life for patients and their families, raising societal expenses. The early introduction of allergenic foods is now advised by clinical practice guidelines, which has changed newborn feeding habits in several areas [12]. Whether early introduction of foods containing allergens would lower the population's overall incidence of FA is yet unknown. Numerous studies, especially in the cases of peanut and egg allergies, have shown decreased FA if numerous allergenic foods were introduced earlier. IgE-mediated and non-IgE-mediated immune mechanisms are the two types of immune processes that may produce FA [13]. The diagnostic process starts with a thorough physical examination and gathering of medical history; at this point, the gold standard for diagnosis is the oral food challenge (OFC). The goal of treatment is to get rid of the offending allergen. People who are at risk of anaphylaxis should also learn how to administer self-injectable epinephrine and notice early signs [14]. One effective tactic to reduce the development of FA in infants is to introduce allergenic foods early in infancy. Atopic dermatitis (AD) is a long-term, itchy, inflammatory skin disorder marked by immunological dysregulation and compromised skin barrier function. Serious AD and early start are important risk factors for the development of FA in youngsters [15].

One in ten children and one in 100 adults are allergic to plants. Prolamins and cupins, two types of storage proteins found in seeds, are linked to the majority of plant allergies. These proteins may result in mild to severe allergic responses and are generally thought to be quite durable against gastrointestinal proteases, acidic environments, and heat denaturation [16]. Kiwi fruit has been added to the CODEX watch list as an emerging allergy by the WHO FAO Expert Committee on Risk Assessment of Food Allergens. Cross-allergenicity is often caused by high sequence and structural homology, which is frequently ascribed to the similarity of the epitopic sequences [17]. A major player in the fresh-cut cauliflower market is cauliflower, a popular vegetable known for its high yield, nutritional content, and financial advantages. However, it is challenging to ensure the quality of fresh-cut cauliflower due to the slowness and poor accuracy of the techniques used to identify surface defects. Studies have shown that machine vision technologies can identify surface defects in agricultural goods with excellent accuracy rates [18]. This suggested an enhanced Mask R-CNN technique that

achieved a 90% accuracy rate in correctly identifying tomato fruits divided into distinct ripeness degrees in a greenhouse setting. To sum up, the development and profitability of the fresh-cut cauliflower sector depend heavily on the identification and detection of surface imperfections [19]. The quality and effectiveness of these procedures may now be enhanced because to developments in artificial intelligence and machine vision technologies. Deep learning is an effective technique for identifying quality issues in agricultural products, especially when it comes to identifying surface flaws in freshly cut cauliflower [20]. This work developed a model for the automated identification of these flaws by combining a CNN with transfer learning, offering important new information for fresh-cut fruit and vegetable quality assessment [21]. Food allergies are immune reactions brought on by unfavorable reactions to certain foods; they may cause life-threatening symptoms such as anaphylaxis and gastrointestinal problems. The immune system's reaction to allergens like histamine and leukotriene that enter the body causes these allergies [22]. Common foods include cow's milk, chicken eggs, α-lactalbumin, β-lactalbumin, and casein, among other allergies. To prevent or reduce allergy diseases, it is essential to comprehend the molecular processes behind food allergens [23].

3. Material and Methods

This section contains the methodology of the study.

3.1 Methodology

This section contains the methodology of the study. The implementation of food allergy classification and the following three consecutive sections,

- Acquiring the image Kaggle
- Feature extraction.
- Predictive food allergy through non-destructive analysis

In step I, the Data set is collected from Kaggle and a preprocessing is performed on it. In step II food allergy classification is performed by implementing Resnet-50 by using COLAB. In step III designing a model for standardized predicting food allergy through non-destructive analysis. The methodology of the proposed work is illustrated in Figure 1.

