Development of Quality Assessment Device for Fruits and Vegetables

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Abstract - Quality measurement of fruits and vegetables is at the centre of attention by the food industry The export market and quality evaluation are affected by assorting of fruits and vegetables. Fruits and vegetables are very important agricultural products in daily life. Evaluating the quality attributes of fresh fruits and vegetables by non-destructive sensing techniques has been an accepted technique today. Quality is a human construct comprising many properties or characteristics. Instrumental measurements are ruling over the world as they are accurate, fast and reduces labour. Non-destructive analysis refers to the surface testing of fruits and vegetables without any intrusive technique affecting the food aspect and quality. Since non-destructive testing makes it possible to examine the condition or quality of food without damaging it, the use of non-destructive analytical techniques is quickly gaining momentum in the food industry. Quality assessment of Fruits and Vegetables becomes challenging in both small- and large-scale areas such as market hubs, cold storages and supermarkets. Dedicated care and handling procedures are required to protect fruits and vegetables from spoilage. Smart equipment works with Non-destructive analysis is required for quality assessment of such areas Automation aids in raising the quality, productivity, and economic growth of the nation's agriculture produce. Manual inspection and grading are still possible, but they are imprecise, time-consuming, unreliable, subjective, difficult, expensive, and easily influenced by the environment. This project suggests an efficient non-destructive method of vegetable quality assessment using a scanner device. This Scanner is fast, accurate, less time consuming, Compact and handy with great ease of access. This equipment can also be fixed in conveyors and programmed with sorting instrument for automatic detection and sorting of fruits and Vegetables. The machine is of 86.6% efficiency. This can be used in smart hubs, cold storage, transport vehicles and market quality inspection.

Index Terms – Convolutional Neural Network (CNN), Quality Assessment (QA), Non-Destructive Analysis (NDA), Machine Vision (MV), Image Scanning(IS)

I. INTRODUCTION

Food Safety and Quality Assurance in fresh produce should be continual procedures that include actions ranging from soil selection and preparation in agricultural operations through final food preparation and consumption. Both Food Safety and Quality Assurance (QA) should emphasize problem prevention, because if safety or quality is compromised, it is difficult or impossible to restore. Furthermore, implementing QA procedures should assist ensure that problems encountered in the past do not have the same impact on future products. Damage to fruits vegetables during transportation or storage is common and difficult to detect, resulting in losses for fruit and vegetable distributors and poorer consumer satisfaction. One of the primary goals of the fruit,vegetable business is to offer unique, inventive commodities of the greatest quality, safety, and nutritional value in order to efficiently meet expanding consumer expectations. Using cutting-edge, unconventional technologies (such as microwave drying, pulsed electric field drying, pulsed light drying, and ultrasound drying) fruits and vegetables can be processed to increase their stability while preserving their thermolabile nutrients, flavor, texture, and overall quality. Some of these techniques can also be used to value waste and by products. The employment of rapid, non-intrusive solutions for process control is critical in the fruit and vegetable industry [24].The challenge for the fruit and vegetable industry is to produce such commodities while also addressing consumer acceptance, quality, and safety. Emerging, novel processing of fruits and vegetables is increasingly being researched in order to develop items rich in bioactive components, while also paying attention to waste and by-product valorization [4].

(1). Quality Evaluation Methods Of Fruit And Vegetables

Fruit and vegetable quality can be objectively verified by testing the physical and/or chemical components associated with the trait. Texture/firmness, taste, flavor and smell, and nutritional quality can all be judged destructively, whereas others can be calculated non-destructively. Some non-destructive approaches, such as optical, vibrational, electrical, nuclear magnetic resonant, and gas analysis techniques, have commercial promise. The chemical composition, physical qualities, or a combination of these two elements determine the quality of fresh fruits and vegetables. Consumers are interested in visual appearance, texture/firmness, sensory, nutritional, and food safety attributes. Some can be estimated using destructive procedures, while others can be calculated using non-destructive approaches. [26].

During the preharvest and postharvest periods, it is estimated that more than 30% of fruit and vegetables are wasted. These losses, however, can be avoided by appropriately assessing ripeness, harvesting period, and quality features throughout the shelf life. Recent projects have focused on using non-destructive technology to analyses the quality standards of fruits and vegetables. These methods are classified into three types: vision-based, spectroscopic, and mechanical. These techniques include hyperspectral and multispectral imaging, vis/NIR and NIR spectroscopy, nuclear magnetic resonance and magnetic resonance imaging (NMR, MRI) spectroscopy, X-ray computed or microcomputed tomography, chlorophyll fluorescence, and terahertz radiation.[13]

(2). Image Scanning

Increased demands for objectivity, consistency and efficiency have necessitated the introduction of computer-based image processing techniques. Recently, computer vision employing image processing techniques has been developed rapidly, which can quantitatively characterize complex size, shape, color and texture properties of foods. Image processing systems play a more and more important role in the food quality evaluation by maintaining accuracy and consistency while eliminating the subjectivity of manual inspections. They offer flexibility in application and can be reasonable substitutes for the human visual decision-making process. Image processing analysis generally consists of the following five step which are
(1) Image acquisition operations to convert images into digital form;
(2) Pre-processing operations to obtain an improved image with the same dimensions as the original image;
(3) Image segmentation operations to partition a digital image into disjoint and non-overlapping regions;
(4) Object measurement operations to measure the characteristics of objects, such as size, shape, color and texture; and
(5) Classification operations to identify objects by classifying them into different groups.
Recent advances in signal processing technology and computational power have increased the attention towards computer vision-based techniques in diverse applications such as agriculture, food processing, biomedical, and military. Especially in agricultural and food processing, computer vision can replace most of the manual methods for screening of seed, grain and food quality.

