

# Machine Vision Based Autonomous Fruit Inspection And Sorting

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**Abstract** -India is a country with agricultural backbone. Major most of the agricultural products in India are grains, vegetables and fruits. As it comes to fruit harvesting and packaging in India, human labor has been an indispensable part. But manual hand picking and packaging offers many drawbacks such as time-inefficiency, monotony etc. Apart from this, with labor costs peaked to extreme high nowadays, it is a need to search for cost-efficient and time-efficient measures for fruit harvesting and packaging. One emerging technology for fulfilment of this purpose is 'Machine Vision' technology. Machine Vision or 'Image Processing' technology is extremely fast, cost-efficient and hygienic. This paper aims at design and development of a low cost automated mechatronic system for inspection and grade-wise sorting of fruits and fruit vegetables such as lemons, tomatoes, apples, guavas, mangoes etc. using image processing technique. Fruits are sorted as immature, rotten and edible. Edible fruits can further be graded and sorted according to size. This paper explained technique to collect data like size, color, defects of fruit particularly lemon and sort it out in different categories as mentioned before. Suitable matlab algorithms like conversion to binary image, area calculation, and average pixel value calculation are used. For sorting Arduino-Uno microcontroller is used. Our vision is to make this system frugal yet efficient with flexible algorithm so that every single fruit farmer can set up his own fruit sorting facility and will avail himself his own market, bringing self-reliability to farmer.

include farmers, Indian in particular, who can't afford cost of today's fruit processing facilities. This project aims at developing a fruit sorting and packaging facility that can be established at very root level itself which will be economical, compact, fast, and accurate and of more justice to farmers. If every farmer can set up own outlet facility for fruit distributing he will be more self-reliant and free of unwelcome expenses incurred in putting fruits at distribution facilities, transport from farm to market.

This project is optimized for inspection and sorting of fruit Indian Lemon (Citrus Limon) only. The algorithm can be reconstructed with simple changes for another fruits. Scope of research in this segment is not inclusive of causes and remedies of these defects; it is limited only to the understanding of external appearances of lemon-skin. Various kinds of skin diseases are found in Indian Lemon Species, depending on weather conditions and region of plantation. Still some of the most prevalent Lemon Skin Diseases are alternaria rot, anthracnose and bacterial blast (common defects of fruits, Agriculture and Natural Resources, University of California). The cull lemon frequency varies depending upon the nature of disease. For example, Bacterial Blast affects lemon production more extensively and more defected lemons can be found in a batch, as compared to alternaria rot disease. This project is limited for inspection of the defect Bacterial Blast only.

**Key Words:** Machine vision, image processing, mechatronic system, matlab algorithm, binary image, pixel value, Arduino-Uno

## 1. INTRODUCTION

India is an agricultural nation. Automation of fruit sorting industry is one of the important milestones in this market. Farmers and distributors do conventional quality inspection and handpicking to sort and grade food products. But these conventional methods has many drawbacks like time consuming, monotonous, slow and inconsistent etc. so automation in this area has greater advantage in terms of efficiency, accuracy, consistency etc. Computer vision systems provide rapid, economic, hygienic, consistent and objective assessment. Agriculturally efficient countries like Israel and Australia have manifested active use of this modern technology and it needs to be inoculated to Indian Fruit Industry. The targeted beneficiaries from this project



