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Design and Development of Automatic Guava Fruit Sorting Machine

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ABSTRACT: The growing Indian population, losses in handling and processing, and rising demands of high-quality food products for export and safety requirements need the development of accurate, quick, and objective quality evaluation of food and agricultural commodities. The goal of this research was to develop an intelligent fruit sorter based on healthy and defective guava. The machine is built up of a conveyor system, segregator, a sensor, and an Arduino Uno board. The suggested system's real-time guava fruit sorting system has been built to automatically classify guava fruits into healthy or damaged quality. Based on the findings of an image analysis technique using algorithms and an embedded system, a machine learning method used a field programmable array in a PLC to control and drive relays through MATLAB. The system was put to the test by sorting and inspecting 200 samples with an 97% accuracy rate for identifying healthy and damaged fruits based on the wavelength difference utilizes conveyor and a segregator.

KEYWORDS: Arduino, Guava Fruit, Conveyor Belt, Sorting machine

I. INTRODUCTION

Agriculture and horticulture have a significant part in the india's growing economy. The quality of the fruits is a significant consideration for consumers, and it has become a need for suppliers to supply high-quality fruits to their clients. Fruit processing entails a number of stages that may be divided into grading, sorting, packing, transportation, and storage. Grading is regarded as the most crucial stage in achieving a high standard of fruit quality. Inspection, or grading, of fruits is still done with the assistance of human specialists in India. The quality of the fruits is determined by external criteria such as size, colour intensity, shape, and surface appearances, as well as internal ones such as sugar and acid content, although external appearance as guava fruit deteriorates from outer surface to inner surface are the most essential elements in fruit grading and sorting. **Chavan** To increase the analysing and sorting time of fruits, design and development of a fruit sorting and quality use of thermal imaging analysis approach based on computer machine vision and image processing techniques has been developed in this study.

II. LITERATURE REVIEW

Chavan et. al. designed, system is designed for sorting and analysing the quality of fruit and it is implemented through MATLAB. The inspection is being performed on the conveyor from external to check quality and sort the fruit. This system also includes an embedded system that increases the speed of work, saving time, effort, and providing higher accuracy than hand sorting.[1] Devgayasam et. al. developed system has features an inbuilt technology that speeds up operations, saving time and effort while delivering greater accuracy than manual sorting. Developed a set of exterior quality characteristics based on the brinjal's RGB. It automatically extracts the attributes from the photos and classifies the brinjal into the appropriate categories.[2] Dabade et. al. utilised, a PLC, a field programmable gate array (FPGA)

regulates and drives a relay based on the output of a photo interrupter. For detection, photodiode IR beams. Various sized objects are passed through the sensors, and the things with the appropriate size are sorted. The drive circuit, which is controlled by the drive controller, drives the belt. Accidents in the industrial business can also be avoided since the usage of operators on the production floor has been decreased.[3]

Tuong et. al. designed and constructed a vision sorting system with a high-resolution vision camera. The programme will run algorithms to detect the attributes of the object to sort and save the location of sorted objects in a database. To test the accuracy of the model generated, the designed system will be tested on tomatoes and passion fruits. In a packing line or sorting product line, a visual line tracking system may recognise and position things travelling on a conveyor belt, and it can interact with other actuators to conduct pick and place cycles. [4] Kanase et. al. designed sorting system for citrus fruit sorting based on weight gives an accurate, easy, reliable, consistent, and portable sorting technique to be used in small agricultural industries. it aims in classifying the fruits by weight which coming on chute through hopper, by moving the fruit near its respective packing place.[5]

Trilok et. al. concentrated on the design of a three-part automated system for coconut segregation: the loading unit, the conveying unit, and the separating unit. The design of specialised rollers in the segregating unit may segregate into four distinct sizes of coconuts at various segregation units. The time it took to segregate 200000 unit's coconuts was assessed to be 5.28 hours, compared to 12 hours for a human segregation procedure. [6]