(3). Image Scanning Trends

An increasing digitization and automation capability is paving the way for new technology, spawning a slew of initiatives, startups, technology firms, and advice services. In recent years, image processing techniques have been extensively used to assess food quality. This paper discusses recent advances in image processing techniques for food quality evaluation, such as charge coupled device cameras, ultrasound, magnetic resonance imaging, computed tomography, and electrical tomography for image acquisition; pixel and local pre-processing approaches for image pre-processing; thresholding-based, gradient-based, region-based, and classification-based methods for image segmentation; size, shape, color, and texture features for object recognition; and The promise of image processing techniques for food quality evaluation is illustrated, as well as certain challenges that need to be overcome or researched further in order to accelerate the deployment of image processing technology for food quality evaluation. In the food industry, some quality evaluation is still performed manually by trained inspectors, which is tedious, laborious, costly and inherently unreliable due to its subjective nature.

(4). Need For Image Sorting

Traditionally, manual quality checking techniques for vegetables were used, but they were inaccurate, time consuming, boring, and somewhat expensive. Manual grading and sorting of vegetables is inefficient and may result in some human mistake. Another issue is manpower demanding, and to address these issues, agricultural companies have implemented numerous automated grading and sorting systems. Sorting tonnes of quality veggies to manufacture food products made from vegetables is another issue that most agriculture and food enterprises encounter due to expense and inaccuracy. In recent years, automated machine vision-based technology has grown in potential and importance in a variety of fields, including agriculture and the food processing industry. One of the most significant processes is vegetable sorting and grading, however as previously said, this is generally done manually. An autonomous vegetable quality checking system accelerates the process, improves accuracy and efficiency, and saves time. The use of a machine vision-based system was intended to replace manual grading and sorting techniques for fruits and vegetables. The manual labor had difficulties in maintaining consistency in grading and regularity in sorting.

A computer vision-based automatic grading and sorting system is required to speed up the process while maintaining consistency, homogeneity, and accuracy. In general, gradation indices include shape, size, color, maturity, defection, and so on. Gradation techniques based on computer vision have evolved as computer image vision technology has advanced. The computer vision gradation technique is real-time, objective, and non-destructive, and it can identify multiple indices at the same time, including size, defect, color, shape, and maturity. The new generation of intelligent grading and sorting algorithms is significantly more powerful than classic visual analysis algorithms; they have automated learning capabilities, ensuring detection performance far above the speed and accuracy of any trained operator.

Automatic vegetable sorting can increase product quality, eliminate uneven manual inspection, and reduce reliance on available labor. Quality is determined by a variety of factors, including flavor (sweetness, acidity), appearance (color, size, shape, flaws, glossiness), and texture (firmness, mouthfeel). Edan stated that multi-sensor quality classification can be used in real-time sorting to improve overall categorization. The use of vision and an impact sensor to classify tomato quality was successful. To sort according to the surface defects requires an analysis as complete as possible of the entire vegetable surface.

Size, shape, and color are the most important factors to consider while sorting vegetables for quality. Size measurement is critical for measuring the surface area of produce. The form of fruits and vegetables is an essential visual quality measure. Human sorters are now used to sort fruits depending on shape. Because radish and carrot get deformed as a result of excess nitrogen, climate, and other variables, these malformed ones are sorted in image processing to improve export quality. Color is another essential quality component that has received a lot of attention. The wavelength of light reflected from an object's surface determines its hue. The wavelength of light varies greatly in biological materials. These spectral changes offer a one-of-a-kind key to machine vision and image processing. Radishes are typically red, white, or purple, whereas carrots are orange. These three basic factors can also be used to evaluate its quality.

(5) Rise Of Raw Food Vegan Diet

The raw food diet is a dietary approach that involves consuming at least 75% of the food in its raw or uncooked form. This mainly consists of raw fruits, vegetables, nuts, seeds, and sprouted grains. Supporters of the raw food diet contend that cooking can deteriorate vital enzymes and nutrients in food, and consuming raw foods can promote better health and a longer lifespan.

Consuming a salad-based diet can provide numerous health benefits that can enhance one's overall well-being. A significant advantage of this type of diet is an increased intake of nutrients. As fresh vegetables are packed with essential nutrients like vitamins, minerals, and fibre, they can promote optimal health. Furthermore, the low calorie and high fibre content of most salad ingredients make them an ideal choice for weight management. This can also help in maintaining regular bowel movements, leading to improved digestion. Studies have shown that consuming a diet that is high in fresh vegetables is associated with a lower risk of chronic diseases, including heart disease, diabetes, and specific types of cancer.

