Pattern recognition based techniques for fruit sorting: A survey

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Abstract— In most of the food industries, farms and fruit markets the quality sorting of the fruits is done manually; only a few automated sorting systems are developed for this. Each fruit changes its color in its life span; including stages not ripe, semi ripped, completely ripped or at the end rotten. Hence, we can predict the quality of the fruits by processing its color images and then applying pattern recognition techniques on those images. By quality of fruit we mean size, ripeness, sweetness, longetivity, diseased/ rotten etc. Some advance technologies which are used for classification of fruits are Infrared Imaging, Magnetic Resonance Imaging, Thermal Sensing, Electronic Nose sensing etc; but these are costlier as compared to color image processing and pattern recognition techniques. This paper summarizes and compares various techniques of Pattern Recognition which are used effectively for fruit sorting. All the fruits have their unique ways of ripening stages; hence the pattern recognition techniques used for one fruit does not necessarily match for the other fruit. This paper reviews the high quality research work done for the quality classification of Apples, Dates, Mangoes, Cranberry, Jatropha, Tomatoes, and some other fruits using pattern recognition techniques.

Keywords- *Classification & predication, Pattern Recognition, Image Processing, Fruit Quality*

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I. INTRODUCTION

In most of the countries sorting and grading of fruit according to maturity level are performed manually. This manual sorting by visual inspection is labour intensive, time consuming and suffers from the problem of inconsistency and inaccuracy in judgment by different human [9]. The fruits produced in the garden are sorted according to quality and maturity level; and then transported to different standard markets at different distances based on the quality and maturity level. Sorting of fruits according to maturity level is most important in deciding the market it can be sent on the basis of transportation delay [1].

As per the 'Vital Stats of India', 40% of the fruits and vegetables produced are wasted; the main reasons for the wastage are

1) No fruit/vegetable processing units are available; machine which are exported from other countries are too costly to install and these are not customized for the Indian Fruit breeds.

2) The fruits/vegetables are sorted manually; in this usually labours throw the fruits left and right into the proper heaps. This throwing process damages the fruits resulting into the lesser life span. Even during the transportation the fruits/vegetable packaging is not done properly.

3) Lack of ware houses where the agricultural products can be stored safely.

This all scenario creates a huge demand for low cost automated fruit/vegetable sorting machine which can be used in various markets, food processing industries, farms and fruit markets. Color and texture are the fundamental character of natural images, and plays an important role in visual perception, based upon this we can classify various fruits [3]. We can predict the quality of the fruits by processing its color, monochrome, infrared, MRI, X-ray images and then applying various pattern recognition techniques on it.

Pattern

A pattern is a set of objects or phenomena or concepts where the elements of the set are similar to one another in certain ways or aspects. There are various definitions proposed for the term *pattern* [7], a pattern could be a fingerprint image, a handwritten cursive word, a human face, a speech signal etc.

Pattern recognition

It is defined as the study of how machines can observe the environment, learn to distinguish various patterns of interest from its background, and make reasonable decisions about the categories of the patterns [7].

Pattern recognition system

The design model of a pattern recognition system essentially involves the following three steps [15, 7]:

1) *Data acquisition and preprocessing*: Here the data from the surrounding environment is taken as the input and given to the pattern recognition system. The raw data is then preprocessed by either removing noise from the data or extracting pattern of interest from the background so as to make the input readable by the system.

2) *Feature extraction*: Then the relevant features from the processed data are extracted. These relevant features collectively form entity of object to be recognized or classified.

3) *Decision making*: Here the desired operation of classification or recognition is done upon the descriptor of

extracted features. Block diagram of a pattern recognition system is shown in figure 1.

