NutriScan: Food Quality Detection using Deep Learning

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I. Abstract

Ensuring food quality is critical to public health and minimizing food waste. This paper presents a deep learning-based system to detect the quality of food items particularly fruits and vegetables through image classification. Leveraging techniques such as image preprocessing, data augmentation, and clustering (K-Means, Agglomerative, DBSCAN), the system trains models to classify food images based on freshness levels, which can be assessed for usage. The YOLOv8 model is employed for real- time, high-precision object detection, enabling identification of defects and spoilage even under challenging conditions. Experimental results demonstrate that the AlexNet model, when paired with Agglomerative clustering, achieves the highest accuracy and F1 score, highlighting the effectiveness of clustering-enhanced classification. This method has significant implications for automated food inspection systems, offering scalable solutions to improve food safety, decrease waste, and improve inventory management. The proposed approach has far-reaching implications for the automation of food inspection processes. It presents a scalable, real-time solution capable of enhancing food safety protocols, reducing food loss due to misclassification, and improving inventory management in the supply chain.

Keywords -Deep Learning, Image Classification, Clustering Algorithms, Data Augmentation, YOLOv8, Data Preprocessing

II. Introduction

Food is a basic necessity for all living beings, acting as the primary source of energy and nutrition required for growth, development, and survival. Carbohydrates, proteins, fats, vitamins, and minerals are the essential nutrients contained, which support many functions of body and maintain overall health. Foods that we directly consume should be well in quantity and quality, they impact our physical and mental performance, improving the ability to lead productive lives. Food that is prepared from fresh, healthy vegetables and fruits is very important for a balanced and nutrition rich diet. Consuming food in good condition is fundamental to maintaining health and preventing illness [1]. Unfortunately, there's been a noticeable rise in the availability of poor-quality raw food items lately, which presents significant health risks to consumers.

Raw materials like fruits, vegetables, meat, and grains can become unfit for consumption due to contamination from various bacteria, fungi, and other harmful substances. This contamination often arises from inadequate storage and improper transportation facilities. Additionally, the practice of spraying hormones, pesticides, and other harmful substances can artificially extend shelf life, masking the true quality of the product. To guarantee the delivery of high-quality food, it's essential to implement and maintain a robust monitoring system that constantly checks for spoilage and damage.

[2] This research is aimed to check the quality of food that is being used as raw materials to prepare further products.

Spoiled fruits and vegetables are a significant concern in the food industry, with the primary objective being their prompt discard to ensure only suitable items are used in food preparation. Modern technology offers numerous avenues for assessing the quality of raw ingredients throughout their transportation and production**.** Image Classification plays a crucial role in determining food quality [3]. This technology enables accurate detection of spoilage, abnormalities, and defects through trained models, which is essential for automated food production units. [3] The freshness and quality of raw food items can be effectively determined by image classification,

ensuring the production of only high-quality food products [4]. Items that are not in good condition, imperfect, or abnormal can be effectively monitored [5], [6].

Deep learning models facilitate the classification of images, even in real-time [7]. They possess the capability to detect damaged raw items and classify them accordingly. You Look Only Once version 8 (YOLOv8) is one such model, known for its accuracy, speed, and precision in image classification. Implementing this technology can significantly improve food monitoring, enhance discarding techniques, and reduce health issues linked to improper food consumption. Its application extends to various ranges of food spoilage detection. By adopting such technologies in food production lines, both the safety and sustainability of food can be substantially enhanced.

III. Literature Review

Ayushi Dhelia, Srishti Chordia and Kanisha B (2024):

Automated food damage detection-[8] This paper presents a AI-based system to automate the detection of spoiled food items in industrial food production environments. The research addresses the limitations of traditional manual inspection by offering a real-time, accurate, and scalable solution for food quality assessment. The approach leverages cloud integration for monitoring, visualization, and real-time updates, making it adaptable for real-world deployment in food production lines, grocery stores, and distribution centers. Using a dataset of over 5,000 annotated images, the system was trained and validated with cloud-based tools to monitor performance. A user-friendly GUI interface was also developed to allow operators to input images or video and receive immediate feedback on food quality.

K. Sekar, T. Yuvarajan, J. S. Tejashwini and T. Dheepa (2025):

Food spoilage detection for enhanced safety and waste reduction- [9] This paper presents an efficient deep learning-based system for real-time food quality detection, addressing the global challenges of food waste and foodborne illnesses. The researchers employ the YOLOv8 object detection model, chosen for its speed, accuracy, and ability to detect subtle visual indicators like color changes, mold, and texture abnormalities. The pipeline includes image acquisition, preprocessing, augmentation, and model inference. The YOLOv8 architecture's convolutional layers enable high-precision feature extraction, even under varying lighting conditions and food types.