(6) Fruits And Vegetables

Fruit and vegetables should be an important part of your daily diet. Indian fruits and vegetables are now more frequently produced and exported. It ranks second in fruits and vegetable production in the world, after China. As per National Horticulture Database published by National Horticulture Board, during 2020-21, India produced 102.48 million metric tonnes of fruits and 200.45 million metric tonnes of vegetables. They are nutritious by nature and include vitamins and minerals that can support our overall wellbeing. They can aid in illness prevention as well. Fruits and vegetables are low in fat, salt and sugar. They are a fantastic source of dietary fibre, which helps keep you satisfied for longer and help you avoid overeating. A high consumption of fruit and vegetables, along with a balanced, healthy diet and an active lifestyle, can enable you to, lower your cholesterol, combat obesity, keep a healthy weight and reduction in blood pressure.

Defects in these fruits and vegetables generally appear due to insect damage, scarring, product decay, and so on. The numerous fruits and vegetable diseases affect the yield's quality, quantity, and stability. These diseases not only lower yield but also destroy the variety and force its eradication from cultivation. Fruit and vegetable illnesses manifest as spots on their surface and can result in significant losses if not addressed right once. An important factor in groundwater contamination has been linked to the overuse of pesticides to treat fruit and vegetable diseases, which raises the levels of hazardous residues on agricultural products. Pesticides are among the most expensive production costs, and using them comes with serious health hazards for both consumers and ecosystems. Therefore, it is necessary to limit their application.

Using scanner devices to identify these defects of fruits and vegetables can bring reduction in time consumption and act as an effective way to immediately identify spoilage as soon as it detoriates. As a single potential spoilage in any one of the fruit or vegetable can spoil the whole bulk quantity which affects exports and imports.

Fig 1 Fruits and Vegetable Market

(7) Radish (Raphanus Sativus L.)

Radish *(Raphanus sativus L.)* belongs to genus Raphanus, family Brassicaceae or Cruciferae originated from the Central and Western China and India [22]. It has diuretic and reviving qualities. Additionally, it is used to treat persistent diarrhea, insomnia, and neurological headache. Additionally helpful for piles and bladder issues are the roots. The seeds of radish are a possible source of non-drying fatty oil appropriate for the production of edible and lighting products as well as for the commercial extraction of protein from radish leaves.

Because of its specialized structure (hypocotyls), which can store starch and other substances, its similar resemblance to actual roots, and its home in the ground, the radish is classified as a root. The surface color of radish can vary from white in Asia to red in Europe through purple green and black [17], while its flesh is white in most European and Asian crops [12]. A plenty of indigenous recipes are radish which gives great health benefits. They are best when eaten raw, can be made sliced for salads and sandwiches or enjoyed whole and dipped into houmous for healthy snack.

Fig 2 Radish *(Raphanus sativus L.)*

They are often used in culinary world which adds a best pungent, peppery element to dishes. Mooli Subzi, Radish dry vegetable. White Radish is used in South Indian Radish Sambhar, Mooli ka Salad, Radish, Cucumber, and Curd Dip, Indian Theplas, Parathas, Mooli Thepla, Radish Nachni Roti, Mullangi Sambar, and Bhatia Kadhi. There are many different types of radish black radish, daikon radish, horse radish, water melon radish. Radishes are prepared in many different ways, they can be pickled, used in sandwiches, roasted. Nutritional profile of radishes is very diverse and offers a scope of nutrients that can has a profound effect on health.

(8) Radish Diseases

Fig 3 Radish *(Raphanus sativus L.)* in a crate

Radishes *(Raphanus sativus L.)* have a significant issue with storage decay, which makes it difficult to keep this produce fresh and increase its postharvest shelf life at both low and high temperatures. Radishes are susceptible to postharvest and storage degradation caused by a number of fungus, however Alternaria and Fusarium species are the most frequent infections when the vegetable is individually wrapped in food packaging film for storage.

The softening and loss of weight are mainly due to the loss of water and they are controlled with high relative moisture along with low temperatures Bruises are due to impacts during the mechanical harvesting and during transportation, when the produce is hand harvested the incidence of this damage is usually smaller. Furthermore, spongy appearance is an alteration that may arise during the harvesting and continues its development during post-harvesting. The most frequent physiological alterations are chilling injuries and cavities. Freezing takes place at temperatures of -0,7ºC.In extreme situations, the roots become brittle, lose moisture, and weaken. The cavities, which might appear before or after the harvesting and become more frequent during storage, are signs of senescence. Low temperatures lessen its occurrence.