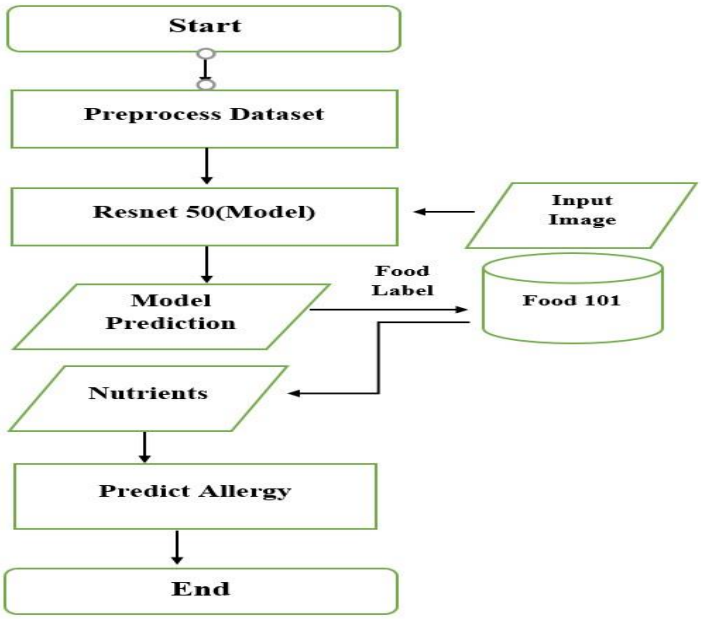

Fig 1: Methodology of Proposed Work

3.2 Dataset Collection

The dataset of food allergy images was collected from Kaggle. More than 15000 high-resolution images of food allergy were taken. The food allergy variety dataset was split into training-dataset and validation with a ratio of 70% and 30% respectively. 11700 images for training and 3300 images for testing. Figure 2 show data set.

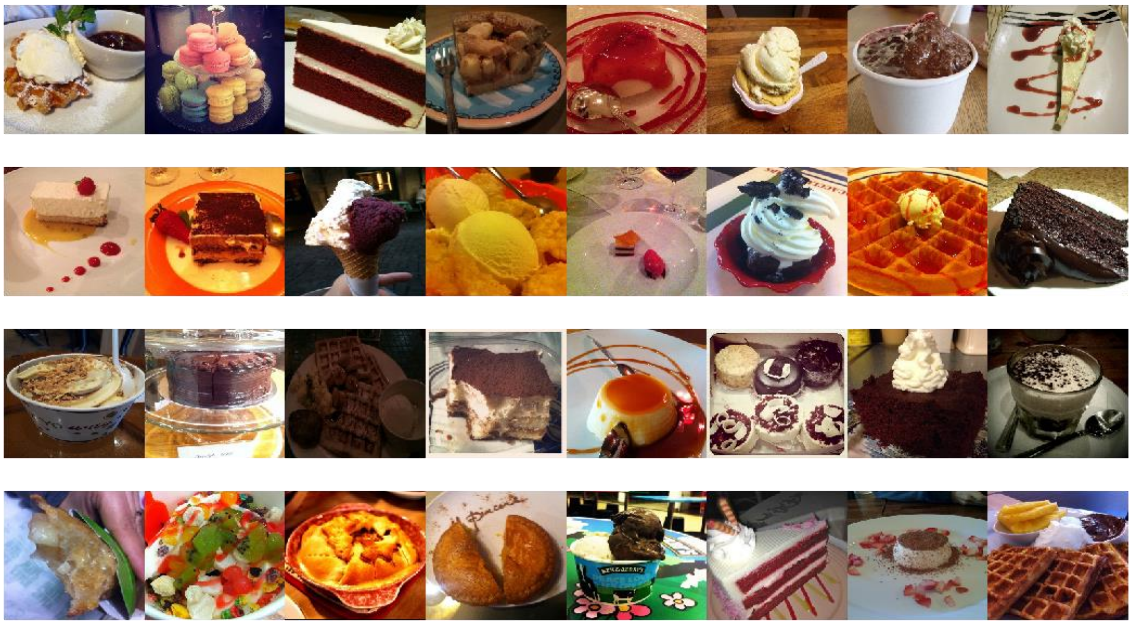

Fig 2 Data Set

3.3 Preprocessing

It recognizes particular characteristics using a convolution kernel, resulting in a feature map that is not redundant. Each feature identifier in convolution removes and eliminates features from the original picture, yielding a map with altitude. Convolution in CNN tries to extract key characteristics automatically using tiny kernels and constant kernel parameters, resulting in weight-sharing across receptive neurons. This approach is necessary for image processing since it cannot deconstruct the symbolic content of the pictures being investigated.

3.4 Recognition Process

Resnet-50 is a highly layered structural neural network that includes convolution, pooling, and fully connected layers. Inception v3 is made up of symmetric and asymmetric building blocks, with a small number of neurons and a bottleneck layer (11 convolutions) to decrease computation needs. The Inception architecture seeks to operate as a multi-level feature extractor, calculating 11, 33, and 55 convolutions inside the same network module.