**Fig-1:** Bacterial blast – commonly found skin defect

### 1.1 Literature Review

The first literature review[1] Abdellahhalimi, Ahmed Roukhe, Bouzid Abdenabi, Nouredine el Barbri is about sorting fruit based on maturity using camera sensing

technique. This project presents a method for automatic evaluation of date fruits maturity based on computer vision. This method was implemented, and tested on a sample of dates fruit images with different levels of maturity. With the help of machine vision system it distinguishes between good or mature and yellow or green date fruits. HSV color space is used to carry out fruit segmentation. The second literature review [2] N. M. Z. Hashim, N. H. Mohamad, Z. Zakaria, H. Bakri, F. Sakaguchi was about development of tomato inspection and grading system using image processing. This paper focused on quality of tomato for inspection. It works by capturing image from tomato fruit and calculating percentage value of color of in order to classify the grade of tomato. Grading system is done by using matlab software. Third literature review [3] P. Sudhakara Rao and S. Renganathan is on new approaches for size determination of apple fruits using image processing with matlab. This paper shows different methods like circle method, parabola method, ellipse method, coefficient of variation method etc. to determine size of different categories of apple and sort it using threshold. Also it explained percentage accuracies of different methods.

Next literature review [4] C. S. Nandi, B. Tudu and C. Koley is on automatic sorting and grading of mango according to the maturity level and size using fuzzy logic. Gaussian mixture model is used to estimate the parameters of individual classes to predict maturity level. Next literature review [5] J. V. Frances, J. Calpe, E. Soria, M. Martinez, Rosado, A.J. Serrano, J. Calleja, M. Diaz presented in their paper a procedure to improve the performance, whether increasing speed or accuracy, of the load-cell-based weighting subsystem in a fruit sorting and grading machine to achieve excellent accuracy.

### 1.2 Proposed Model

The proposed project model is optimized for fruit-Indian Lemon (Citrus Limon). In this section, CAD models are inserted for better understanding of system layout. Additional parts (Belt Side-Guard, Inspection chamber housing) are intentionally excluded.

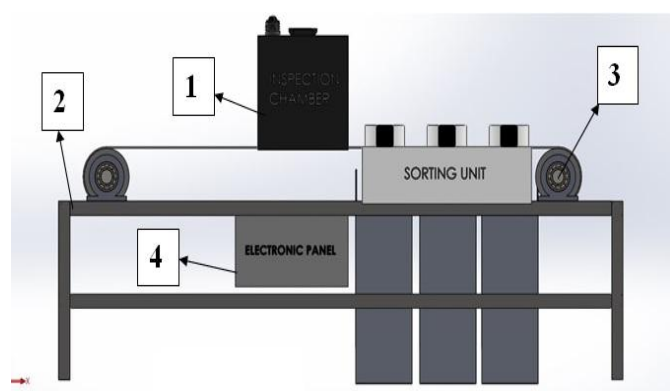


Fig-2: Front view of proposed model

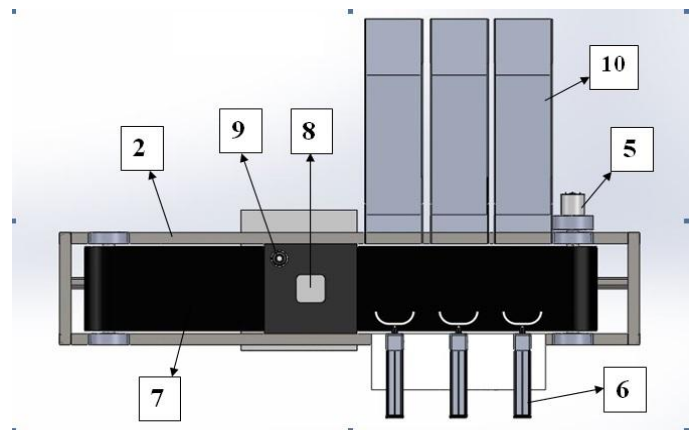


Fig-3: Top View of the Proposed Model

Numbers in above diagrams denote:

1. Inspection Chamber
2. Frame
3. Shaft assembled with bearings
4. Electronic Panel
5. Drive motor
6. Actuators
7. Conveyer belt
8. HD Webcam
9. CFL
10. Guide-ways

Functioning of the system is demonstrated with help of above views. Fruits are placed on conveyer at regular position intervals by fruit placer. They move from left to right on the conveyer belt. Fruits are retained in their place by cup shaped minute indentations. As they move into illuminated inspection chamber, overhead webcam captures their image which is processed in computer based MATLAB software and proper decision is drawn after processing the image in the pre-fed algorithm regarding activation of linear actuators to sort the fruit forward. As per the output, linear actuator actuates and pushes fruit into proper guide-way sorting the fruit as defected into Guideway-1, raw into Guideway-2 and small mature fruit into Guideway-3. Large mature fruits are sorted undisturbed at the end of the conveyer travel.