(9) Carrot (Daucus carota)

Fig 4 Carrot, *(Daucus carota)*

Carrot, *(Daucus carota)* is an herbaceous, generally biennial plant of the Apiaceae family which produces an edible taproot. Among common varieties root shapes range from globular to long, with lower ends blunt to pointed. Besides the orange-colored roots, white-, yellow-, and purple-fleshed varieties are known. Carrot is a cool climate crop which is grown in subtropic as well as temperate climate zone. Carrot is mostly used as an edible produce for millions of people all over the world. Carrot is good source of calcium, potassium, mineral and natural nitrates. Carrots are also good source of carotenoids, vitamins, dietary fibers and antioxidants. Carrots are very much popular for its abundant nutrient. Quality analysis of carrot based on the product quality is most basic and important operation. In tradition method quality evaluation of carrot is done manually and its expensive and is time consuming with low performance. Carrot is mostly used in salads and halwa, sambar. Vegetable biriyani , roasted carrot, carrot curry, glazed carrot, carrot smash, carrot juice, carrot supe and carrot poriyal.

Now a days, fruits and vegetables industry has sustained due to the introduction of image processing method and such method had been successful in non-destructive assessment various food products. Grading of fruits and vegetable based on the quality of produce after harvesting. So, carrot must be used as soon as possible in order to get superior fresh characteristics. In order to improve the efficiency of grading and sorting and for automatic detection purpose.[11]

(10) Carrot Diseases

During the cultivation of carrot large variety of diseases are been detected which results in the reduction of yield and market value. Most of the carrot diseases is caused by organisms like mycoplasma, which results in stunting, yellowing, leaf bronzing, sterility and leaf like petals and aster yellow, black rot, bacterial soft rot, nematodes, common scab, black root rot, cavity spot, rubbery brown rot, heat canker. Carrots are attacked by a large number of pathogens. Due to the nature of the carrot, the damage is caused by various pathogens and microorganisms which is an important factor that limits the carrot production. To give best quality of carrot to the consumer, fruits and vegetable industry update the technologies like image processing of carrot.

II. LITERATURE SURVEY

Nowadays fruit and vegetable industry has sustained due to the introduction of image processing methods and such methods has been successful in the non-destructive assessment of various food products. Increasing concern on quality and safety of food in worldwide business. Non- invasive methods or non-destructive methods creates an esteemed value, especially in fruit and vegetable industries. Non-destructive procedures are a component of high-quality controls and they complement the majority of existing approaches. In addition, consumers have a tendency to want more information about the items they buy nowadays as a result of their enhanced awareness. [10]

The trend of microprocessors methods of signal analysis and sensors has opened up new establishments to employ techniques for this purpose. It took a lot of work to establish this strategy because there is a profitable demand and interest in finding food and agricultural products that are more uniform in quality and consumer favourites. [1]

Quality evaluation of fruits and vegetables is done by both destructive and non-destructive methods. Destructive method of analysis determines how a procedure react under pressure till it fails. It's not suitable in fruit and vegetable industry, as it ruptures the fruit and vegetable tissue and is difficult to evaluate the whole lot at a time. Destructive testing is more expensive and generate waste. This testing is less efficient because Destructive testing is direct approach and does not provide accurate result. [6]

If the testing is done by destructive method in large food manufacturing industry in order to analyses the hidden characteristics of the product, an analyst must destroy the various aspects of the product. Destructive method of analysis provides reliable result due to its manual process and material degradation procedure cost the manufacturer. Non-destructive analysis is similar to destructive analysis but it will not permanently damage any produce. This is based on physiological property which connects with certain quality factor of fruits and vegetables. Both the internal and the external attributes of fruits and vegetables are very much important and internal attributes plays an important role in influencing a consumer selection of the particular product. Non-destructive analysis is non-invasive, rapid and suitable for real time analysis so non-destructive analysis are emerging as highly efficient means of analyzing the quality of the material. [7]

(1) Quality Of Agricultural Products

In today's post-harvest and processing of agricultural products, assessing the quantity and quality of agricultural products without causing any harm and reducing food waste has a significant place. Non-destructive methods attributed quality valuation methods have increased dominant factor and considerable attempts for fresh fruit and vegetable these years.

NDM is created to focus on creating best needed systems to evaluate the agricultural product quality which has been improved the standardization which is required to classify the marks of food quality in an item, required for selling the material. The non-destructive evaluation techniques concentrate on aspects of food such structure, mechanical, physical, and chemical qualities. The application of non-invasive measurement is the great approach for food processing techniques. [19]

The main aspects of fresh inspection are color, size shape texture and number of defects. Defect or damage usually occurs in radish and carrot due to rotting, bruising, scab, fungal growth, injury disease etc. Proper care should be taken following post-harvest of these vegetables. [20]

(2) Computer Vision Techniques

Machine vision, near-infrared spectroscopy, hyperspectral imaging, electronic noses, ultrasonic measurement, and acoustic emission measures are examples of common non-destructive evaluation methods. Scientists have concluded that the main components of food are water, carbohydrates, fats, and proteins. Changes in the agricultural product's chemical structure frequently have an impact on the processing techniques. [9]