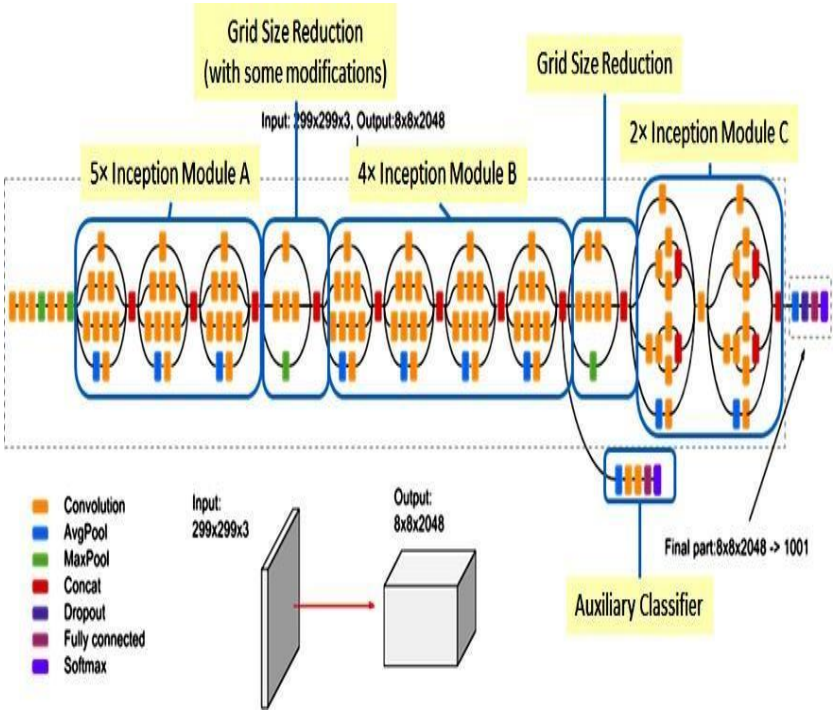

Fig 3 Process of CNN

Figure 3 show process of CNN. Inception v3 was used to classify popular four types of food allergies in Pakistan and ASIAN Nation. The resnet-50 model processed the image and classified it into the appropriate class. The CNN model used a food allergy image as input, which underwent convolution and pooling operations before being input for fully connected layers. The softmax was applied for multiclass classification.

4. Results & Discussions

The implementation of the proposed methodology is performed to get the best results. A comparative analysis with different models is conducted, and results are obtained and explained by using the proposed methodology with the help of graphs and tables. Results are achieved by dataset distribution into the training dataset and testing dataset with the proportion of 70% and 30% respectively. In transfer learning for dataset distribution, it is a general thumb of rule larger training datasets good quality of dataset results in better performance. In the proposed work, the above-mentioned distribution of the dataset is used to avoid the model becoming underfit due to the small training dataset. Some important terminologies are also defined here to better understand the result analysis. Figure 4 shows the Result Of Resnet 50 Of Training And Validation Set. The results show that the training loss of the model is decreasing continuously as the training progresses and we stop the training at an optimal loss.

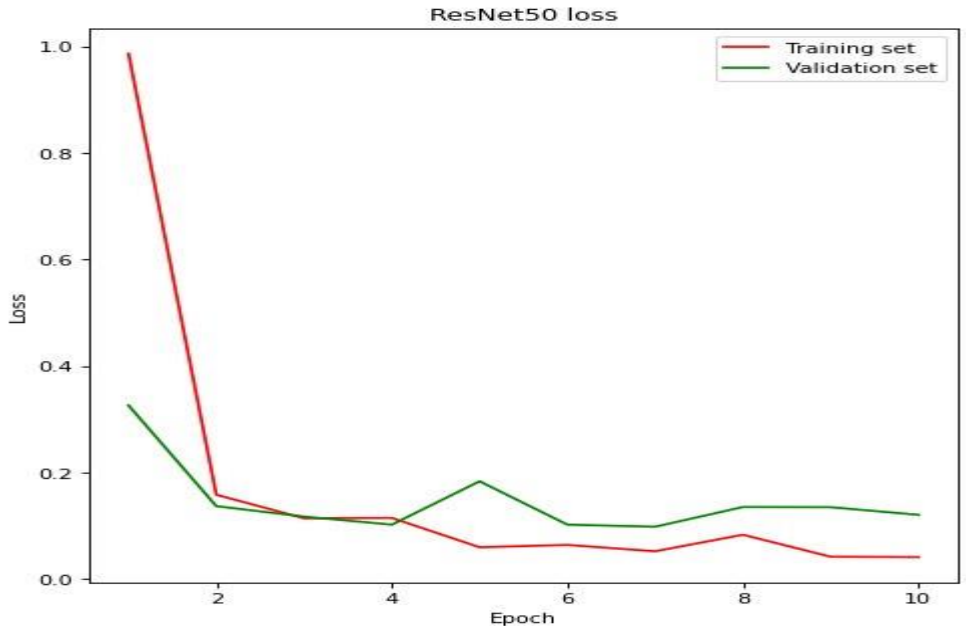

Fig 4 Result Of Resnet 50 Of Training And Validation Set.

