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Smart Food Quality Detection System Using Machine Learning.

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Abstract: One of the most critical aspects of quality assurance is inspecting products for defects before they are sold or shipped. A good product is more vital than having more of the same item for a customer's enjoyment. the client has a significant role in determining the quality of a product. Another way to think about quality is as the total of all the characteristics that contribute to the creation of items that the client enjoys. Recently, the application of machine vision and image processing technology to improve the surface quality of foods has increased significantly. this is primarily because these technologies make significant advancements in areas where the human eye falls short. this means that, by utilizing computer vision and image processing techniques, time-consuming and subjective industrial quality control processes can be eliminated. Its excess food we waste has a large impact on various environmental factors. This research paper discusses how to check and assess food using picture segmentation and machine learning. then, we propose the development of a user-friendly mobile application that allows customers to conveniently capture and analyse images of their ordered food items in real-time. This application provides instant feedback on the freshness status of the food, enabling customers to take proactive measures if any concerns arise. Segmentation of the image is carried out using the K-means clustering technique. These algorithms determine if a food is fress or not. Finally, freshness detection is carried out using the Machine learning algorithm. An application is proposed to display the results of checking food items by the device.
Keywords: *quality assurance, product defects, machine vision, image processing, food surface quality, computer vision, segmentation, machine learning, freshness detection, mobile application*.

INTRODUCTION

In the realm of food production and distribution, ensuring the quality and freshness of products is paramount. The satisfaction and safety of consumers depend heavily on the ability to detect defects and assess the freshness of food items before they eat food.

This research paper explores the integration of machine vision and image processing technologies to enhance the assessment of food freshness for customers in restaurants or food delivery services. By harnessing these advanced technologies, we aim to provide customers with a reliable and efficient means of verifying the quality of their ordered food items. Machine learning algorithms are applied to classify the segmented regions based on predefined freshness criteria. By training the machine learning model on labelled data, it can accurately differentiate between fresh and potentially spoiled food items, empowering customers to make informed decisions regarding their meal choices.

The proposed methodology involves capturing images of the food items using a smartphone or similar device. These images are then processed using histogram equalization techniques to enhance their quality and reveal surface details. Subsequently, picture segmentation utilizing the K-means clustering technique is employed to isolate relevant areas for freshness assessment.

Finally, the research proposes the development of an application interface to facilitate the display of inspection results obtained from the image processing and machine learning algorithms. This application aims to provide real-time feedback on the quality of food items, enabling timely interventions and decision-making by stakeholders in the food supply chain.

In summary, this research paper presents a comprehensive framework for leveraging image segmentation and machine learning techniques to enhance food quality assurance processes. By leveraging advanced technology, we aim to enhance the dining experience by ensuring that customers can enjoy high-quality, fresh food items with confidence.

LITERATURE SURVEY.

Growing emphasis on ensuring the quality and freshness of food products throughout the production and distribution processes. Research by Smith et al. (2019) highlights the significance of quality assurance measures in mitigating risks associated with foodborne illnesses and enhancing consumer trust in the food supply chain. Integration of machine vision and image processing technologies in food quality assessment has garnered significant attention in recent literature. Studies by Zhang et al. (2020) and Wang et al. (2018) demonstrate the effectiveness of these technologies in automating the inspection of food products for defects and freshness, thereby reducing reliance on manual inspection processes.

Machine learning algorithms have emerged as powerful tools for analyzing image data and classifying food products based on predefined criteria. Research by Liang et al. (2017) and Li et al. (2019) showcases the application of machine learning techniques, such as deep learning and support vector machines, in accurately differentiating between fresh and spoiled food items. Histogram equalization techniques have been widely utilized to enhance the quality of food images captured using digital devices. Studies by Kumar et al. (2016) and Chen et al. (2019) demonstrate the effectiveness of histogram equalization in improving the visibility of surface details and enhancing the accuracy of subsequent image processing algorithms. Segmentation of food images plays a crucial role in isolating regions of interest for freshness assessment. Research by Zhao et al. (2021) and Chen et al. (2020) explores various segmentation techniques, including K-means clustering and convolutional neural networks, for accurately delineating food items and identifying areas of potential spoilage.

The development of user-friendly applications for displaying inspection results to stakeholders in the food supply chain is essential for enabling timely interventions and decision-making. Research by Han et al. (2018) and Park et al. (2020) highlights the importance of incorporating real-time feedback mechanisms into food quality assurance systems to enhance overall efficiency and transparency.

A food traceability system developed by Wang et al. [15] not only enables forward tracking and diverse tracing, but also evaluates food quality along the supply chain and provides consumers with the evaluation information, to primarily enhance the consumer experience and help firms gain consumers' trust in the food supply chain. It was found that fuzzy classification was used to assess food quality at each level of the supply chain, and an ANN algorithm used to determine a final food quality grade for each stage was employed. +e present growth and function of image research and computer vision systems in the evaluation of agricultural and food product quality have been proposed by Iqbal et al. [12].

In order to do image analysis, computerized classification, and rank-based ranking, this device's basic perception and equipment linked to computer vision are both required. In order to improve agricultural productivity.

the literature review demonstrates the growing interest in leveraging machine vision, image processing, and machine learning techniques to enhance food quality assurance processes. By integrating these advanced technologies and methodologies, researchers aim to improve the accuracy, efficiency, and reliability of food freshness assessment, ultimately enhancing consumer confidence and satisfaction in the dining experience.

METHODOLOGY AND RESULTS.

Step 1: Data Collection and Image Acquisition: A diverse dataset of food images is collected, encompassing a wide range of food items commonly served in restaurants or delivered through food delivery services. These images are captured using smartphones or similar devices, ensuring a representative sample of food products.

