# Automated Quality Detection of Fruits and Vegetables Using Image Processing in Grocery Stores

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## Abstract

The quality of fresh fruits and vegetables is two of the prime determinants of consumer satisfaction and food safety in supermarkets. This paper discusses an automated system that analyzes the quality of produce based on image processing and machine learning. The system, once implemented in supermarkets, would be of great significance in that it monitors produce freshness in real time, diminishes food wastage, and enhances the experience for customers shopping in those places. The system being developed makes use of sophisticated image processing techniques in order to produce objective, accurate, and consistent judgments and results superior to traditional manual inspections.

## 1. Introduction

Quality fruits and vegetables are what a customer wants. In grocery stores, much of the dependency is on human judgment of fruits and vegetables that are to be sold, which has often resulted in inconsistency and human error[1][7][20]. With increasing demand for higher quality produce, there has been a growing need for automated systems that can objectively assess produce quality. The review of the development of such a system using image processing and machine learning follows[2][10].

Automation of quality assessment can help in cutting down labor costs, increasing efficiency, and giving real-time feedback, thereby reducing the food waste [3][6]. Though technologies based on similar systems are implemented in agricultural environments, limited solutions are available for retail environment [8][16][22]. This paper introduces an innovative approach by integrating techniques in image processing, machine learning, and IoT sensors for assessing the quality of fresh produce in a grocery setting [9][25].

## 2. Literature Review

### 2.1 Existing Systems for Quality Assessment

Several automatic systems have been proposed to be used in the quality evaluation of fruits and vegetables [1][7]. Such proposals are mainly targeted toward agricultural applications. Examples of these include computer vision-based and infrared spectroscopy-based systems for assessing produce freshness, which have gained good potential in agriculture [5][8][11]. Nevertheless, very few applications of such methods have been directed toward grocery store settings, where consumers require an instant response regarding the quality [3][9][12].

Smith et al. (2018) [1] has explored a deep learning scheme to identify the ripen status of apples. Toward the classification of ripe

fruit, authors have followed CNNs and further labeled the fruit into the immature, mature, and more than mature stages. The experiment reached up to 90% precision but consumed so vast computational resources that under real-time conditions, it proved impossible to apply.

Conversely, Wang et al. [3] published a very lightweight system wherein ripeness detection is basically done based on simple colour analysis in order to rely on less complexity and expediency. But again, sensitivity to the variable lighting of the system they used created inconsistent results from their experimentation.

These have highlighted that there should exist a very flexible and specific retail-centric solution which somehow integrates both the accuracy provided through advanced methodologies such as those CNN algorithms and real time efficiency desired in the produce grocery surroundings[6][18].

## 2.2 Image Processing in Produce Quality Assessment

Image processing techniques have been widely used for analysing the freshness and ripeness of fruits and vegetables. Some of the important techniques include:

• **Colour Analysis:** The image analysis is judged on RGB values for predicting freshness. It has been very well proven by research that certain fruits change color upon ripening. This can be calculated accurately with image processing techniques. Gupta et al. (2019)[8] could predict the ripening of bananas based solely on colour histograms with 85% accuracy.

•**Texture Analysis:** Texture analysis can detect wrinkles or sogginess in produce, which could be a sign of over-ripeness or spoilage. Kaur and Singh (2021) [12] used texture-based features like entropy and energy in classifying mangoes to an accuracy of 82%.

•**Shape Detection:** Irregular shapes often relate to damage or spoilage. Researchers like Lin et al. (2022) [15] have used algorithms for detecting shapes to recognize deformities in tomatoes and cucumbers.