Computer vision techniques for classifying fruits and vegetables may also be used to automatically sort fruits from a set of various fruits. At supermarkets, selecting various fruits and vegetables is a common duty. To establish the price of a particular fruit or vegetable, the cashier must be able to recognize both the species (such as banana, apple, or pear) and the variety (such as Golden Delicious, Jonagold, or Fuji). Although product packaging has attempted to solve this issue, most customers still prefer to choose their own purchases, which cannot be boxed and must instead be weighed. [25]
This issue is frequently solved by assigning codes to each type of fruit and vegetable, but this technique has drawbacks, such as the need to remember a lot of codes, which might lead to price issues if not done correctly. At many supermarkets, a tiny book with images and codes is given to the cashier as assistance, although this method has the drawback that it takes time to go through the booklet. It has taken a lot of effort to automate the visual evaluation of fruits for size and color. Yet, due to the wide variances in types of flaws and the natural changes in skin color across various types of fruits, the identification of defects on fruits using photographs is rife with issues. [2]

Companies must teach staff to inspect produce as it moves along a conveyor belt in order to maintain the quality standards needed for fruit and vegetable production lines. Fruits and vegetables are divided into certain groups by these experts based on their visual qualities. However, this strategy is not competitive and occasionally inaccurate for quick and accurate quality standards. Assumedly, it follows that a smart-methods-based automated framework is essential. There have been reported on a number of techniques focused on the capture of more precise pictures. [15]

The use of a machine vision-based system was intended to replace manual grading and sorting of fruits and vegetables. The manual labor had difficulties in maintaining consistency in grading and regularity in sorting. Aside from that, the fruit processing contains numerous procedures that can be broadly described as grading, sorting, packaging, shipping, and storing. Grading is regarded as one of the most critical steps in achieving a high standard of quality.

The computer vision-based quality assessment contains four fundamental stages, to be specific, securing, division, highlight extraction and order. By utilizing computer vision framework, numerous attributes like surface, shape, variety, size and deformities can be evaluated and reviewed naturally. Hyperspectral computer vision framework joins both spectroscopic and imaging methods which give otherworldly data to every pixel of the spatial picture.

For vegetable classification and recognition, developments in deep learning and convolutional neural networks are extremely effective. The features of an image are learned through deep learning, which also extracts contextual details and global features that will reduce error. The computer vision system offers an automated, low-cost, and non-destructive method. At the moment, multispectral and hyperspectral computer vision systems are widely used to evaluate the quality of fruits and vegetables.[27]

(3) Artificial Intelligence And Imaging Techniques

The goal is to examine how artificial intelligence and imaging techniques which can be used to analyses external faults in fruits and vegetables using soft computing. Many business processes, including washing and packing, are highly automated, the world's most crucial monitoring measures are still done by hand (e.g., quality inspection and grading). In order to achieve this, we propose the introduction of an efficient classifier based on an analysis of the geometric (sizes, shapes), color, and skin texture of vegetables and fruits. The RGB image of the fruits and vegetables is perceived. The pre-processing strategy has been used to improve image quality.
The targeted fruit and vegetable portion is the focus of the segmentation process. According to the data collection, features are extracted using the Segmentation-based Fractal Texture Analysis (SFTA) method. [23]

Automation improves the nation's quality, production, and economic growth in agriculture science. The selection of fruits and vegetables has an impact on the export market and quality assessment. The most important sensory quality of fruits and vegetables is appearance, which influences their market value and the preferences and choices of consumers. Although though humans are capable of sorting and grading, their work is inconsistent, time-consuming, variable, subjective, burdensome, expensive, and easily impacted by their surroundings. Thus, a clever technique of fruit grading is required. Researchers have used computer vision in recent years to create a variety of algorithms for grading and sorting. This paper presents a detailed overview of various methods i.e. pre-processing, segmentation, feature extraction, classification which addressed fruits and vegetables quality based on color, texture, size, shape and defects.

The difficulty for picking robots to correctly identify target fruits and vegetables is greatly increased by issues with fruit images that are collected by picking robots in natural environments, such as uneven lighting, complicated backgrounds, occlusion of branches and leaves, and overlapping fruits and vegetables. In contrast, the backgrounds of most fruits and vegetables are a similar color. [28]

Fruits and vegetables with similar-colored backgrounds are more difficult to identify than those with backgrounds of different colors because their hues resemble those of their leaves and the nearby weeds. Therefore, accurate fruit and vegetable identification in backgrounds with similar colors is essential to achieving dynamic fruit and vegetable growth monitoring and intelligent picking, which has significant value and applicant The close-color background and various processing techniques in the identification process were used to summaries the distinctive qualities of fruits and vegetables.[21]

The following techniques have been outlined, including fruit and vegetable detection in the process, image capture, image pre-processing, feature extraction, and image segmentation. Several techniques have also been contrasted. The current research was finally addressed, and a solution for the various processing phases of fruit and vegetable detection in backdrops with comparable colors was suggested. To recognize fruits and vegetables with a close-color background, deep learning techniques were integrated with some classical techniques, providing references for subsequent research in other areas. Ion potential for improving plantation management. [14] Farmers and distributors sort and grade agricultural and food items using traditional quality inspection and handpicking, which is time-consuming, difficult, and inefficient. Manual sorting and grading are based on traditional visual quality inspection performed by human operators, which is time-consuming, inefficient, and inconsistent. Traditionally, harvesting is done through manual sensory observations. Color, look, texture, and odor are common quality criteria used to determine harvest maturity. Sorting and grading collected product is the first and most critical stage in the post-harvest process.