Qiang Sun(2024):

Food Image Classification and Safety Detection Using Pretrained CNNs- [10] This paper presents a deep learning-based approach for food image classification and food safety detection using pretrained Convolutional Neural Networks (CNNs). Key challenges in ensuring food safety that is addressed by automating the detection of harmful substances, contamination, spoilage and damages through misclassification via image analysis is highlighted in this study. The main component of the system uses pre-trained CNN models which are further fine-tuned to classify food types and analyze the quality by comparing features in the image against a reference database. ImageNet, a large scale dataset that trains CNNs demonstrate higher performance in extracting image features and identify minute differences that contrast to traditional methods. This paper concludes by stating that pretrained CNNs are a encouraging solution with large scalability for improving the quality and safety in food production units. Future scope discusses about increasing datasets, fine tuning the model architecture and unifying detection of object for a wide range of safer food applications.

Dr. Keshavamurthy, Mariyam Steffi J, Meghamala M, Meghashree M, Neha (2019):

Automated Food Quality assessment and Iot monitored sorting with Conveyor belt-[11] This paper presents a detailed system for automating the detection of food quality, transportation safety, group classification and storage techniques, based on raw items such as fruits and vegetables. The proposed solution combines IoT and Convolution Neural Networks(CNNs) with Computer Vision for assessing the conditions in storage, and an

automated conveyor belt to flawlessly perform operations in food production industries. This system uses Computer Vision and CNN for Fruit and Vegetables Detection. It implements a CNN model with 12 layers (including convolutional pooling, and fully connected layers). It describes both the types (e.g., banana, tomato, orange) and quality (rotten, spoiled or fresh) of fruits and vegetables. Images are captured and analyzed in real-time, and the results are transferred to an Arduino controller. The raw items are placed on the conveyor belt and sorted based on CNN output. Different motors are used to place the fruit and guide them to respective categories. The system displays the classification output result on an screen or a monitor.

Hajipara V Hasti, Sanghvi A. Jatan, Tapan Nahar, Vijay Dubey, Chandrashinh Parmar (2024): Image Processing and Machine Learning Methods for Assessing Food Quality- [12] This paper reviews modern image processing and machine learning techniques for assessing food quality in a non-invasive and efficient manner. Traditional methods are costly and slow, prompting the need for automated systems in the agriculture and food industries. The study explores image preprocessing techniques like binarization, segmentation, and noise reduction, along with feature extraction methods based on shape, texture, and color. It highlights the use of hyperspectral imaging and data preprocessing (PCA, KPCA, PWCF) to enhance accuracy. Various machine learning models— including Random Forest, SVM, and MLP—and deep learning architectures such as EfficientNet-B4,

ResNet-50, YOLOv4-Tiny, and GANs are compared. EfficientNet-B4 achieved the highest accuracy (94.29%) in food classification. The paper demonstrates the potential of AI to improve food quality inspection, reduce waste, and support real-time monitoring in food processing.

R Usha, Basi Reddy A, Dr. P Chandrakanth, Dr. R Senthamil Selvan(2023):

This paper presents a smart food monitoring system that uses sensors and a Convolutional Neural Network (CNN) to predict and prevent food spoilage. [13] The system integrates gas, humidity, and temperature sensors along with image analysis to assess the freshness of fruits and vegetables. It sends alerts when spoilage conditions are detected and regulates the environment to extend shelf life. A Raspberry Pi–based architecture, combined with Arduino and various actuators, automates control in smart storage setups. Using the Fruits360 dataset, the CNN model is trained to classify 40 types of produce into freshness categories (fresh, newly spoiled, spoiled) and achieves 96% accuracy. The paper emphasizes the growing role of IoT and machine learning in reducing food waste, enhancing food safety, and supporting intelligent inventory systems. It also explores alternative natural food preservation techniques and outlines the potential for deploying this technology in cold storage, homes, and supply chains.

IV. Comparative Analysis

Comparision of different technologies used and results

Sl.No	Authors	Techniques used	Results
1.	Atkare Prajwal, Patil Vaishali , Zade payal, Dhapudkar Sumit(2020) [1]	pH Sensor, MQ-135 & MQ-3 Gas Sensors, LM35 Temperature Sensor, Microcontroller-ATMEGA 328P	The system classifies food as good or bad based on sensor thresholds. Sensor values are displayed on the LCD.
2.	K. Sukvichai, P. Maolanon, K. sawanyawat and W. Muknumporn(2019) [2]	Convolutional Neural Networks(CNNs). Raspberry Pi 3. Keras with TensorFlow backend. Food-101 dataset.	Accuracy of 81.1% in food category classification. Low-power devices like Raspberry Pi for real-time food analysis

