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Classification of Fruits Based on Quality Using Artificial Intelligence

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Abstract

The visual inspection method for fruit grading is prone to judgment distortion among different individuals. There is a demand for an automated fruit classification machine to replace labor-intensive processes with an intelligent system for fruit quality classification. This study proposes a practical real-time fruit quality classification system that classifies the fruit's appearance in order to decrease human effort costs in the fruit industry. For the sorting and classification of fruits, there are different parameters such as color, weight, size, shape, and density. Research on fruit quality classification based on color, size, and volume is nearing completion in the laboratory but has not yet been implemented in practical applications. The assessment of fruit quality remains unresolved. The study aims to develop a system capable of classifying fruits based on color, volume, size, shape, and density. This categorization system, utilizing image processing, integrates artificial intelligence components such as a camera, computer vision, and artificial neural network. The system employs captured fruit images to ascertain mass, volume, and surface defects on the fruit.

Keywords: Quality, artificial intelligence (AI), computer vision, YOLO, object detection, preprocessing

INTRODUCTION

The quality of the product is an important requirement in the case of any fruit or vegetable. Quality is necessary for being acceptable in the market. Measuring the quality of fruit in all aspects is an important step in the food industry. The measurements of quality parameters provide speed as well as accuracy in calculating the quality factors involved.

The methods that were proposed earlier did not provide enough information for making decisions in terms of classification in the case of quality and ripening of fruits.

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METHODOLOGY

To overcome this problem, we have come up with an approach that classifies fruits in terms of shape, size, density, and volume using artificial intelligence which can be useful for industries, and it can help in reducing manual labor.

Survey of Existing System

Problems of existing system

Classification of fruits and vegetables is relatively more complex due to the huge variety, for example, irregular interclass shape, color, and texture. The limitations led to the absence of a system for automated classification of fruits and vegetables into multiple classes.

Challenges

1. *The state of the art:* While automated fruit and vegetable classification systems have been developed, there is a lack of examples demonstrating their commercial application to date.
2. *Data acquisition:* Sample images that consist of real-world information are known as datasets, and the process of collecting such images is called image acquisition. Active sensors and passive sensors both are used for this purpose and further exploited for potential usage. Many factors are dependent on the type of sensor one selects, for example, the environment of the application and the features sensed.
3. *Data preprocessing:* Raw images obtained from visual sensors contain various forms of noise and distortions. As a result, these unprocessed images are unsuitable for extracting features in computer vision and image processing applications. Preprocessing is essential to mitigate this noise and enhance the images for improved performance.
4. *Feature extraction:* A piece of information related to some topic, that is, identification, grouping, fetching, and reorganization is called a feature descriptor. Fruits and vegetables are characterized by various visual attributes, commonly referred to as features, which play a crucial role in their classification and recognition. These attributes typically include color, shape, size, and texture.

Problem Statement

There always arise issues in picking the right fruit in the agricultural field, industrial fields as well as in hyper malls, providing cheap or rotten fruits that do not last long to be fresh for a longer period of time can lead to degradation in the quality of the fruits as well as can result into huge losses for the industries. People face difficulties in identifying the species of the fruit that can affect their dietary expectations, Determining the cost of a fruit becomes tough without having knowledge of the species and parameters. Traditional techniques need a lot of laboring efforts, due to poor quality, farmers and sellers sprinkling chemicals and a lot of ripening powder that can be threaten and affect the physical condition of human life on a large scale. It has the potential to influence the country's gross domestic product.

Proposed System

The proposed fruit classification system is designed to identify the external quality of fruit, which uses a camera as an image sensor and artificial intelligence algorithm as a classifier. Here fruits are identified using the YOLO (You Look Only Once) algorithm using the characteristics of the image such as height, width, shape, color, etc. The new system involves using the same Artificial intelligence technology that detects the fruit's quality based on size, shape as well and volume using the camera as a sensor along with TensorFlow for object detection, Keras frameworks and neural networks are also involved for the entire processing which is applicable only for mango and guava.