4.1 Model Accuracy

Accuracy is the amount of classified correctly instances of the total instances. Predictive models' accuracy is important to correctly quality determination of predictions to form the scientific evidence for policies and decision making. Measurement of Predictive accuracy differentiates between observed and predicted values. Predictive accuracy based on predicted and observed value differences for the new samples and predicted values refers often to the values that were modeled based on training samples. Figure 5 shows the accuracy of ResNet 50.

$$\text{Accuracy} = \frac{\text{Number of correct predictions}}{\text{Total number of predictions}}$$

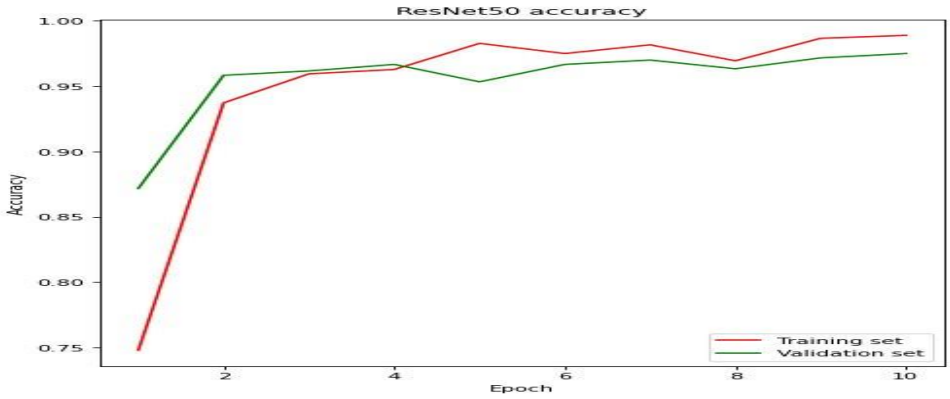

Fig 5 Accuracy of ResNet 50

4.2 Identification of Food Allergy

The experimental results show the model prediction on the test image set. The results show the model performance in Figure 6.

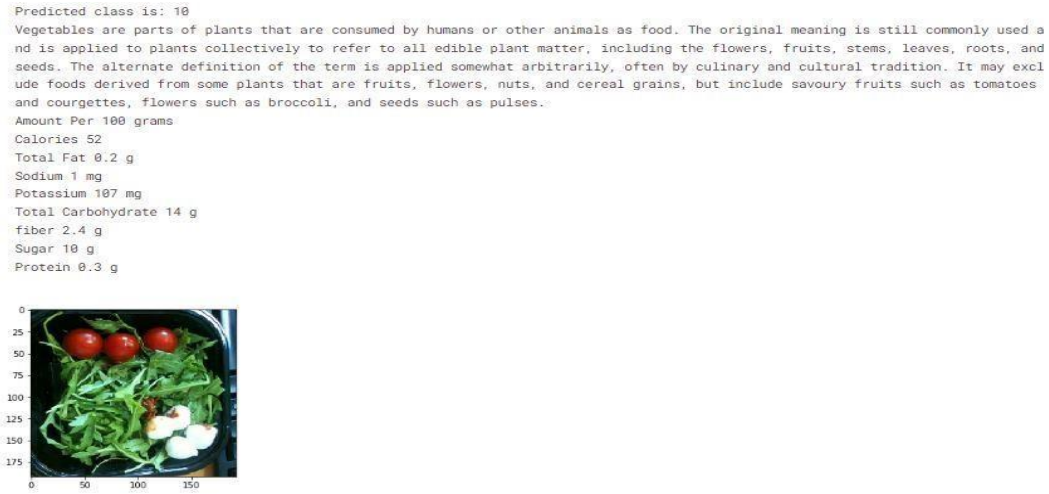

Fig 6 Result of Model Performance

5. Conclusion and Future Work

Using the data acquired, transfer learning Resnet-50 gave an amazing answer to our project. To extract a useful discriminative feature, the model must be fine-tuned by altering the hyperparameters. On the other hand, transfer learning is the most effective way of classifying (food) photographs and determining their nutritional content. This strategy yields 95% accuracy. This research presents a complete and non-invasive approach to addressing food allergies. Identification that could help keep children healthy. Early detection of food allergies may assist in avoiding childhood illness. In the future, we may develop mobile apps employing our knowledge for end users, allowing them to utilize their phones to detect food sensitivities and avoid illness. As a result, in the future, there will be no need to manually extract picture categorization characteristics. The original features may be extracted by employing kernel matrices as local feature extractors.