3.	Mohammed A. Subhi, Sawal Md. Ali(2018) [3]	Deep CNN-Basic model: 3 layers (2 convolutional + 1 fully connected),Advanced model: 24 layers (21 convolutional + 3 fully connected). Activation Function: ReLU. Softmax Layer: For final classification. Custom Dataset: 5800 images across 11 Malaysian food categories.	Significant accuracy gains. The deep CNN outperformed traditional methods and shallow models.
4	Ye He, Chang Xu, Nitin Khanna, Carol J. Boushey, Edward J. Delp(2014) [4]	Color Features: Scalable Color Descriptor (SCD), Dominant Color Descrptor (DCD). Classification Algorithms:K-Nearest Neighbors (KNN): Vocabulary Tree	Top-1 Accuracy: 64.5% Top-4 Accuracy: 85.1% Best results achieved by combining DCD, MDSIFT, and SCD features. System improved classification accuracy by 22% (Top-1) and 10% (Top-4) over prior methods.
5.	Dongmei Zhang, Yanbing Du, Lixue Yuan(2024) [5]	K-Means Clustering Algorithm. Four-Quadrant Rule. Analytic Hierarchy Process (AHP): Blockchain & Deep Learning	Priority early warning system for food safety, focusing on fresh produce. Emphasized a shift from reactive to preventive supervision using AI.

6.	Wei Zuo, Weiwei Zhang, Zengchao Ren(2023) [6]	PyTorch Framework. PReNet (Progressive Region Enhancement Network):Combines progressive local feature learning with self-attention-KL- divergence. Food2K Dataset:Contains 1,036,564 images across 2,000 food categories.Built from Meituan's food image repository. CNN Architectures for Benchmarking: ResNet, DenseNet, Inception, SE-ResNeXt, etc.	PReNet (ResNet50): • Top-1 Accuracy: 84.03% • Top-5 Accuracy: 98.21% Outperforms other models like VGG16, Inception-v4, and SENet154 on Food2K. Shows high generalization ability across various food image datasets.
7.	Ms. P. Saranya, Dr. R. Durga(2023) [7]	(CNNs): ResNet, VGG, DenseNet, NasNet, Inception. Thermographic imaging, hyperspectral imaging, and deep learning. Food items like cashew nuts, coffee beans, honey, olive oil, rice, maize, wheat, and wolfberries	High classification accuracy achieved for detecting adulterants in various food products. • E.g., Rice syrup detection in honey: 95% accuracy. • Coffee bean quality recognition: 93%. • Wheat kernel classification (CNN-ATT): 93.01%. • Maize seed classification (DCNN): Testing accuracy of 94.4%. ZP species identification: CNN model achieved 99.35% accuracy.
8.	Ayushi Dhelia, Srishti Chordia and Kanisha B (2024)[8]	YOLOv8 object detection model with cloud-based infrastructure	Precision increases steadily, Loss functions (box loss, class loss, DFL loss) decrease over time, mAP@50 (Mean Average Precision at 50% IoU) increases, indicating better detection accuracy
9.	K. Sekar, T. Yuvarajan, J. S. Tejashwini and T. Dheepa (2025)[9]	YOLOv8 (You Only Look Once, version 8), Fine-tuned with the Food-101 dataset (101,000+ images from 101 food categories)	94–95% accuracy, Outperforms traditional methods, especially in complex lighting and diverse food types, Provides a scalable, practical tool for improving food safetyand reducing waste.
10.	Qiang Sun(2024)[10]	Pre-trained Convolutional Neural Networks (CNNs)-VGG16 and ResNet. Transfer learning and fine-tuning. Feature extraction.	ResNet Accuracy: 92%. VGG Accuracy: 91%. Precision/Recall (ResNet): 0.88 / 0.90. Precision/Recall (VGG): 0.87 / 0.89