Rapid Color Grading for Fruit Quality Assessment Color mapping was done for several fruits using Direct Color Mapping process and depending on the color of the gradation process. The strawberry can be graded utilizing an automation method based on its form, size, and color. The detection of apple fruit illness was produced using means clustering segmentation.
Although the quality of fresh fruits and vegetables can be defined differently depending on consumer preference and final utility, a standardization to identify the degree of quality in commodities is required for marketing fresh and safe products. The tree is obtained from real time and simulation using MATLAB in real time utilizing digital camera under different lighting conditions with application software for intelligent segmentation and automatic yield computation of fruits and vegetables. The captured images are filtered to eliminate background noise before the fruit region is separated from its background.

Fruit and vegetable image processing has been extensively used to find defects in size, shape, and color. Image categorization can be demonstrated in the classification of vegetables and the detection of fruit diseases. An image is segmented to extract the region of interest, and the characteristics from that segmented region are then calculated and used in training and classification. Experts divided vegetables into seven groups, after which they divided them further into groups based on characteristics including color and the shape of outward flaws.

Non-destructive methods are effective than traditional conventional methods as non-destructive methods are mainly based on physical properties which correlate well with certain quality factors of fruits a Size, shape, color, gloss, firmness, texture and freedom from external defects such as visible blemishes, dullness, etc., are various external quality factors of importance. non-destructive methods are mainly based on physical properties which correlate well with certain quality factors of fruits and vegetables. It is rapid, precise, reduces the processing time, reduces cost, save energy, improve the shelf life.

Sensory characteristic of fruits and vegetables like appearance impacts their market value. Digital image processing technology helps to process images and attempt an extension for their analysis. Computer vision technology corresponds the effect of the human vision in inspecting quality of fruits and vegetables by electronically perceiving an image, interpret and recognize the characters and an information is provided for the quality grading and sorting machine.

III. Materials and Methods

Carrots, Radish, Mangoes were the sample used for trails to deduct the Quality and calculate the spoilage of the raw material Many trials are conducted in the selection of materials. Also, the materials should have their own properties with high strength. The materials used for fabrication of this machine are:

- Node MCU
- ESP32CAM
- MQ-135
- OLED Display
- Thonny (Application Software)
- TP4056 battery charging circuit
- Lithium-ion battery(3.7V)
- Boost converter
- Toggle Switch

(1)Design and Fabrication

The proposed methodology involves detecting the quality of carrots and radishes using an ESP32CAM module. The module is connected to a laptop, and a Python code with a convolutional neural network (CNN) and OpenCV with contour is used to detect the affected percentage. The detected data is sent to Thing Speak cloud and displayed using a webpage.

(2) Python Code with CNN and OpenCV

The Python code will be used to process the images captured by the ESP32CAM and detect the quality of the carrots and radishes. It will use a CNN to classify the images as healthy or unhealthy, and OpenCV will be used to detect the affected percentage using contour detection.

(3)Thingspeak

Thing Speak is an Internet of Things (IoT) platform that allows you to collect, analyze, and visualize data from sensors or other devices. In this methodology, we will be using Thing Speak to store and display the detected data.

(4)Image Scanning Steps

- Image Acquisition: Capturing pictures of radish and carrot in computerized structure/digital form and stored in an advanced digital media.
- Image Pre-processing: Perform resizing of radish and Carrot images.
- Segmentation: Segmentation is utilized for partitioning and isolating an image into different parts which are desirable.
- Feature Extraction: Acquiring features like color tone, surface texture and shape
- Image Characterization: This part examines property of image features including organizing its data into categories

Thresholding is a type of image segmentation, where we change the pixels of an image to make the image easier to analyze. In thresholding, we convert an image from color or grayscale into a binary image, i.e., one that is simply black and white.

(5)Procedure For Fabrication:

- Connect the ESP32CAM module to your laptop via the USB cable.
- Install the necessary software, including the Arduino IDE, Python 3.x, OpenCV library, TensorFlow, Kera's, and Thing Speak account.
- Program the ESP32CAM module using the Arduino IDE and upload the code to the module. The code should capture images of vegetable and stream them to the laptop.
- Write a Python code with a CNN and OpenCV to process the images captured by the ESP32CAM and detect the quality of the carrots and radishes. The CNN should classify the images as healthy or unhealthy, and OpenCV should be used to detect the affected percentage using contour detection.
- Use Thing Speak to store and display the detected data. The data can be sent to Thing Speak using the Thing Speak API. The data can be displayed on a webpage using the Thing Speak channel widgets.
- Run the Python code and capture images of the carrots and radishes using the ESP32CAM module. The detected data will be sent to Thing Speak and displayed on the webpage.