## 2. DESCRIPTION

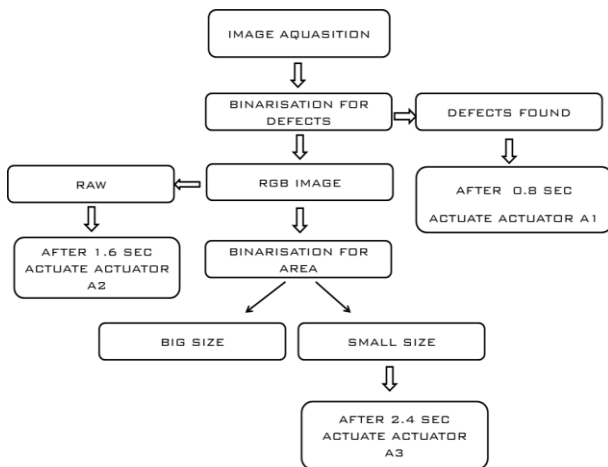


Fig-4: Flow chart

The above flowchart shows how different processes are carried out along with their sequence. First of all, image acquisition takes place. Webcam provided in inspection chamber captures image of lemon when it comes in front of it and sends it to computer. Further, different features from image are extracted with the help of matlab program as follows.

The algorithm contains following three major subprograms:

1. In binarization for defects algorithm, the captured image is processed to obtain any skin defects. Here system is specialized to look for bacterial blast defect only. Algorithm first converts this image extracted into binary image. Here yellow color is extracted for binarization. From binary image defected area of fruit can be calculated. Thus, if lemon is identified as defected, signal is sent to actuator 1 for actuation and defected fruit leaves the conveyor belt with the help of actuator 1.

Area calculation algorithm:

- Start.
- Read the input color image using imread function.
- Read the input pixel of color image in three different planes (RGB).
- Convert it into binary image by assigning 1 value to extracted yellow region with the help of threshold and 0 value to remaining part.
- Calculate area of defected region with region properties tool in matlab and store it in variable a1.
- If  $a1 > \text{threshold}$ , consider it as defected.

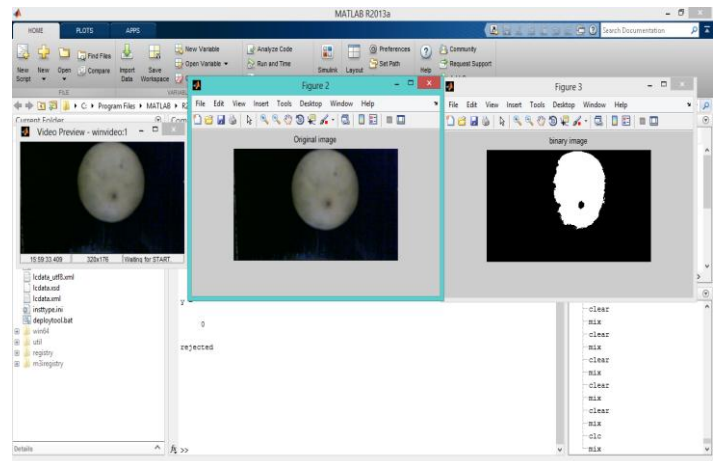


Fig-5: matlab algorithm performance for defected area

2. If the lemon is not defected, it is checked whether is raw/ matured in this algorithm. As the lemon is detected to be defect free in first algorithm, the next algorithm is for color detection. The lemons are processed to calculate percentage of green color on the skin and lemons crossing a specified green percentage threshold are identified as raw and are actuated out by actuator 2.

