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Original Research Article

FRUIT GRADING AND SORTING SYSTEM USING IMAGE PROCESSING

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Abstract- With increased expectations for fruits of high quality for export business, the need for accurate and fast quality determination continues to grow. Proposed Fruit Grading and Sorting System give an automated technique to fulfill these requirements. We have chosen apple fruit as the product under test for this project. This system consists of two main parts which are grading and sorting. Grading part deals with image acquisition, pre processing and feature extraction of apples. First the apple images are captured by using 8MP camera. Image pre processing techniques like thresholding, morphological operations are applied to make the images more suitable for analysis. Features include external parameters of apples which are shape, size, color and texture. Form factor is used to find the shape of apples. GLCM technique is used for texture recognition. RGB and HSI color models are used for color analysis. The second part is sorting which deals with classification of apples based on the grades obtained in first part. Sorting of fruits is achieved by developing a mathematical model.

I. INTRODUCTION

In today's world there is growing demand for quality products. Also the foreign trends and export businesses are increasing. If we go with manual sorting of products, it may not give expected results in stipulated time span. Our aim is to bring automation in grading and sorting process.

In manual sorting the decisions are subjective. If an expertise examines a fruit and it is found that the fruit is bad according to some expert constraints. But if same fruit is shown to another expertise, he may classify it as good. Hence manual sorting gives subjective results which may lead to wrong decisions in export business. Also manual sorting is slow process and manpower is wasted unnecessarily.

Automatic grading and sorting gives faster results. Also it is reliable. Automatic sorting gives same results for a test for every time that test is performed. The results obtained are of type true or false. So, problem of subjective decisions in manual sorting is solved using automation.

In this project we can work on any type of

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fruit. We have chosen Apple fruits for the experimentation. India is third largest producer of apples [1]. So, export business of apples is larger than other fruits. We can grade the apple on basis of various external and internal parameters. External parameters include shape, size, color and texture. Internal parameters are sugar content, water content, nutrition value, firmness of apple etc. But to limit the scope of the project we have considered only external parameters.

On the basis of size apples can be sorted as small or big. On the basis of texture sorting can be smooth or rough and so on.

A mathematical model is developed for classification or sorting of apples.

II. DESIGN OF SYSTEM

The block diagram of the system is as shown in Fig. 1. It shows the basic building blocks of the system.

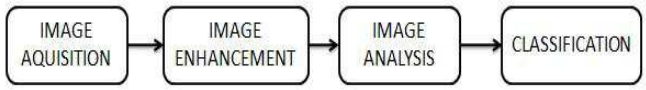

Fig. 1. Block diagram of grading and sorting system

A. Image Aquisition

In this process the image of object of interest is captured with a camera of required resolution. Requirement of resolution varies according to applications. If we want all the details of the object then we should choose a camera with higher resolution. In other cases such as shape detection a camera with average resolution will serve the purpose.

In our project, images are captured using 8 MP web camera which is attached to computer through USB. Photos of 3 different sizes of apple are taken i.e. small, medium and big. Database of 75 such images is prepared. The image size is kept 448 x 310 for all the images. This size is suitable for fast computation. The proposed design of real time working system is as shown in Fig. 2. The apples will be moving on conveyor belt. Image is captured by the camera and it will pass on to the machine through USB cable. A part of database is shown in Fig. 3

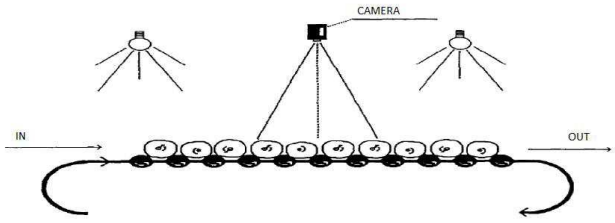

Fig. 2. Real time working system

B. Image Enhancement

It is the process of manipulating an image so that the result is more suitable for a specific application [3]. Thus a method which is suitable for enhancing X-ray images will not be useful for enhancing images taken in visible light.

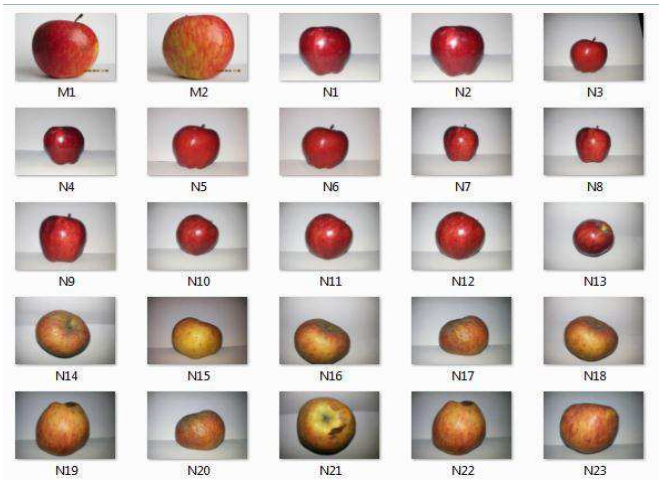

Fig. 3. Snapshot of the database collected

For image enhancement one has to go for image preprocessing. Pre processing involves Thresholding and Morphological operations. Thresholding is a process in which we suppress all unwanted part from the image by converting that into background color or any other pixel value. In this way we can extract region of interest from the image.

Basic morphological operations are erosion and dilation. Derived morphological operations are opening and closing. In erosion image details smaller than the structuring element are filtered. Dilation grows or thickens objects in a binary image [3]. Opening and closing operations are performed using combination of erosion and dilation. These are used to fill small holes in the image and also to reshape the image so that the image will be perfect for analysis.