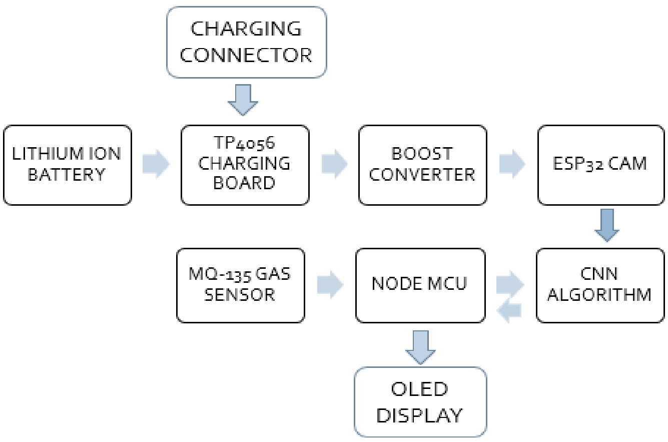

Fig 5 Block Diagram for Fabrication

IV. RESULTS

(1) Working of Quality Scanner

- The lithium-ion battery is used to drive the device and the battery is connect to ESP32 Cam which is a microcontroller used to assess the program.
- ESP 32 Cam is linked to NODE MCU device is programmed with phyton code in assistant of Thonny software and OpenCV library is used.
- For the voice assistance, we use Thing Speak.api which gives command for the result and observation through voice
- When the device is turned on using toggle switch and esp32 cam is connected with Thonny application software using WIFI module.
- Once the device is connected with Thonny application , we should position the camera towards the sample and camera captures the image of the sample by pressing the key "q". Further, the image is get processed by comparing with OpenCV library and the results can be processed.
- And the results will be depicted in app(html). This results can be acquired in PC and mobile applicationss

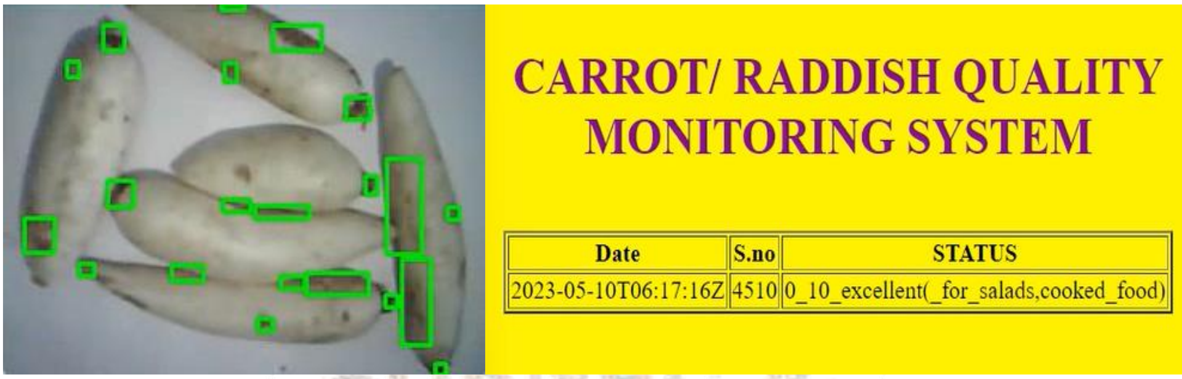

Fig 6 Result observation of Radish (3.685% Spoiled)

Fig 7 Result observation for Mangoes (30.1652% Spoiled)

(2) Determination Of Quality Scanner Efficiency

The efficiency of the Quality Scanner refers to the number of successfully examined vegetables per total number of vegetable present. The efficiency of the detector was calculated based upon the formula given in Equation

$$\text{Efficiency}(\eta) = \frac{number\ of\ successfully\ identified\ vegetable}{total\ number\ of\ vegetable\ present} x100 \qquad \text{(Equation 1)}$$

Efficiency(η) =(26)/30x100

Efficiency(η)= **86.66%**

(3) Determination Of Precision Of Result

Determination of Precision is done for checking the error percentage of the quality scanner which is done by placing the sample in the tray and positioning the camera in particular height and set of trails and the highest value of difference is taken for error determination were taken and consistency is determined

S.no	Sample	Distance (cm)	Trail	Percentage of spoilage	Difference
1			1	6.9535	-
2			2	6.5195	+0.434
3	Radish	30 cm	3	7.3935	-0.874
4			4	7.6535	-0.26
5			5	7.675	-0.0215

Table 1 Determination of Precision of Result

Hence from the analysis of difference given in the above-mentioned table the Accuracy is depicted it is concluded to be ±0.874 or ±0.9.

(4) Determination Of Correct Height Range for Detection (Cm)

Determination of Correct Range for detection refers to the Height between the ground (where the materials were placed for detection) to the Camera Lens which gives correct spoilage value. The samples were placed in trays and the camera is positioned in different Heights and the testing trails where taken, The Height which gives nearest correct Percentage without deviation (%) is taken

S.No	Sample	Height (cm)	Trials	Percentage of Spoilage	Difference
1	Carrot	15 cm	1	3.09	0.43
			2	3.523	
2		30 cm	1	4.3395	0.11
			2	4.448	
3		45 cm	1	4.635	0.12
			2	4.513	
4		60 cm	1	3.512	0.34
			2	3.854	
5		75 cm	1	2.364	0.56
			2	2.925	

Table 2 Determination of Correct height range for Detection

At the Positioned height from which the difference between trails is least, is observed to be the correct height for Detection. As the least distance was observed at 30 cm and 45 cm for detection of spoilage where the difference value is found to be 0.11 at 30cm and 0.12 at 45cm. Thus, it is recommended to have a distance range at these positions.

