**Fruits and vegetables quality evaluation using computer vision: A review**

**ABTRACT**

In agriculture science, automation increases the quality, economic growth and productivity of the country.The export market and quality evaluation are affected by assorting of fruits and vegetables. The crucial sensory characteristic of fruits and vegetables is appearance that impacts their market value, the consumer’s preference and choice. Although, the sorting and grading can be done by human but it is inconsistent, time consuming, variable, subjective, onerous, expensive and easily influenced by surrounding. Hence, an astute fruit grading system is needed. In recent years, various algorithms for sorting and grading are done by various researchers using computer vision. This paper presents a detailed overview of various methods i.e. preprocessing, segmentation, feature extraction, classification which addressed fruits and vegetables quality based on color, texture, size, shape and defects. In this paper, a critical comparison of different algorithm proposed by researchers for quality inspection of fruits and vegetables has been carried out.

**STATEMENT OF THE PROBLEM**

In representing the conception for human brain, images are the most basic method in physical classification of foodstuff and agricultural industry. Factors affecting fruits and vegetables can be quantified visually which is laborious, expensive and is easily effected by physical factors, including inconsistent evaluation and subjective results. The market prices are determined by such inspections and, also, the ‘‘best-if-used-before date”. The trained human investigators have done the quality inspection by feeling and seeing. This method is significantly inconsistent.

**METHODOLOGY**

Quality inspection of fruits and vegetables using image processing technique involves five steps, as depicted in Fig. 2, namely, image acquisition, pre-processing, image segmentation, feature extraction and classification.

1.image acquisition

In food applications, image acquisition tools used are camera, ultrasound, magnetic resonance imaging (MRI), and electrical tomography and computed tomography (CT). To generate the digital image charged coupled device (CCD) and complementary metal oxide semiconductor (CMOS) image sensors are used.

2.pre-processing

preprocessing enhance the image data, which overcome reluctant distortions and enlarge the features of image that are essential for processing and build a relevant image (degraded form) than the original for a definite application. The approaches used for an image pre-processing for food quality assessment are pixel preprocessing and local pre-processing. Pixel preprocessing ‘‘converts an input image into an output image such that each output pixel is correlated to the input pixel having the corresponding coordinates”. The uttermost frequent method for pixel pre-processing is color space transformation (CST) for assessment of food quality.

3. image segmentation

After preprocessing, image segmentation is required which separates a digital image into distinct areas. The major function is to separate the background for processing the significant area during the object evaluation. A proper segmentation is crucial for further progress in image analysis and an improper segmentation will diminish the classifiers performance.

4.Feature Extraction

After image segmentation, features are estimated for further analysis. These features are the basic factors in a computer vision system as they consist of effective data for image perceptive, interpretation, object classification. In this process, extracted features form feature vectors that are classify to recognize the input. These feature vectors defines the object shape uniquely and precisely. The feature extraction aim is to enlarge the rate of recognition by extracting the features. In the food industry, these features give the explicit data that can be considered for quality assessment and analysis. Color, textural and morphological features are frequently used to analyze the defect and maturity of the fruits and vegetables

5.Classification

The essential feature for food quality evaluation is classificationwhich contribute a structure in which artificial simulation of human thinking is done to guide humans form sophisticated judgments instantaneously, correctly and persistent. By using image processing techniques, fruits and vegetables images can be described by set of features such as color, size, shape and texture. These features are used to form training set, then classification algorithm is applied to extract knowledge base which make a decision of unknown case. In computer vision system, a wide variety of methods: KNN, SVM, Artificial Neural Network (ANN), Deep Learning/Convolutional Neural Network (CNN) have been developed for classification in food quality evaluation. KNN targeted on similitude of samples measured by distance metric.

**TESTING**

Testing is an active to verify that a correct system is being built and is performed with the intent of finding faults in the system. However not restricted to being performed after the development phase is complete, but this is to carry out in parallel with all stages of system development, starting with requirements specification. Testing results, once gathered and evaluated, provide a qualitative indication of software quality and reliability and serve as a basis for design modification if required. A project is said to be incomplete without proper testing.

System testing is a process of checking whether the developed system is working according to the original objectives and requirements. The system should be tested experimentally with test data so as to ensure that system works according to the required specification. When the system is found working, test it with actual data and check performance. The testing procedure that has been used as follows:

The basic levels are unit testing, integration testing, system testing and acceptance testing. These different levels of testing attempt to detect different types of faults. The different levels of testing are as follows:

UNIT TESTING

. INTEGRATION TESTING:

. SYSTEM TESTING:

WHITE BOX TESTING:

.BLACK BOX TESTING**:**

**SOFTWARE REQUIREMENTS**

A software requirement specification (SRS), a requirements specification for a software system, is a complete description of the behavior of a system to be developed and may include a set of use cases that describe interactions the users will have with the software. In addition it also contains non-functional requirements. Non-functional requirements impose constraints on the design or implementation (such as performance engineering requirements, quality standards, or design constraints) the software requirements specification document enlists all necessary requirements that are required for the project development. To derive the requirements we need to have clear and thorough understanding of the products to be developed. This is prepared after detailed communications with the project team and customer.

Operating System: WINDOWS 8 or above for better performance

Front end: Python (For web application), Android (Mobile Application)

Back end: MYSQL

Software:SubLimeText, WAMP, Android Studio

Web Browser: Internet Explorer/Google Chrome/Firefox

Web Server: Apache

**HARDWARE REQUIREMENTS**

The most common set of requirements defined by any operating system or software application is the physical computer resources, also known as hardware. A hardware requirements list is often accompanied by a hardware compatibility list (HCL), especially in case of operating systems. An HCL lists tested, compatible, and sometimes incompatible hardware devices for a particular operating system or application.

Processor: Intel Pentium or above.

Hard Disc: 320GB.

Display Type: PC Display.

Keyboard: PC/AT Enhanced PS/2Keyboard (110/10Key).

Mouse: First/Pilot Mouse Serial (c48).

Input Device: Mouse, keyboard

Output Device: Monitor, Mobile Display

**CONCLUSION**

This paper highlights the use of image processing and computer vision technology in the field of food industry and agriculture. The most important quality characteristics of agricultural products are size, color, shape, texture and defect. To replace manual inspection of food, computer vision system is used which provide authentic, equitable and non-destructive rating. The computer vision based quality inspection comprises of four main steps, namely, acquisition, segmentation, feature extraction and classification. In this paper, an attempt has been made to explore and compare the various methods/algorithms proposed by researchers in each step. It can be concluded from the extensive survey carried out in this paper that although number of researchers have proposed various methods for the quality inspection of fruits and vegetables still a robust computer vision based system with improved performance is required to be built.

In the literature the images of fruits and vegetables are captured mainly from one direction. However, the system performance may improve by considering the images of fruits and vegetables captured from different directions. Authors have utilized different color spaces for the color based feature extraction, still one may explore combination/ other color space to improve the performance. It can also be concluded from the work carried out in this paper that one can include the images from different regions to make the system regional bias free. In the work reported in literature, fruit and vegetable grading, sorting and disease recognition are done on single fruit. A generalized system may also be designed to grade or sort and detect the defects of multiple fruits and vegetables