C. Image Analysis

Image analysis involves feature extraction from the image. To simplify feature extraction, edge detection and texture segmentation techniques are used. Various color models are used for color analysis.

Edge detection is used to get boundaries of the input image so as to analyze various properties of the image like shape, area, perimeter etc. For detecting edges in the object, various edge masks are applied on the image. Typical edge masks are Sobel edge operator, Prewitt's edge operator, canny operator. Amongst the above operators, canny operator gives best performance [3]. Edge detection operation is shown in Fig. 4.

From Area and Perimeter we can find out form factor for apple which is given by the formula as follows [4] –

$$Form\ factor = \frac{4\pi * Area}{Perimeter^2}$$

Form factor for a particular shape is constant. If we take a circle with small radius and another circle with bigger radius, then the form factor for both the circles will be same which is 1. So, form factor will determine the object in the input image is an apple or some other product. If object is found to be an apple then only further process will take place and otherwise the process is terminated.

Texture segmentation is used to examine textural properties of the object in an image. Gray Level Co occurance matrix i.e. GLCM is used for this purpose. GLCM gives distribution of intensities and also relative position of pixels in an image [3]. Different textural parameters are contrast, correlation, energy and homogeneity.

Contrast is a measure of intensity contrast between a pixel and its neighbor over the entire range. For a constant image, contrast is zero. Correlation gives idea about how a pixel is correlated to its neighbor. It can be either positive or negative. Energy is a measure of uniformity which is '1' for a constant energy image. Homogeneity measures the spatial closeness of distribution of elements in

GLCM. If GLCM is a diagonal matrix then homogeneity is one.

For color analysis we have used two color models which are RGB i.e. Red, Green, Blue model and HIS i.e. Hue, Saturation, Intensity model. First we have extracted all the three planes to analyze each plane separately. Red plane is of importance in this project. We have found out mean intensity of Red plane. If apple is perfect Red in color, then Red plane will look more whitish and mean intensity will be more towards 255. But an apple may have some Yellow bands mixed with Red.

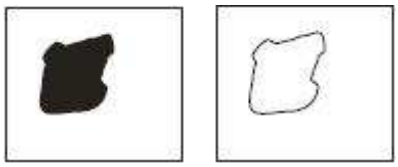

Fig. 4. Edge detection operation

So, to make better classification we have considered standard deviation of Red plane in addition. This gives by how much value other pixel values deviate from mean. If deviation is greater than specified amount, then apple is not perfectly Red. Along with mean and deviation we have found out skewness and kurtosis. Skewness is a measure of symmetry. A distribution is symmetric if it looks same to the left and right of the centre point. Kurtosis is a measure of whether the data are peaked or flat relative to normal distribution. Data with high Kurtosis have distinct peak near the mean, decline rapidly [5].

In this way we have got 9 different properties of apple from input image which are – Area, Perimeter, Form factor, Red plane intensity, Red plane deviation, Contrast, Energy, Correlation and Homogeneity.

D. Classification

Apples are classified using a mathematical model based on above 9 parameters. While developing a mathematical model we have to first recognize the problem and problem variables [6]. In our project, the problem variables are the 9 parameters. Then construct relation between variables. So, we can put a limit on above parameters. The apple whose extracted data fits into the limits will be classified as good apple for exporting. And the apple, whose features will fall out of the limits, will be kept aside.

III. SOFTWARE AND HARDWARE REQUIREMENTS

MATLAB is used for processing on the input images. Also the camera is interfaced through MATLAB for capturing images as shown in Fig. 2 above.

When the machine will get input image through USB, the machine will process on the image and will give the result. If the result is “GOOD” then the apple will move on to the conveyor belt ahead. If the result is “BAD” the alarm will strike so that the lineman can take that apple out of conveyor belt.

IV. RESULTS AND DISCUSSIONS

All the 9 features are extracted from every image in the database collected. The values are stored in an excel sheet. Input image is as shown in Fig. 5a. Result of thresholding operation and morphological operations is shown in Fig. 5b.

Fig. 5a. Input image

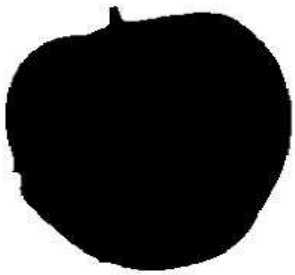

Fig. 5b. Result of thresholding and morphological operations

Edge Detection is shown in Fig. 6. The form factor is determined from this image. First Area and Perimeter are calculated using MATLAB functions and the the form factor is calculated. The typical form factor for apple is found as 0.0176. A margin of ±15 % is kept on this value. So, any object having form factor 0.0176 ± 15% will be recognized as an apple by the machine.

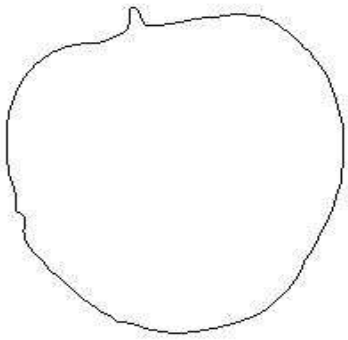

Fig. 6. Edge detection

An apple with good texture has less contrast, more energy. But an apple with bad texture has more contrast and less energy.

V. APPLICATIONS

Various applications of "Apple Fruit grading and sorting system using image processing" are –To increase productivity.

1) To sort and grade products to meet export standards.
2) To avoid errors in manual sorting and grading.
3) To reduce manual efforts.

VI. CONCLUSION

We have developed a system which will grade and sort the apples automatically. This will speed up the classification process. The system developed, works only on apples. In future we can have a system which will be applicable for all fruits. The system will first find out which fruit is present at input and then will work on its features. With help of this we can develop an Android application for sorting so that the system becomes more user friendly.

VII. ACKNOWLEDGMENT

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