References

[1] B. Senapati, J. R. Talburt, A. Bin Naeem and V. J. R. Batthula, "Transfer Learning Based Models for Food Detection Using ResNet-50," 2023 IEEE International Conference on Electro Information Technology (eIT), Romeoville, IL, USA, 2023, pp. 224-229, doi: 10.1109/eIT57321.2023.10187288.

[2] H. S. Ahmad *et al.*, "Improving Water Use Efficiency through Reduced Irrigation for Sustainable Cotton Production," *Sustainability*, vol. 13, no. 7, p. 4044, 2021. [Online]. Available: https://www.mdpi.com/2071-1050/13/7/4044.

[3] J. Amara, B. Bouaziz, and A. Algergawy, "A Deep Learning-based Approach for Banana Leaf Diseases Classification," in *BTW*, 2017.

[4] L. Bolier, M. Haverman, G. J. Westerhof, H. Riper, F. Smit, and E. Bohlmeijer, "Positive psychology interventions: a meta-analysis of randomized controlled studies," (in eng), *BMC Public Health*,

vol. 13, p. 119, Feb 8, 2013, doi: 10.1186/1471-2458-13-119.

[5] A. B. Naeem et al., "Heart Disease Detection Using Feature Extraction and Artificial Neural Networks: A Sensor-Based Approach," in IEEE Access, vol. 12, pp. 37349-37362, 2024, doi: 10.1109/ACCESS.2024.3373646.

[6] D. Doğruel, G. Bingöl, M. Yılmaz, and D. U. Altıntaş, "The ADAPAR Birth Cohort Study: Food Allergy Results at Five Years and New Insights," *International Archives of Allergy and Immunology*, vol. 169, no. 1, pp. 57-61, 2016, doi: 10.1159/000443831.

[7] D. M. Fleischer *et al.*, "A Consensus Approach to the Primary Prevention of Food Allergy Through Nutrition: Guidance from the American Academy of Allergy, Asthma, and Immunology; American College of Allergy, Asthma, and Immunology; and the Canadian Society for Allergy and Clinical Immunology," *The Journal of Allergy and Clinical Immunology: In Practice*, vol. 9, no. 1, pp. 22-43.e4, 2021/01/01/ 2021, doi: https://doi.org/10.1016/j.jaip.2020.11.002.

[8] R. X. Foong, J. A. Dantzer, R. A. Wood, and A. F. Santos, "Improving Diagnostic Accuracy in Food Allergy," (in eng), *J Allergy Clin Immunol Pract*, vol. 9, no. 1, pp. 71-80, Jan 2021, doi: 10.1016/j.jaip.2020.09.037.

[9] S. Halken *et al.*, "EAACI guideline: Preventing the development of food allergy in infants and young children (2020 update)," (in eng), *Pediatr Allergy Immunol*, vol. 32, no. 5, pp. 843-858, Jul 2021, doi: 10.1111/pai.13496.

[10] Naeem, A. B. ., Senapati, B. ., Mahadin, G. A. ., Ghulaxe, V. ., Almeida, F. ., Sudman, S. I. ., & Ghafoor, M. I. . (2024). Determine the Prevalence of Hepatitis B and C During Pregnancy by Using a Machine Learning Algorithm. International Journal of Intelligent Systems and Applications in Engineering, 12(13s), 744–751. Retrieved from https://www.ijisae.org/index.php/IJISAE/article/view/4704.

[11] M. Kebede, D. Ehrich, P. Taberlet, S. Nemomissa, and C. Brochmann, "Phylogeography and conservation genetics of a giant lobelia (Lobelia giberroa) in Ethiopian and Tropical East African mountains," *Molecular Ecology*, vol. 16, 2007.