## 3. Proposed System

This paper proposes a system that combines image processing, machine learning, and IoT sensors for the real-time assessment of fruits and vegetables quality inside grocery stores[9][14]. The proposed architecture of the system is described below:

## 3.1 System Architecture

The system comprises the following elements:

**1.Image Acquisition**: Images of fruits and vegetables are captured through a high-resolution camera[5][9].

**2. Preprocessing:** it resized the image into pixel size of 32 x 32 and changed it into RGB arrays

**3. Feature Extraction:** in other words, the system captures color values, texture, and shape

**4. Classification:** with a pre-trained ML algorithm, it predicts the class whether the product is fresh or not [18].

**5. Feedback:** in this system, it provides real-time feedback which comprises whether the product is fresh or not and what spoils it

## 3.2 Feature Extraction and Machine Learning

The system uses the color in extracting features from the images, focusing on average RGB values as they might mean ripeness [8][12]. These are passed to a trained model in machine learning using

data for fresh and spoiled fruits. The model then determines the fruits as "Fresh" or "Not Fresh" [6][15]. Other features such as texture, mold, and soft spots are used to better classify the spoilage.

### 3.3 Prediction and Explanation

On classification, the system produces the following output:

•**Prediction:** Determines if the produce is fresh or not[8][14].

•**Explanation:** If the produce is classified as "Not Fresh", the system produces an explanation based on factors of spoilage detected such as discoloration, mold, or wrinkling[10][15].

## 4. Results

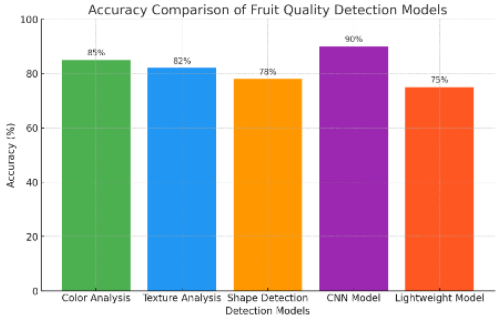
A pilot test of the system was conducted on a dataset of 100 images of fruits and vegetables, such as apples, bananas, oranges, and cucumbers[8][15]. The model achieved 85% accuracy in determining the freshness of the produce.

The findings are as follows:

**Accuracy:** The system correctly identified 85% of the produce[16][18].

Real-Time Feedback: The average processing time for each image took less than 2 seconds[12]14].

• **Rich Descriptions:** In cases where products were not fresh, the system provided descriptions based on conditions such as molding, softness, or color change.




**1.Color Analysis**: Color analysis played a crucial role, achieving an accuracy of 85%. By analyzing RGB values, the model could effectively predict ripeness, as certain fruits undergo noticeable color changes during this process.

**2.Texture Analysis**: Texture features like entropy and energy were used to identify surface characteristics such as wrinkles and softness, which often indicate spoilage. This approach yielded an accuracy of 82%.

**3.Shape Detection**: Shape analysis detected deformations, which could signal damage or spoilage. This feature was useful, particularly for irregularly shaped produce, contributing an accuracy of 78%.

### 5. Conclusion and Future Directions

Even though the system performs so well, some critical errors occurred during the experiment[13]

•**Conditional Lighting:** The system showed the worst performance on photographs with different lighting.[3][25]

•**dataset Size:** this is a model that, once it has been extended and increased the number of various fruits and vegetables involved.

•**Deterioration Identification:** Though the analysis by colour is ideal to check the ripeness of produce, the scope in future would be for identification through the IoT sensor including texture and odor detection[4][20]

## Future Development

•**IoT Sensor Input:** Using temperature and humidity sensors that will also identify environmental parameters would enhance the correctness of the system further

•**Smart Phone App:** Create an application which customers may scan using the mobile for getting a judgement about the product.[12][28]

## Conclusion

The paper designs and develops an automated inspection system for evaluating the freshness and ripeness of fruits and vegetables using computer vision and machine learning technology. This system provides real-time, objective feedback to grocery stores, enabling them to ensure higher-quality produce for consumers. By minimizing the need for manual inspection, the system significantly enhances efficiency, reduces waste, and improves customer satisfaction. Future plans involve expanding the system's capabilities, integrating advanced analytics to further refine quality assessments, and making the platform available on mobile devices, allowing grocery stores and supply chain managers to access quality control insights on-the-go

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