Rasekhi et. al. created an automated fruit sorter based on size. Two pieces made up the hardware. A camera, a robotic arm, and control circuits are included in this picture acquisition system. The second component was a robotic actuator with all of the necessary electrical circuitry. A suitable image processing approach was used for sorting reasons, and two models of size thresholds were established and put into a variety of image processing algorithms, which were then linked with Artificial Neural Network (ANN) techniques for classification purposes. With very few mistakes, the sorter test rig was able to categorise the goods into three groups. Algorithms based on Area, Perimeter, and the ANN model had lesser errors, according to the findings.[7] Arjun Kadam et. al created a prototype and successfully tested a turmeric rhizomes sorting process using image processing according to the specified specifications. After fabrication, the automatic sorting system is put to the test on the job site. The sorting efficiency improves by up to 70%. The benefits of this equipment may also be mounted on a cart for mobility to other locations.[8] Kannaki et. al presented the design, construction, assembly, and commissioning of an automated Sorting machine employing a Weighing mechanism. Conveyor system, weighing mechanism, and electronics system controller comprise this system. Any item travelling in the conveyor has its weight measured. The object is then sorted using a controller based on its weight, which is determined by comparing it to a standard weight for that object.[9]

Abdullahi et. al studied to build and create an automatic tomato sorting system that uses a colour sensor. A conveyor system, a sorting unit, a TCS34725 RGB colour sensor, and an Arduino Uno board make up the machine. The TCS34725 RGB colour sensor detects the tomato's colour, while the Arduino Uno, a PIC development board based on the ATmega328 microprocessor, oversees the entire process. The tomato would be classified as ripe or unripe based on the frequency of the colour intensity acquired by the sensor. The total accuracy of the method was 97.8%. With one line, the system sorting performance was predicted to be 2807 tomatoes per hour.[10] Rupnar et. al developed Manually operated gravity type fruit sorter for small scale grading operation. A hopper, grading channel, and collecting unit made up the created manually operated sorter. Tomato sorting was tested using the created sorter using standard test code. The average efficiency of grading was determined to be 79.2 percent. For sorting Tomato fruits, the overall performance of the created hand operated fruit sorter was determined to be good.[11] Adamu et. al, built, and tested using an embedded system (based on Arduino) considering the automated fruit sorting machine to serve as a time-saving, low-energy, and cost-effective choice for sorting and grading fruit for both domestic and commercial purposes. Sorting is done based on the wavelength of a mature fruit's colour compared to an unripe or faulty fruit's hue. The employment of a colour sensing module, an open-source operating system, an android remote application, and a mechanical system makes this feasible. Finally, the test results demonstrate that the machine system has a 90% accuracy rate for sorting ripe and unripe/defective crops.[12]

Ashraf Shaikh et. al suggested system uses Image Processing Techniques to Sort and Grade a variety of fruits. The grading procedure begins with the capture of a fruit picture with a camera, which is then evaluated using different image processing algorithms. Fruits are sorted based on colour and shape factors throughout the sorting process. It will increase the quality while also reducing the amount of time it takes.[13] Bankole et. al designed and developed an

automated sorting object of a conveyor belt the Programmable Logic Controllers (PLC) with a capacitive proximity sensor to detect a value range of objects. The result obtained shows that plastic, wood, and steel were sorted into their respective and correct position. [14] Behere et. al reviewed the development an application of mechanical quality evaluation of products in the field of agricultural and food. It uses mechanical linkages vision system, a tool used in image analysis and automated sorting and grading is highlighted. [15]

Yadav Kadam et. al described the real-time tomato fruit sorting system has been designed to automatically classify the fruits into different kinds. The image processing technique is used to pre-process and extract features, while KNN, a machine learning algorithm, is utilised to classify the fruits into distinct categories. The OpenCV library is used to implement the system on the Raspberry Pi. The accuracy of the suggested method was 88 percent.[16] Poltok et. al used A TCS3200 colour sensor and an Arduino Uno Microcontroller, to create tools for categorising citrus fruits utilising the RGB (Red, Green, Blue, RGB) colour approach to differentiate RGB colours of oranges. Citrus fruit will fall into position according to the hue of the citrus fruit. The findings of this study will classify citrus fruit into three categories.[17] Pingju et. al., evaluated the use of several technologies in the fruit automated sorting system, such as detection and control technology, digital image processing technology, computer peripheral device and interface technology, Pattern Recognition technology.[18]

III. DESIGN OF SORTING MACHINE

The conveyor system with inspection unit, segregator, and embedded system with controller were constructed as the major functional components of an automatic guava fruit sorting machine. These components were produced as a single unit based on theoretical considerations, and an automatic fruit sorting system was created using these three components. As per usual practise, the performance of the designed automatic fruit sorting system was evaluated using guava fruit.

Construction:

This paper was devoted to the development of an automatic fruit sorter based on Healthy and defective guava. The hardware consisted of two units. An image acquisition apparatus equipped with a thermal camera, segregator unit and controller circuits with microcontroller. The second unit consisted of a robotic segregator with required electronic circuits. The construction of automatic sorting machine is being divided into following categories.