[12] M. Kebede, D. Ehrich, P. Taberlet, S. Nemomissa, and C. Brochmann, "Phylogeography and conservation genetics of a giant lobelia (Lobelia giberroa) in Ethiopian and Tropical East African mountains," (in eng), *Mol Ecol*, vol. 16, no. 6, pp. 1233-43, Mar 2007, doi: 10.1111/j.1365-294X.2007.03232.x.

[13] A. Khan, D. Khan, and F. Akbar, "Bibliometric analysis of publications on research into cotton leaf curl disease," (in eng), *Discoveries (Craiova)*, vol. 8, no. 2, p. e109, Jun 7 2020, doi: 10.15190/d.2020.6.

[14] P. Krithika and S. Veni, "Leaf disease detection on cucumber leaves using multiclass Support Vector Machine," *2017 International Conference on Wireless Communications, Signal Processing and Networking (WiSPNET)*, pp. 1276-1281, 2017.

[15] Naeem, A. B., Khalid, F., Soomro, A. M., Del Mundo, A. D., Zaidi, A., Senapati, B., & Doshi, O. P. (2023, March 29). Early Gender Identification of Date Palm Using Machine Learning | Journal of Computing & Biomedical Informatics. Early Gender Identification of Date Palm Using Machine Learning | Journal of Computing & Biomedical Informatics. https://www.jcbi.org/index.php/Main/article/view/147.

[16] W. Loh and M. L. K. Tang, "The Epidemiology of Food Allergy in the Global Context," (in eng), *Int J Environ Res Public Health*, vol. 15, no. 9, Sep 18, 2018, doi: 10.3390/ijerph15092043.

[17] C. Lozoya-Ibáñez, S. Morgado-Nunes, A. Rodrigues, C. Lobo, and L. Taborda-Barata, "Prevalence and clinical features of adverse food reactions in Portuguese adults," (in eng), *Allergy Asthma Clin Immunol*, vol. 12, p. 36, 2016, doi: 10.1186/s13223-016-0139-8.

[18] Naeem, A.B., Soomro, A.M., Saim, H.M. et al. Smart road management system for prioritized autonomous vehicles under vehicle-to-everything (V2X) communication. Multimed Tools Appl (2023). https://doi.org/10.1007/s11042-023-16950-1.

[19] Bowler, A.L.; Ozturk, S.; Rady, A.; Watson, N. Domain Adaptation for In-Line Allergen Classification of Agri-Food Powders Using Near-Infrared Spectroscopy. Sensors 2022, 22, 7239. https://doi.org/10.3390/s22197239

[20] Naeem, A. B. ., Senapati, B. ., Chauhan, A. S. ., Makhija, M. ., Singh, A. ., Gupta, M. ., Tiwari, P. K. ., & Abdel-Rehim, W. M. F. . (2023). Hypothyroidism Disease Diagnosis by Using Machine Learning Algorithms. International Journal of Intelligent Systems and Applications in Engineering, 11(3), 368–373. Retrieved from

https://www.ijisae.org/index.php/IJISAE/article/view/3178.

[21] B. I. Nwaru *et al.*, "The epidemiology of food allergy in Europe: protocol for a systematic review," (in eng), *Clin Transl Allergy*, vol. 3, no. 1, p. 13, Apr 1, 2013, doi: 10.1186/2045-7022-3-13.

[22] S. L. Prescott *et al.*, "A global survey of changing patterns of food allergy burden in children," (in eng), *World Allergy Organ J*, vol. 6, no. 1, p. 21, Dec 4, 2013, doi: 10.1186/1939-4551-6-21.

[23] Naeem, A. B., Senapati, B., Chauhan, A. S., Kumar, S., Orosco Gavilan, J. C., & F. Abdel-Rehim, W. M. (2023, February 17). Deep Learning Models for Cotton Leaf Disease Detection with VGG-16 | International Journal of Intelligent Systems and Applications in Engineering. Deep Learning Models for Cotton Leaf Disease Detection With VGG-16 | International Journal of Intelligent Systems and Applications in Engineering. https://www.ijisae.org/index.php/IJISAE/article/view/2710.

[24] A. B. Naeem *et al*., "Heart Disease Detection Using Feature Extraction and Artificial Neural Networks: A Sensor-Based Approach," in *IEEE Access*, vol. 12, pp. 37349-37362, 2024, doi: 10.1109/ACCESS.2024.3373646. keywords: {Heart;Medical diagnostic imaging;Artificial neural networks;Medical diagnosis;Hospitals;Feature extraction;Cardiovascular diseases;Deep learning;Biosensors;Sensor systems;Identification of persons;Heart disease;deep learning;ANN;feature extraction;sensor},