The following components are explained briefly here:

1. *Keras Framework:* Keras, a high-level deep learning library built on TensorFlow, is authored in Python and offers an API (application programming interface) reminiscent of scikit-learn for constructing neural networks. By abstracting the intricacies of tensor algebra, optimization methods, and numerical techniques, Keras empowers developers to swiftly create neural networks, prioritizing rapid prototyping and experimentation.
2. *TensorFlow:* TensorFlow serves as a comprehensive platform for machine learning, encompassing functionalities such as multidimensional-array-based numeric computation, GPU (graphics processing unit), and distributed processing support, automatic differentiation, as well as model construction, training, and export. As a free and open-source software library dedicated to machine learning and artificial intelligence, TensorFlow is versatile across various tasks, with a specific emphasis on the training and inference of deep neural networks. The Google Brain team created TensorFlow initially for internal research and production use at Google. The Apache License 2.0 covered the first release in 2015. A subsequent version, TensorFlow 2.0, was introduced by Google in September 2019. TensorFlow supports multiple programming languages such as Python, JavaScript, C++, and Java, making it versatile for applications across various sectors.

3. *Neural Networks:* A neural network, a form of artificial intelligence, employs deep learning techniques to enable computers to process data in a manner inspired by the human brain. Structured with interconnected nodes in layered arrangements reminiscent of the human brain, it establishes an adaptive system, allowing computers to learn from errors and enhance their performance over time. Thus, artificial neural networks try to solve difficult problems, like encapsulating documents or face recognition, with greater accuracy.

Importance of Neural Networks

Neural networks empower computers to autonomously make intelligent decisions with minimal human intervention, owing to their capacity to learn and establish intricate, nonlinear relationships between input and output data. They excel in tasks such as forming generalizations and inferences. Additionally, neural networks exhibit proficiency in comprehending unstructured data, enabling them to draw overarching conclusions without explicit training. An example includes their ability to discern the similarity in meaning between two distinct input sentences.

Neural networks have several applications across many industries, such as the following:

1. Medical diagnosis by medical image classification
2. Financial predictions by processing historical data of financial instruments
2. Electrical load and energy demand forecasting
3. Process and quality control
4. Chemical compound identification

Technology Used

The proposed system is developed using the following technologies: Python, Keras Framework, MYSQL.

By implementing this system, we aim to modernize the training and detection of this system with additional parameters to achieve better accuracy and achieve the desired goal.

LITERATURE REVIEW

We review various research papers, manuals, and documents related to our project concept. The following is some literature that will prove useful for recognizing different ways as well as strategies to build this project.

Patel et al. [1]—Image Processing-based Fruit Detection and Grading Classification System

Methodology: Computer vision has primarily been employed in assessing and gauging the quality of fruits. This technology holds the promise of automating human grading processes while minimizing the need for repetitive inspection tasks. Tasks such as defect detection, categorization, and evaluating the maturity of fruits based on their visual characteristics are all carried out through computer vision.

Observation: A computer vision system is employed for labor-intensive fruit inspection, delivering equitable, non-destructive testing, and precise outcomes. The process involves four essential steps: image acquisition, image segmentation, feature extraction, and classification, constituting the key components of computer vision-based feature analysis.

Aherwadi et al. [2]—The Prediction of Fruit Maturity, Quality, and Shelf Life is Accomplished through the Application of Deep Learning Algorithms

Methodology: The article aimed to classify the fruits according to their maturity level, whether they were ripe, partially ripe, or unripe. Extensive deep learning techniques were used to identify the fruit images.

Observation: In this study, the authors proposed two approaches using deep learning methods (convolutional neural network [CNN] and AlexNet) for banana fruit images on our original dataset,

augmented dataset, and available dataset. The methodology under consideration is applicable exclusively to bananas.

Khan [3]—Artificial Intelligence and Machine Learning in Food Industries

Methodology: In this system, artificial intelligence (AI) is used. While humans carry a lot of germs and diseases, even when they breathe, exhausts are dangerous especially while working in the food production sector. By using robots, the continuous rise in foodborne diseases will alternatively drop to a large extent. The task gets easier when AI is put to use instead of a labor force as it keenly monitors each stage specifically without any repetitive errors.

Observation: Advanced equipment and devices are used that aid in minimizing repetitive mistakes and wastage of limited products, low-cost deliveries, transportation, instant services, and accessible wireless communication systems, as well as to yield satisfying results and customers.

Hasanzadeh et al. [4]—Non-destructive Detection of fruit Quality Parameters Using Hyperspectral Imaging, Multiple Regression Analysis and Artificial Intelligence

Methodology: Hyper-spectral imaging was conducted using a CCD (charge coupled device) detector, with a tungsten halogen bulb serving as the light source. Spectroscopic examinations were carried out using a spectrophotometer, and titrations were performed with the assistance of a refractometer.