Conveyor system with thermal camera.

A conveyor belt consists of two or more pulleys, with a continuous loop of material which rotate over them. One or both of the pulleys are powered, moving the belt and material on the belt forward. There are two main industrial classes of belt conveyors; those in general material handling such as those moving boxes along inside a factory and bulk material handling such as those used to transport industrial and agricultural materials, such as grain, coal, ores etc. The conveyor system is equipped with a motor, a thermal camera at a set distance, and two connections with DC geared motors at inspection sites, as shown in the image. The conveyor structure is used to move guava fruit from the inspection station to the segregator section without the need for human interaction. The conveyor specifications are as follows:

Table No.1: Conveyor specifications

Conveyor Specifications:	
Conveyor Length	2485 mm
Conveyor Breadth	990 mm
Conveyor Height	1010 mm
Conveyor /Motors Speed	90W, 230V high speed motor

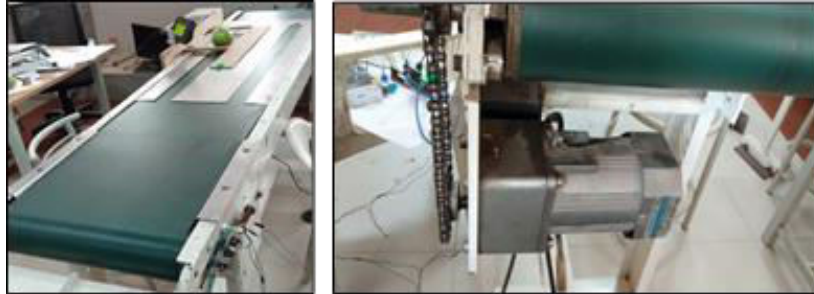


Figure No.1: Conveyor system with thermal camera

Real-time guava fruit inspection with MATLAB interface.

In this system, guava fruit on the conveyor belt are transported to inspection station and rotated by link attached to conveyor system as shown in following figure. When a fruit enters the inspection point, a thermal camera captures the image, which is then analysed in the MATLAB interface. The fruit surfaces from all sides are checked and compared in MATLAB code, and depending on the outcomes, a synchronisation signal is created through a MATLAB interface to a microcontroller.



Figure No.2: Realtime Inspection of guava fruit and thermal images processed in MATLAB

Segregator as Robotic system for separation of guava fruits.

Images are processed in term of healthy, fruit eaten by bird, disease and physical structure. By analysing such parameter, the quality of fruit is decided. A segregator is constructed with channel arrangements based on the size of the conveyor belt, as illustrated in the picture, to distinguish these different types of fruit. These three segregator channels are constructed and connected with two links driven by a DC geared motor at 10 rpm. The link will be operated based on decision made by microcontroller signal from MATLAB interface. If fruit is healthy it passes from channel 1, if fruit is defective it passes from channel 2 and if foreign material is recognised it is passes from channel 3. The process will continue for analysing the fruit and sorting of fruit.



Figure No.3: Segregator system with DC motor and linkage

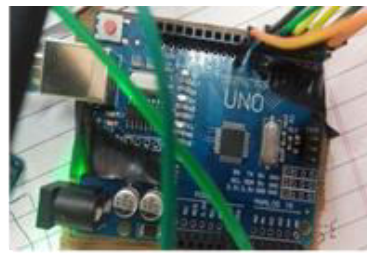
Embedding of Arduino microcontroller and other auxiliary components.

The embedded system is made up of an Arduino microcontroller with motor driver control, as well as an SMPS and a 9-volt battery to perform automatic sorting of guava fruit. The following components are employed in the present study:

Table No.2: Auxiliary components

Components	Qty.
Arduino	2
L293d	2
SMPS	1
9v Battery	1

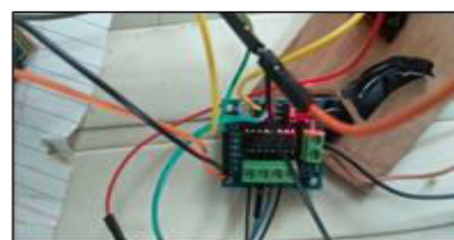
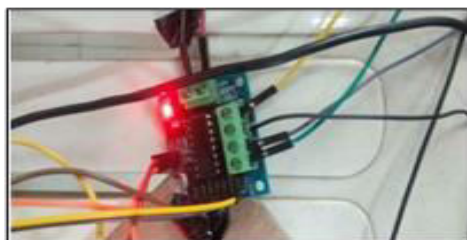
The Arduino 1 controller assists in Received a signal from MATLAB and sent it to Arduino 2 for execution. The Conveyor motors and Distributor motors are to be operated according to the Arduino microcontroller and the strategic decision by Arduino 1.