(5) Determination Of Infected Vegetable (%) (Theoretical)

Determination of infected vegetable (%) refers to the number of infected-vegetable successfully identified by the scanner after sensing. The bad ones are identified by the scanner. (Theoretical) The percentage of infected vegetables is calculated based upon the formula given in Equation

$$\text{Infected Vegetable (\%)} = \frac{number\ of\ successfully\ Identified\ infected\ Vegetable}{total\ number\ of\ vegetable\ present} \times 100 \qquad \text{(Equation 2)}$$

$$\text{Infected Vegetable (\%)} = \frac{5}{16} \times 100$$

Infected Vegetable (%) = **31.25%**

(6) Determination Of Good Vegetable (%) (Theoretical)

Determination of good vegetable (%) refers to the number of good vegetables successfully identified by the detector after sensing via ESP32cam. The percentage good vegetables are calculated based upon the formula given in Equation

Good Vegetable (%) = 100 – Percentage of Infected Vegetables (Equation 3)

Good Vegetable (%) = **68.75%**

(7) Comparitive Analysis of Quality Scanner with Other Image Processing Techniques

We have compared the performance of different approaches for addressing vegetable classification and spoilage detection [8] used dataset with 2 – Normal and anthracnose- affected fruit types Pre-Processing with K-means Features with Texture features and the color space training was done with RGB BPNN classifier with a Accuracy of 84.65% and [18] used dataset 15 with cropping and with various co-occurrence features such as contrast ,energy, local homogeneity, cluster shade and cluster prominence is done with HSV and the training was done with minimum distance classifier with an accuracy of 86%. An average classification error of 1% and 3% was reported for fruit and vegetable classification and fruit disease classification, respectively. In Apple, Orange, Tomato the color and texture features was extracted using Gray-level Co-occurrence Matrix and support Vector Machine and their accuracy was about 84%. The review made by [5] analyzes the use of computer vision and image processing techniques in the agri-food industry. They define that the most relevant quality properties of agricultural products are color, size, texture, shape, and defects. Hence, the authors present an overview of different methods for preprocessing, segmentation, feature extraction, and classification using these features. They study several approaches for classification in food quality evaluation, including KNN, SVM, ANN, and CNN. According to them, DL-based approaches such as convolutional neural networks are very efficient for fruit classification and recognition, reducing the error remarkably in classification. [16] applied CNNs with data expansion techniques to select a total of 5822 color images in ten-class food items from the ImageNet comparing its method against bag-of-feature (BoF)and support vector machine (SVM) models. BoF with SVM showed accuracy results of 56% while the CNN model performed an accuracy of 74% and 90% without and with data augmentation techniques, respectively. [3] developed a machine vision system for sorting apples according to surface defects, including bruises. Their system could detect surface defects using a combination of a routine based on artificial neural networks and principal components, and three different threshold segmentation routines. When they evaluated using eight apple varieties, the routines were able to detect 77%–91% of the individual defects and were able to measure 78%–92.7% of the total defective area. Comparing with these methods this project working with CNN method has an efficiency of 86.6% at single threshold level. But if the threshold is adjusted the efficiency ranges from 84-90% with least error rate of ±0.9%.

V. CONCLUSIONS

Assessing the quality of fruit and vegetables is crucial to ensure that consumer receive fresh, nutritious and safe produce. Quality Assessment of fruits and vegetables is essential for maintaining consumer satisfaction, promoting health and ensuring food safety. The analysis of fruits and vegetables for several aspect criterions is a continual task; machine vision systems are best befitted for conventional analysis and quality assurance. So, the purpose of the project is to design and develop a low-cost efficient, non-destructive scanner for Quality Detection of vegetables mainly to prevent the post-harvest losses. In order to alter manual inspection of vegetables, computer vision is used efficiently which provide authentic characteristics approach, equitable and non invasive rating. Identification, quality and testing the analysis of infected vegetables is determined using quality scanner. Monitoring using this quality scanner is easy as it has both devices (OLED and Computer display). Therefore, this enables in achieving real-time data through cloud and reducing time and increase efficiency. This detector does not require any high skilled technicians or gadgets. The device is compact, user friendly, portable and quiet cheap when compared to other devices. As a result it can be used in Smart Hubs, Cold Storage, Transport Vehicle and Market Quality Inspection. This device is more feasible to operate and can also be applied in Industrial Conveyors and Sorters. On the test and trial in super market and grocery shop, the percentage of spoiled vegetables is found to be 31.25% and we observed that the quality detector was more efficient due to high accuracy. The speed and accuracy of the system expedite production and improve both safety and quality control. The efficiency of the device is 86.6%, but manual examining takes about 3-4hrs for the same because of strain and discomfort faced by the laborers.

VI. REFERENCES

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