International Journal of Computer Science and Mobile Computing

A Monthly Journal of Computer Science and Information Technology

ISSN 2320-088X

IMPACT FACTOR: 7.056

IJCSMC, Vol. 11, Issue. 1, January 2022, pg.95 – 100

DETECTION OF DEFECTS IN FRUITS USING IMAGE PROCESSING IN MATLAB

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DOI: 10.47760/ijcsmc.2022.v11i01.011

Abstract— Human Operators have been replaced by Machines and various new technologies in the field of Fruit processing. The automation of tasks done by the human operators is highly encouraged in many industrial applications. One such important task is to detect the defects in fruits based on the damage caused to it on its peel. The defect in fruits is identified mainly based upon the damage caused to its peel, when the detection is done manually. To automate this process, Image Segmentation is one of the main techniques the system's accuracy heavily depends on as it is the first step that identifies the flaws in the fruits. The image fed to the system is converted into a digital image to either enhance it or collect some necessary information from it using Image Processing. This segmentation of fruit images can be done using various methods that have been developed over time. A hybrid algorithm is proposed in this paper which performs the segmentation using split and merge method. The K-means algorithm splits the original image based on the Euclidean colour distance in $L^*a^*b^*$ space to return a segmented result. Then the image is merged after a graph representation of the picture. This is an efficient procedure that can replace the manual procedure and automate the process. The system also takes less time and produces highly accurate results in terms of human observation.

Keywords— Image Processing, Defect detection, Image Segmentation, Hybrid Algorithm, K means Segmentation

I. INTRODUCTION

Agriculture and agro-industry are a huge source of economy in India. With the increasing population, demand for high quality food also increases. To meet these requirements, proper grading and sorting of fruits is also necessary. The quality of food is highly important in food processing. This requires a thorough quality check of the food products required during the process. One such food product is fruits. The manual labour required for the process cannot always be accurate and highly efficient. The labour cost and productivity can be highly effective with the process being automated. The system not only checks for defects based on the damage occurred to the skin, but also checks for any internal defects and considers that aspect too. The in capabilities of human inspection can be replaced by the systems go beyond the electromagnetic spectrum visible to the human eye. Some automated grading system also use near-infrared imaging to increase the accuracy of the results.

The automated process will be highly appreciated in factories or industries where huge amount of food is processed on a regular basis.[1] The Image Processing is one technique used to detect the flaws in fruits. Image Processing is a technique to convert the image into the digital format which leads into the enhancement of the image given as input or either collect effective information from the image. This digital image can either be a binary image, indexed image, grayscale image or TrueColor image. To obtain the exact information that is required from the digital images the process goes through many phases. The various phases in image processing are Image Pre-processing, Image Segmentation, Feature Extraction and Image Classification.[2]

II. LITERATURE SURVEY

In this paper, the techniques used for the sorting and grading of fruits are K- means clustering Segmentation and Otsu's thresholding algorithm. But before these techniques were proposed, there were other methodologies that were used for the grading and sorting of fruits. Blob detection technique is one way to identify the defects in fruits. This technology identifies the defects on a particular spot by differentiating the affected region with the unaffected region of the skin of the fruit. The brightness or the colour of the surface is evaluated based on the comparison with its adjacent surface and are the flaws are brought out with a circle. Here one can also examine the size of the fruit using major axis calculation. After sorting, the palette used changes its directions.[3] Speeded Up Robust Feature (SURF) is one such technique that is used for the grading process. In this process, a square shaped filter is used which is an equivalent to Gaussian smoothing. The database of the system consists of some images with which the images given as an input are compared for the features of an unflawed fruit. Based on the results obtained during the comparison a final result, announcing if the fruit is flawed or not is generated. To identify the SURF points of interest Hessian matrix is used.[4] RGB and HSV colour space model is a technique to automate the process of sorting. The surface of the fruit is detected using computer vision system and image analysis. HSV stands for Hue, Saturation, Value. To produce the segmentation of the image of the fruit, a process is executed for the standard colour of the fruit in HSV. The comparison between HVS and RGB are then studied to generate the results.[5]

One other method that is used for external defect detection of fruit is Image processing using numerous methods in MATLAB which will be further discussed in this paper. In the following method, first the input image with be disintegrated into segments using K means clustering. Then the clusters are processed and integrated using Otsu's thresholding. There are various methods used for the segmentation of an image.

One is K- means clustering, the image is partitioned into K-sets from n-observations. Here K should be less than n. From the cluster, the best sum of squares is selected through initial centroids. Another method of Segmentation is Watershed Segmentation. This process is based on the simulation of the flood. The other method used is Otsu's Thresholding pf the clusters. One other edge detection is used, which is an optimization technique. The last method that can be used, requires Gabor filter. Here, the image is decomposed for further processing.[6]

III. PROPOSED METHODOLOGY

All The method proposed in this paper consist of K-means clustering and Otsu's thresholding. The procedure consists of 4 phases in total.