Arduino 1 – MATLAB operation Arduino 2 – DC Motors Operation

Figure No.4: MATLAB & DC Motor Operation

The two L293 modules are used to rotate the conveyor motors at the inspection station and the distributor/segregator motors at the segregator in both directions, as illustrated in the diagram. The L293d Module is a Receives microprocessor signals and transmits the corresponding signal to the motors. This module is used to control the link on the conveyor that allows for fruit inspection and segregation predicated on MATLAB outputs.



L293D Module – 1 – for Conveyor DC motor

L293D Module – 2 – for Segregator DC

Figure No.5: L293D Module

Auxiliary components such as SMPSs are utilised to provide 12V/24V signals for DC motors, while 9V supply battery are used to start L293D modules.

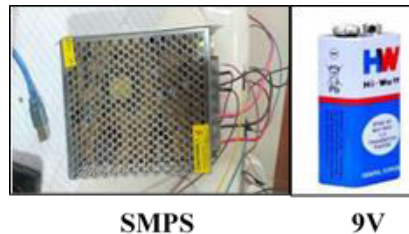


Figure No.6: Auxiliary components

Working and assembly:

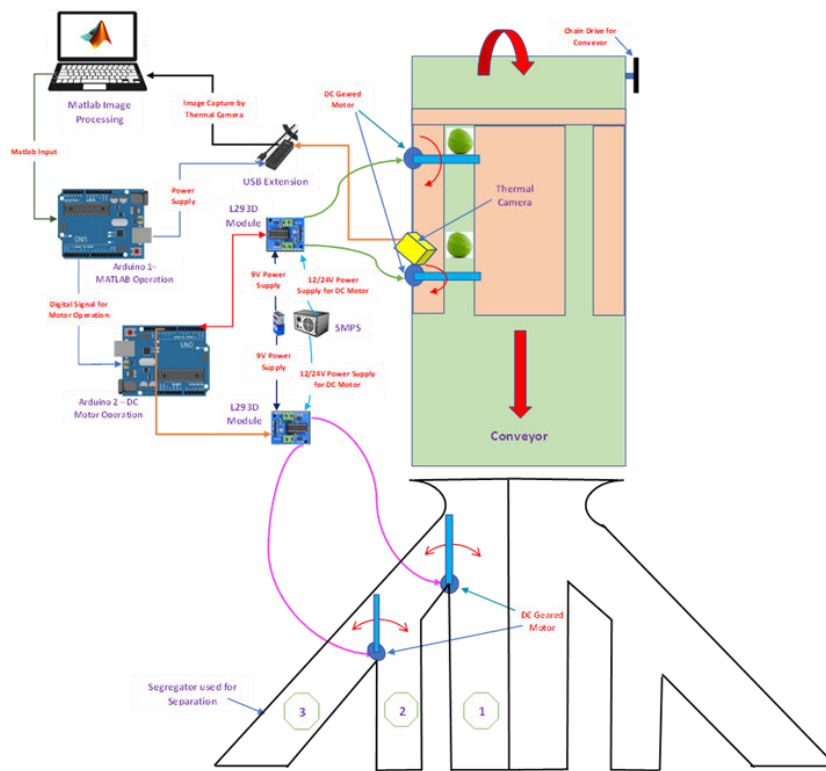


Figure No.7: Schematic diagram of proposed system

This work is anticipated the use of thermal imaging with MALAB interface, conveyor system and automated segregator for real-time elimination of defected guava fruit on conveyor. An Arduino microcontroller delivers essential role in the integration among all operations.

When a supply of is turned on for the conveyor motor, it begins to rotate. It will regulate the movement of the guava-feeding conveyor belt. The various sorts of fruits are initially put onto one end of the conveyor belt. Fruit is carried to the inspection centre through a conveyor belt, which has two links that are driven by a dc motor. The program is designed up in such a way that the link will not open until the previous guava fruit has been inspected, and no fresh fruit has been reached for inspection.