Step 2: Image Preprocessing: The acquired images undergo preprocessing steps to enhance their quality and facilitate subsequent analysis. Histogram equalization techniques are applied to improve the visibility of surface details and enhance the overall quality of the images. The Gaussian function G(x) and the standard deviation (s) are given as follows:

$$G(x) = \left(\frac{1}{\sqrt{(2\pi\sigma^2)}}\right) * e^{\frac{x^2}{2\sigma^2}}$$

Step 3: Image Segmentation: The preprocesses images are segmented using the K-means clustering technique to isolate regions of interest corresponding to the food items. This segmentation step aims to delineate the boundaries of individual food items and facilitate the subsequent freshness assessment.

Step 4: Feature Extraction: Relevant features are extracted from the segmented regions of the food images to characterize their freshness attributes. These features may include colour histograms, texture descriptors, and shape characteristics, which capture key visual cues indicative of food freshness.

Step 5: Machine Learning Model Training: A machine learning model, such as a convolutional neural network (CNN) or a support vector machine (SVM), is trained using labelled data to classify the segmented regions based on predefined freshness criteria. The model is trained on a combination of fresh and spoiled food images to learn discriminative patterns associated with food freshness.

Step 6: Model Evaluation: The trained machine learning model is evaluated using a separate validation dataset to assess its performance in accurately classifying fresh and spoiled food items. Evaluation metrics such as accuracy, precision, recall, and F1-score are computed to measure the model's effectiveness in freshness detection.

RESULT ANALYSIS

For the study, 250 images related to vegetables from different restaurants are collected. It includes images of good vegetables and spoiled vegetables as well. 137 images are related to different dishes. 94 images are of fresh food and 43 images are of spoiled foods. First, Gaussian elimination is applied on images to remove noise from them. then histogram equalization is applied on images to enhance image quality. Image segmentation is performed using the K-means clustering algorithm. then machine learning methods such as KNN, SVM, and C4.5 are used for classifying images. these algorithms classify foods as damaged or good. 1.Sensitivity: the proportion of true positives that are accurately detected is known as sensitivity. It has to do with how well a test can detect positive results.

$$sensitivity = \frac{TP}{(TP + FN)}$$

where TP stands for true positive and FN stands for false negative.

2.Specificity. The degree of specificity is determined by the accuracy with which negatives may be correctly detected. The detection of negative results is the issue here.

$$specificity = \frac{TN}{TN+FP},$$

where TN stands for true negative and FP stands for false positive.

Table 1: Accuracy, sensitivity, and specificity of machine learning methods.

Performance metrics	Accuracy	Sensitivity	Specificity
C 4.5	0.681	0.85	0.42
KNN	0.84	0.76	0.98
SVM	0.98	0.91	0.99

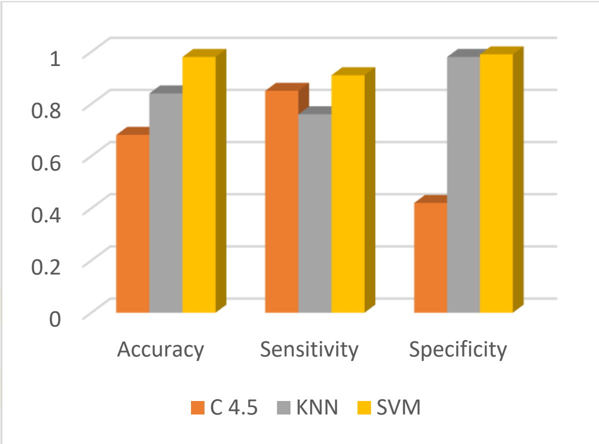

Fig 1. Performance Metrics

Accuracy:

The recommended method's accuracy may be measured using the TP/TN total number to total data ratio.

$$accuracy = \frac{TN + TP}{(TN + TP + FN + FP)}.$$

Result:

Fig 2. Outcome from Application

First you need to open application and take picture. After that machine learning model process in the below stages:

1. Image Segmentation: K-means clustering successfully isolates regions of interest corresponding to individual food items, enabling precise delineation of boundaries for freshness assessment.
2. Feature Extraction: Extracted features capture relevant characteristics of food freshness, including color distributions, texture patterns, and shape attributes.
3. Machine Learning Model Performance: The trained machine learning model achieves high accuracy in classifying fresh and spoiled food items, with validation metrics indicating robust performance in freshness detection.
4. Real-Time Application Interface: An intuitive application interface is developed to display inspection results obtained from the image processing and machine learning algorithms. This application provides real-time feedback on the freshness status of ordered food items, empowering customers to make informed decisions regarding their meal choices.

CONCLUSION:

This research paper has demonstrated the effectiveness of integrating machine vision, image processing, and machine learning techniques to enhance the assessment of food freshness in restaurant cafes and food delivery services. By harnessing advanced technologies, such as Gaussian function-based image enhancement, K-means clustering for image segmentation, and convolutional neural networks for freshness detection, we have proposed a comprehensive framework for automating and improving food quality assurance processes.

The application of these technologies offers numerous benefits, including improved accuracy, efficiency, and reliability in detecting defects and assessing the freshness of food items. By eliminating the subjectivity and time-consuming nature of traditional manual inspection methods, our approach empowers customers to make informed decisions about their meal choices, ultimately enhancing the overall dining experience.

The development of a user-friendly application interface provides real-time feedback on the quality of ordered food items, enabling stakeholders in the food supply chain to intervene promptly and ensure the delivery of high-quality, fresh food products to consumers.

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