Observations: Tables present qualitative specifications and parameters, encompassing weight, diameter, pH, soluble content, titrable acid, and total phenol for both golden and red delicious apples. The study delves into exploring the impact of various preprocessing methods on these characteristics.

Gill et al. [5]—Fruit Image Classification Using Deep Learning

Methodology: Here a logic has been coined to process and represent knowledge Fuzzy type 2 handles the problem of ambiguity. Member functions are major tools for dealing with imprecise data. Histogram localization is used for the result.

Observation: A deep learning method is developed to classify fruit images and to create discriminate features. CNN was employed, and recurrent neural network (RNN) was used for creating sequential models. long short-term memory (LSTM) was used to categorize images well.

Minh Trieu and Thinh [6]—Quality Classification of Dragon Fruits Based on External Performance Using a Convolutional Neural Network

Methodology: The utilization of feature recognition poses challenges for computer vision in the context of machine learning algorithms. A self-learning model is employed to identify the color threshold of dragon fruit.

Observation: A self-learning model was introduced to increase the accuracy of the image segmentation, which improved accuracy by 7%. The system can reduce cost and manual power and identify characteristics of dragon spike.

Chen et al. [7]—Implementation of a Fruit Quality Classification Application Using An Artificial Intelligence Algorithm

Methodology: An object detection model is created using the Tiny Yolo algorithm as a baseline we have also implemented an elimination and comparison algorithm for reducing errors, and an object tracking algorithm as well as a convolution layer and deconvolution layer is also used.

Observation: A tiny-YOLO neural network is used for object detection and compared several other models in terms of performance we have built a model architecture using TensorFlow and Keras framework, a camera is used as a sensor, four-layer convolution model is used for object detection accuracy achieved is 88%

Khatun [8]—Fruits Classification Using Convolutional Neural Network

Methodology: For experimentation, a total of 1260 samples were taken for training and 140 samples were taken for testing. The image preprocessing and filtering stages involve eliminating noise, enhancing sharpness, and applying smoothing techniques to the image, along with resizing operations.

Observation: This paper investigates the classification of various fruit varieties with diverse backgrounds using the CNN algorithm for both training and testing.

Fredes and Valenzuela [9]—A review of Convolutional Neural Network Applied to Fruit Image Processing

Methodology: CNNs are used which include their frameworks pooling layer, where 2*2 filter is applied. CNN is trained. Then transfer of learning with CNN can be used for the development of many tasks based on complexity layer and filters are increased.

Observation: Here fruit image processing is done using CNN approaches. Three areas where CNNs are used are classification, quality control, and fruit detection. CNN approaches have demonstrated outstanding results, reaching up to 100% in evaluation, with the most significant advancements observed in the field of robotic harvesting.

Nemade and Sonavane [10]—Co-occurrence patterns Based Fruit Quality Detection for Hierarchical Fruit Image Annotation

Methodology: It represents overall architecture of the fruit image annotation, images are organized from the collected image samples. Image preprocessing techniques such as noise elimination, color segmentation, and shadow removal are applied to enhance the input images. A co-occurrence pattern for fruit quality and sub-category discovery grounded on deep features such as color, shape, size, and texture features are presented.

Observation: The distribution of RGB color space is observed using the color histogram, the shape of the fruit images is identified as round or oval. The texture features are computed using a transform-based hybrid DWT (discrete wavelet transform) + Gabor filter.

Widiyanto et al. [11]—Classification of Mango Fruit Quality Based on Texture

Methodology: Here digital image processing and the K-nearest neighbor algorithm are used. It involves the acquisition process, then the digital image processing which includes preprocessing, segmentation, and feature extraction processes, and then the characteristics data is stored in the database.

Observation: The classification process of the mango quality class was carried out using a prototype that had been successfully designed and made using digital image processing technology for extracting the GLCM (gray-level co-occurrence matrix) texture features of mango images and the K-nearest neighbor algorithm for its classification method.

Setiawan et al. [12]—Classification of Palm oil Fresh Fruit Bunch Using Multiband Optical Sensors

Methodology: Sample preparation is executed by incorporating an optical sensor in the process. The grader is responsible for conducting misclassification. Distinctions between model classes evaluated by the grader and FFB (fresh fruit bunch) oil yield are determined using Euclidean and Mahalanobis distances.

Observation: The model, constructed using oil painting content data from the main colony's FFB, was also evaluated for estimating FFB from smallholder plantations. The resulting bracket model demonstrated greater accuracy in this context.