1. Image Pre-processing
2. Image Segmentation
3. Feature Extraction
4. Image Classification

1. Image Pre-processing

In Image pre-processing, the process is done on the images at lowest level of abstraction. Though the information in the image is increased, it could surely be altered if the information is considered as a measure of entropy. This means that the information cannot be added but it can be removed if necessary.

The goal of image pre-processing is to enhance the required and necessary data and suppress unwanted distortion and noise. The enhancement of the desired features in an image helps with the analysis and also further image processing. There are 4 different types of Image Pre-Processing techniques and they are:

1. Pixel brightness transformations/ Brightness corrections
2. Geometric Transformations
3. Image Filtering and Segmentation
4. Fourier transform and Image restauration

This is the first step of Image Processing Technique to detect the defects in fruits.[7]

2. Image Segmentation

Reflections in images, background disturbance, shadows and shades contribute to a huge part of noise obtained in images. Image segmentation helps in removing this noise from the images and focuses on the description of the fruit to reduce its scene complexity. Rocha et al. performed a method based on k-means clustering technique to subtract the background of the image. This segmentation technique provides accurate and efficient results with per unit cost.[8]

2.1. K-means Clustering Algorithm

Step 1: The system is fed with an input image.

Step 2: Based upon the image and defects suspected on the fruit, the clusters are formed.

Step 3: The RGB image is converted into grayscale image.

Step 4: The 2-D image is now converted into a 1-D array of length “ $r \times c$ ”.

Step 5: Intensity range is calculated.

$$\text{Range} = [(\text{Maximum value}) - (\text{Minimum value})]$$

Step 6: Centroid value is calculated.

$$\text{Centroid 1} = \text{Range}/\text{No. of clusters}$$

$$\text{Centroid 2} = (2 \times \text{Centroid 1})$$

Step 7: Difference between the intensity and Centroid values is calculated.

Step 8: Based on the minimum intensity values clusters are formed.

Step 9: Repeat steps 1 & 2 for all the other values of intensity 1 & 2.

$$\text{Centroid 3} = (3 \times \text{Centroid 1})$$

$$\text{Centroid n} = (n \times \text{Centroid 1}) \text{ [9]}$$

K-means clustering techniques allow the formation of more than two clusters. One cluster consists of the majority of the damage. The clusters are then observed by the empirical observation. This lets us know about the number of clusters formed from the segmented images. Once a particular number say ‘c’ number of clusters are identified; the fruit will be declared flawed.

3. Feature Extraction

Applying Machine Learning to the raw data obtained might not give us highly accurate results, which is why feature extraction method is used. The raw data is converted into numerical features which is further processed while storing it in original data set. The intriguing parts of an image is represented as a compact vector feature. In this phase of Image Processing, the defects in the fruits are highlighted and brought out by RGB extraction.[10][11]

4. Image Classification

Image Classification is a technique to categorize and label. In this step, the defected and flawed fruits are differentiated from the fresh fruits and this information will be displayed in the comment window of our reference. Now the fresh fruits and the flawed fruits are separated from each other successfully. A contour is drawn between the fresh and infected parts based upon the varying threshold values. The Otsu’s Thresholding identifies the scars, infected parts, defects and helps in categorizing or labelling the fruits.[12]

IV.FLOWCHART

V. SIMULATION AND RESULTS

The images of a good fresh Banana and a damaged or defected apple are given as input images to the program. The system tested with a good, unflawed fruit and with a defected one.

Fig. 1 Fresh Banana

This is an image of a fresh banana that consists of no defects on it. When the testing takes places using MATLAB, the results are as below.

Original Image(Banana)

Result: Good

Fig 2: The Image Processing Technique Result for the Banana

The Proposed method deems the banana to be good and hence the result is verified using human interpretation.

Fig 3: Defected Apple

The above is an image of a defected apple. Here are the results when it is tested using Image Processing.

Internal Image(Apple)

Otsu threshold

Result: Infected

Fig 4: The Image Processing Technique Result for the Infected Apple

The Proposed Methodology deems the apple to be infected.

VI. CONCLUSION AND FUTURE SCOPE

The paper discusses about the detection of defects in fruits using Image Processing in MATLAB. K-means Clustering and Otsu's Thresholding are techniques used in various phases of Image Processing here. Although this automation technique heavily decreases the labour cost, it still cannot detect internal flaws completely. The method tests the external skin of the fruits and produces results. This should be avoided and lead us into upgrading the system into a highly accurate one which test far beyond external flaws. We plan to improve the system to not only identify the defects but also calculate its percentage and detect other food products too that require grading and sorting.

ACKNOWLEDGEMENT

The three of us would like to express our gratitude to our college directors, and **B.PRIYANKA** ma'am for motivating us and being there for us in the project and choosing the project as well. We would like to thank our **DR.S.RAMANI** ma'am for her role in the Project.

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