Color detection algorithm

- Read the input image.
- Read RGB pixels values and store these values in variables like r, g, b.
- Calculate the mean of RGB values and store it in different variables like r1,g1,b1.
- If  $g1 > \text{threshold}$ , then consider it as raw lemon and send signal to actuator 2.

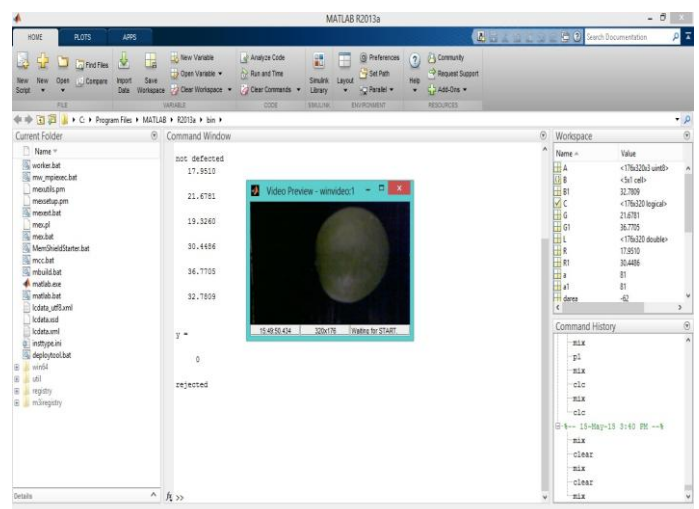


Fig-6: matlab algorithm performance for Rawness

3. Now only fresh, not defected, and mature lemons are remaining to process it further. Here lemon is sorted



out. The algorithm to calculate out area (previous) is run again Area calculated is compared with threshold area and lemon is identified as small or big. Respective signals are sent to respective actuator 3 as per above flow chart.

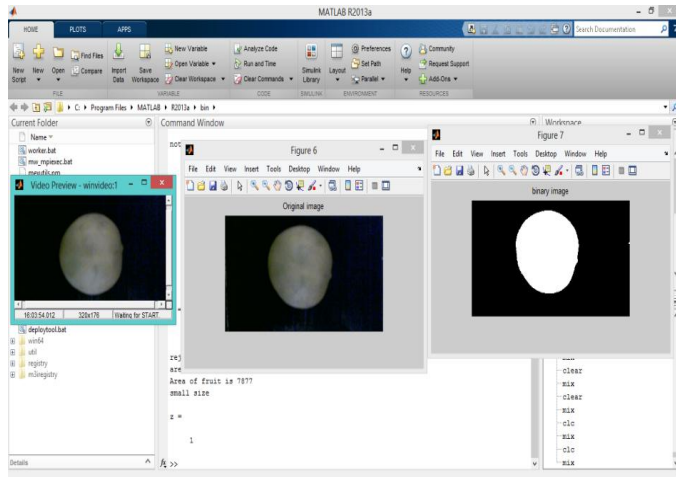


Fig-7: matlab algorithm performance for area calculation

### 2.1 Electronic Panel

The electronic control circuit consists of RS232 Cable, Microcontroller development Board and Motor drivers. The Microcontroller development Board employed is Arduino Uno MUC Board, L298d Full Bridge Motor Drivers and a 12 V AC to DC Adaptor.