Mimma et al. [13]—Fruit Classification and Detection Application Using Deep Learning

Methodology: In this study, the authors employed an online framework called Make Sense to label images and generate corresponding XML files. Subsequently, the labeled images underwent preprocessing using the Robofow tool, where conventional preprocessing techniques were applied, including resizing.

Observation: An automated fruit classification and detection system has been created through the application of deep learning techniques, employing two datasets. The intended application of this system extends to industries and supermarkets, serving both as a practical tool and an educational resource for children.

Bhargava and Bansal [14]—Fruits and Vegetables Quality Evaluation Using Computer Vision

Methodology: Statistical classifier is used for classifying. Gaussian model is used, and Bayesian discriminant analysis is performed with involvement of artificial neural network.

Observation: The most important quality characteristics of agricultural products are size, color, shape, texture, and defect. The computer vision-based quality inspection comprises four main steps, namely, acquisition, segmentation, and feature extraction.

Gill et al. [15]—A Review of Automatic Fruit Classification Using Soft Computing Techniques

Methodology: It presents the application of various image processing techniques (for preprocessing) and soft computing models (for classification) apple defect detection and quality classification are performed using multilayer perceptron (MLP) neural networks. It has been deduced that soft computing models have shown remarkable performance, and nondestructive assessment is achieved using computer vision systems and soft computing models.

Comparison Between the Existing System and the Proposed System

Table 1 illustrates a comparison between the proposed system and the existing system in terms of functionality.

SYSTEM MODULE

A system for detecting and grading fruits using image processing techniques is structured into five stages, as illustrated in Figure 1.

1. *Image Module:* This consists of samples of fruit images that are going to be used for detection. A complete dataset of fruit is present.
2. *Image Preprocessing:* It is a process that removes all the noise, nausea, and outliers present in the image, so they become suitable and clean for further extraction process.
3. *Image Segmentation:* In this step, the image is divided into different parts known as segments.
4. *Classification:* This process calculates the numerical properties of the image and then classifies it into various categories depending on the types of features involved.
5. *Identification:* After the previous steps are performed efficiently this is the last step where we identify the quality of fruits and also the breed.

Table 1. Comparison between the existing and proposed system.

Parameters	Existing system	Proposed System
User friendly	Yes	Yes
Detection based on	Color, texture, morphological features	Shape, size, density, volume
Reliable	Yes	Yes
Complexity	Less	Comparatively even lesser than the existing one
Speed	Fast	Fast
Manual work	Needed	Limited as compared to the existing one
Features	3	4
Object detection	Yes	Yes

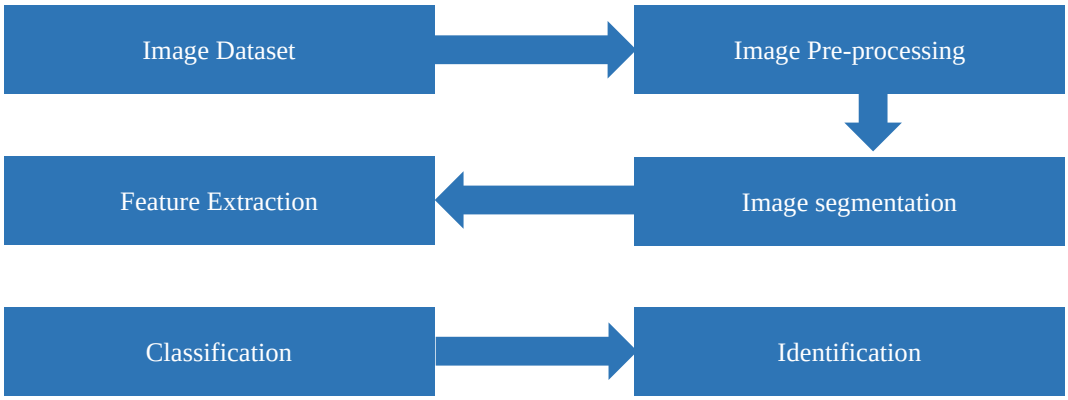

Figure 1. Stages of image processing.

CONCLUSION

The existing system relies on parameters such as color, texture, as well as morphology features. But there is something lacking that can be surely improved and we will introduce those parameters, namely density and volume along with shape and size so we can have a complete overview of the fruit without missing its details. Other parameters are not included to avoid complexity. It is purely based on artificial intelligence, Keras framework, and neural networks. TensorFlow and Python will be used for the building of code. As everywhere, artificial intelligence is also taking over the food and fruit industry. In this way, we can increase quality production and then businesses can flourish.

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