The first link stops the guava fruit and allows it to be passed one by one to the second link, which is the inspection centre. The fruit is brought to the inspection centre at second link on conveyor and placed on an image processing unit's platform to check external quality of guava fruit, where a thermal camera module takes a picture of the fruit and determines the quality of the guava fruit. The signal is sent to the sorting mechanism by the embedded system, which is

controlled through programming. With the help of conveyor movement, the fruit is transferred to the sorting/segregating mechanism.

The segregating mechanism consists of a link, which rotates according to the signal received from the embedded module. Due to gravity, once the fruit reaches the segregating unit at the other end of the conveyor, it will fall on the segregator unit. The linkage rotates in response to the signal, and the fruit is dropped into the appropriate channel for varied quality guava fruits. There are three distribution channels for healthy and defective guava fruit. The channel has two DC motors that open and close the channel based on the decision signal sent by the embedded system. Guava fruit is separated into two categories: healthy guava fruit and defective guava fruit, which is damaged, bird-eared, or disease. The process will continue for analysing the guava fruit and sorting of fruit. This process can reduce the time consumption and lead to increased productivity. The assembly of the components is shown in above figure 6.



Figure No.8 Inspection and segregation process

IV. RESULTS & DISCUSSION

Using image processing, the system tests are carried out to identify guava fruit quality in two grades: healthy guava fruit and defective guava fruit (i.e. guava fruits that are damaged, bird-eared, or diseased) in terms of their criteria. Sorting operations are carried out according to specified parameters. The system was put to the test by sorting and inspecting 200 samples with an 97% accuracy rate for identifying healthy and damaged fruits based on the wavelength difference utilizes conveyor and a segregator.

Table No3 the results of accuracy percentage of sorting trial

Sr No.	Type of Fruit quality tested	Total no. of fruit tested	Manual inspection Results	Testing of Developed system
1	Healthy Guava	50	50	50
2	Bird Eaten Guava	50	50	49
3	Physical Damaged	50	50	48
4	Disease guava	50	50	49
5	Random guava Sample	200	200	194

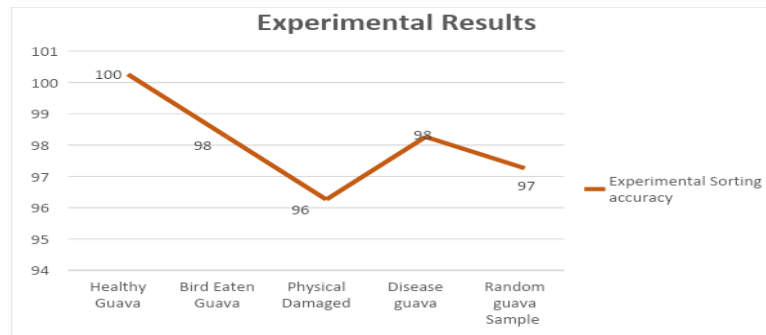


Figure No.9 The results of graphical representation of accuracy percentage of sorting trial

The result obtained show that for the no of trials of guava sorted using the developed system for the different quality of guava fruit under investigations (i.e. Healthy, damaged, bird-eared, or diseased guava fruit), each fruit was sorted correctly into the designated compartment and collected in fruit basket at the end of each channel of segregator. The time required to sort the fruit is approx. 24 sec and continuously one by one inspections on conveyor.

V. CONCLUSION

The designed machine has effectively operated on exterior texture detection to identify and eliminate defective guava from the conveyor line, resulting in improved dealing with product quality features in food processing industries. four different quality of guava fruit were used to evaluate the machine performance. Freshly collected varying grade guava fruits were used to evaluate the effectiveness of the developed automated fruit sorter. The designed sorter was tested each sample and assessed for performance in terms of grading efficiency, production capacity, percentage of damaged fruits, bird eaten, disease one. The Guava fruits were sorted based on each quality and evaluated in two categories: healthy and damaged, eaten by birds, and illness one from the outer skin under defective guava fruit. To evaluate the grading effectiveness of the proposed automatic sorting machine, 50 of each kind of guava fruit, such as 50 healthy, 50 damaged, 50 bird eaten, and 50 disease guava fruit, were tested. The grading efficiency of automatic sorter was obtained with the variety of guava fruit was 100, 98, 96, and 98 percent respectively. for healthy guava, bird eaten guava, physically damage and disease guava respectively. When 200 random samples of guava were inspected using a sorting machine, the grading efficiency was 97 percent. Overall, the overall performance of the developed fruit sorter was determined to be good, and the sorter may be utilised for a variety of different spherical and round fruits at the farm level. A slight variation in efficiency during three tests was observed because of manually loading of guava fruits.

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