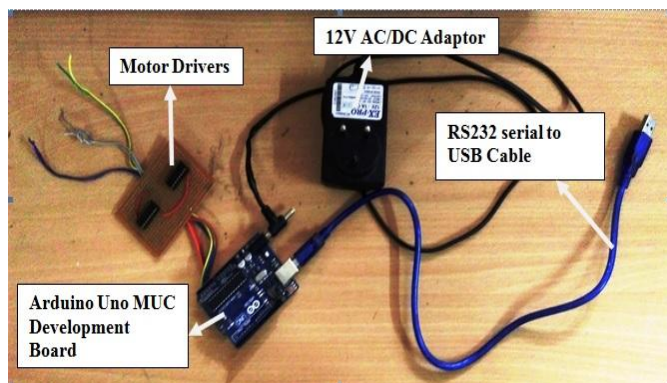


Fig-8: Electronic control circuit

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver

chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter

Technical Specifications:

- a. Microcontroller: ATmega328
- b. Operating Voltage= 5V
- c. Input Voltage (recommended)= 7-12V
- d. Input Voltage (limits)= 6-20V
- e. Digital I/O Pins= 14 (of which 6 provide PWM output)
- f. Analog Input Pins= 6
- g. DC Current per I/O Pin= 40 mA
- h. DC Current for 3.3V Pin= 50 mA
- i. Flash Memory= 32 KB of which 0.5 KB used by bootloader
- j. SRAM= 2 KB
- k. EEPROM= 1 KB
- l. Clock Speed= 16 MHz

### 2.2 AVR ATMEGA 32 Algorithm

The Microcontroller is programmed to send actuation signals to motors as discussed here. The keywords sent through MATLAB are as follows:

- C – To actuate out the cull lemon
- R – To actuate out the raw lemon
- S – To actuate out the small and fresh lemon

The keywords sent through MATLAB are in ASCII format and are converted to binary format by MAX232 as per follows:

Table -1: ASCII – Binary Character Table

Character	ASCII Code	Binary
C	067	01000011
R	082	01010010
S	083	01010011

The microcontroller is tested for accuracy of the code on software 'HyperTerminal 7.0' by passing keywords through serial port of the computer and is found out to be correct and out of any deficiencies.

### 3. CONCLUSIONS

It is testified that machine vision is an alternative to unreliable manual sorting of fruits. The proposed model is a demo version. The framework is lightweight and easily portable. The algorithm runs successfully and can be modified at any point of time depending upon lighting conditions varying from place to place and time to time. Also other types of fruits also can be sorted with little modifications in algorithm. The microcontroller used is inexpensive yet highly effective and can easily

reprogrammed on Arduino Platform to change control settings for actuators and changing the time delays. To increase accuracy further in terms of speed, longer lengths of belt can be used. It is advisable to use multiple (at least 2) cameras with different orientations to get rid of problem of single faceted image acquisition. Also by installing a GPS system in the electronic panel, fruit batch inspection reports can be sent to the administrator farmer without necessity of his presence at the setup.

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## REFERENCES

- [1] Abdellahhalimi, Ahmed roukhe, Bouzid abdenabi, Nouredine el barbri "Sorting dates fruit bunches based on their maturity using camera sensor system" journal of theoretical and applied information technology, 20th October 2013. Vol. 56 No.2
- [2] N. M. Z. Hashim, N. H. Mohamad, Z. Zakaria, H. Bakri, F. Sakaguchi "Development of Tomato Inspection and Grading System using Image Processing", International Journal Of Engineering And Computer Science Volume 2 Issue 8 August, 2013 Page No. 2319-2326.
- [3] P. Sudhakara Rao and S. Renganathan "New Approaches for Size Determination of Apple Fruits for Automatic Sorting and Grading", Iranian journal of electrical and computer engineering, vol. 1, no. 2, summer-fall 2002
- [4] C. S. Nandi, B. Tudu and C. Koley, " machine vision based techniques for Automatic mango fruit sorting and grading based maturity level and size", C. S. Nandi et al.
- [5] J. V. Frances, J. Calpe, E. Soria, M. Martinez, A. Rosado, A. J. Serrano, J. Calleja, M. Diaz, "Application of ARMA modeling to the improvement of weight estimations in fruit sorting and grading machinery," IEEE 2000, pp 3666-3669