11.	Dr. Keshavamurthy, Mariyam Steffi J, Meghamala M, Meghashree M, Neha (2019)[11]	OpenCV, Convolutional Neural Network, Keras, Arduino, NodeMCU ESP8266, ThingSpeak(Cloud), Sensors DHT11 (for temperature & humidity), LDR (light intensity)	Classified fruit types, non-destructive, automated, and cost-effective food quality detection
12.	Hajipara V Hasti, Sanghvi A. Jatan, Tapan Nahar, Vijay Dubey, Chandrashinh Parmar (2024)[12]	Segmentation (Otsu, Watershed), Binarization (MSRCR), Motion blur removal (Wiener filter). CNNs, YOLOv4-tiny, EfficientNet-B4, ResNet-50, DenseNet-201, Faster R-CNN, JDNet.	Food Classification Accuracy: EfficientNet-B4: 94.29%, Apple Freshness (ML): 92.57% accuracy, Apple Bruise Detection (PWCF): Upto 100% F1-score.
13.	R Usha, Basi Reddy A, Dr. P Chandrakanth, Dr. R Senthamil Selvan(2023)[13]	Convolutional Neural Network, Raspberry Pi and Arduino, Fruit360 Dataset	96% accuracy in classifying and predicting spoilage. Provided timely spoilage alerts via text notifications.
14.	Muhammad Reza Fahlevi, Maulia Rahman, Dini Ridha Dwiki Putri, Lahmudin Sipahutar, Fetty Ade Putri, Muhatri(2020) [14]	K-Means Clustering Algorithm. Software: RapidMiner. Features Used for Clustering:Sosoh degree (polish level),Water content,Broken grains.	Clusters Formed: Cluster 0: 12 brands of very good quality rice. Cluster 1: 12 brands of good quality rice. Cluster 2: 6 brands of poor quality rice.
15.	Sergii Babichev, Mohamed Ali Taif, Volodymyr Lytvynenko(2016) [15]	Agglomerative Hierarchical Clustering Algorithm: Inductive Modeling Methods: External Balance Criteria:CQN1: Measures differences in mass centers of clusters.CQN2: Evaluates object distribution relative to cluster centers.	Effective division of data into non-overlapping, well-separated clusters. Optimal number of clusters identified using balance criteria. “Aggregation” data: best performance with 7 clusters. “Compound” data: best results with 4 or 7 clusters.

V. Conclusion

The project demonstrates a robust deep learning-based approach for food quality detection using image classification. By integrating YOLOv8 for real-time detection, advanced image preprocessing, data augmentation, and clustering techniques like K-Means and Agglomerative clustering, the system effectively classifies fruits and vegetables based on their freshness. Among the tested models, AlexNet combined with Agglomerative clustering delivered the highest accuracy and F1-score, validating the impact of clustering on model performance. The solution offers a scalable and efficient method for enhancing food safety, reducing waste, and supporting automated quality control in food supply chains. Future improvements may include expanding the dataset, refining model architectures, and integrating IoT for real-time deployment.

References

[1] Prajwal, P. Vaishali, z. payal and D. Sumit, "Food Quality Detection and Monitoring System," (2020)

[2] K. Sukvichai, P. Maolanon, K. sawanyawat and W. Muknumporn, "Food categories classification and Ingredients estimation using CNNs on Raspberry Pi 3" (2019)

[3] M. A. Subhi and S. Md. Ali, "A Deep Convolutional Neural Network for Food Detection and Recognition" (2018)

[4] Y. He, C. Xu, N. Khanna, C. J. Boushey and E. J. Delp, "Analysis of food images: Features and classification" (2014)

[5] D. Zhang, Y. Du and L. Yuan, "Utilizing Artificial Intelligence Technology to Enhance the Efficiency of Food Safety Supervision," (2024)

[6] W. Zuo, W. Zhang and Z. Ren, "Food Recognition and Classification Based on Image Recognition: A Study Utilizing PyTorch and PReNet," (2023)

[7] P. Saranya and R. Durga, "Food Safety Control Using CNN Model in Image Processing Technique," (2023)

[8] Ayushi Dhelia, Srishti Chordia and Kanisha B, "YOLO-based Food Damage Detection: An Automated Approach for Quality Control in Food Industry" (2024).

[9] K. Sekar, T. Yuvarajan, J. S. Tejashwini and T. Dheepa, "An Efficient Deep Learning Approach for Food Quality Detection" (2025)

[10] Q. Sun, "Food Image Classification and Food Safety Detection based on Pretrained Convolutional Neural Network" (2024)

[11] Keshavamurthy, S. J. Mariyam, M. Meghamala, M. Meghashree and Neha, "Automatized Food Quality Detection and Processing System Using Neural Networks" (2019)

[12] Hajipara V Hasti, Sanghvi A. Jatan, Tapan Nahar, Vijay Dubey, Chandrashinh Parmar, “Image Processing And Machine Learning Methods For Assessing Food Quality” (2024)

[13] R Usha, Basi Reddy A, Dr. P Chandrakanth, Dr. R Senthamil Selvan “Development of CNN Model to Avoid the Food Spoiling Level” (2023)

[14] M. R. Fahlevi, D. R. D. Putri, F. A. Putri, M. Rahman, L. Sipahutar and M. Muhatri, "Determination of Rice Quality Using the K-Means Clustering Method," (2020)

[15] S. Babichev, M. A. Taif and V. Lytvynenko, "Inductive model of data clustering based on the agglomerative hierarchical algorithm,"(2016)

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