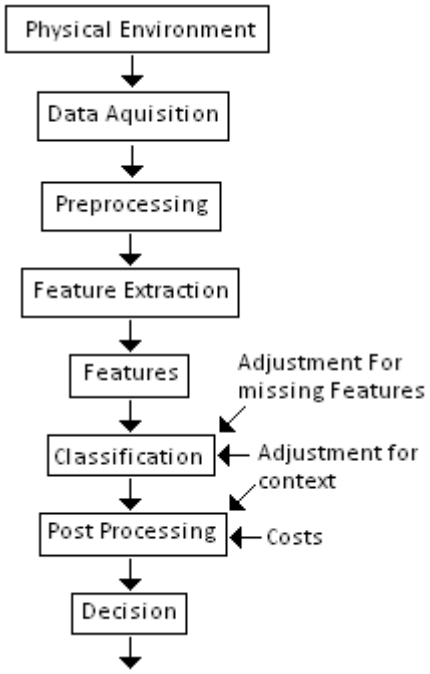

Figure1. Pattern Recognition System

There are various types of fruit families like citrus, apples, mangoes, berries etc., each family has many breeds. Based upon the breed and family the fruit gets a shape, color and ripening stages. Each fruit family changes its color in its life span; for ex. lemons are deep green initially then become light green, yellow and finally brownish when they are rotten. Due to the diversity in shape, color and ripening stages amongst fruit families; pattern recognition techniques applied for classification varies.

II. METHODOLOGY

A. *Data Aquisition*

The input to the Pattern Recognition System is usually transducer, such as a camera or a microphone array[15]. In mostly all the fruit sorting machines developed so far this is a camera, to capture the color images of the fruits as an input to the pattern recognition system [10, 14]. To maintain the consistency in the images an imaging box is designed in which the images of all the fruits to be classified are taken. Light intensity is kept constant inside this Box; this is very crucial as the digital cameras give different color reflections when the intensity changes.

A automated Mango sorting machine developed has fixed imaging box upon a conveyor belt, the box is illuminated with 120 lux intensity of light, as shown in the figure2. A Charge Coupled Device (CCD) camera mount on the top of the imaging box transmits images to the computer attached of size 480 ×640 pixel in JPEG format [1, 9]. In a research for classification of cranberries, the image of a cranberries sample was acquired using a 3.2 megapixels digital camera. The images are coded in the JPEG format, with a resolution of 2048 by 1536 pixels [8].

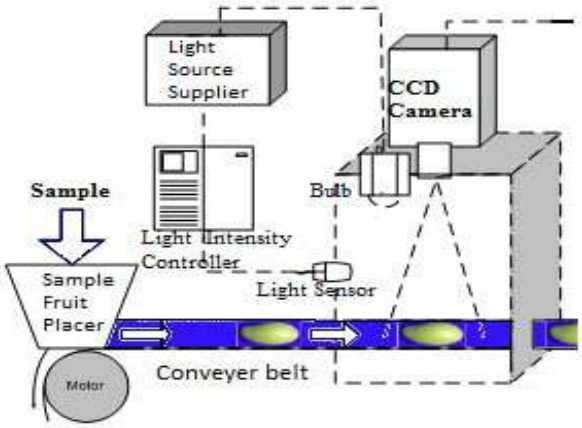

Figure2. An Imaging Box on Conveyor Belt

For the classification of tomatoes, color based multi-channel, real time, data acquisition and processing technique program based on FPGA is used [13]. Color signals of tomatoes were discovered by color sensors and then acquired by data acquisition and processing unit[13]. For classification of apples, Image acquisition device used for this research is simply composed of a high resolution (1280x1024 pixels) monochrome digital camera, four interference band-pass filters, a frame grabber, a diffusely illuminated tunnel with two different light sources (fluorescent tubes and incandescent spots), and a conveyor belt on which fruits are placed.

Some other data acquisition techniques are Infra Red, Magnetic Resonance Imaging, X-Rays, and Thermal Sensing.

B. *Preprocessing*

These transducers have their own limitations due to this the input to the system may contain noise, which has to be removed, this is done by preprocessing. Once the noise is removed then the object of concern should be extracted from the image by removing the back ground. This is achieved by using various segmentation algorithms as shown in fig.3.

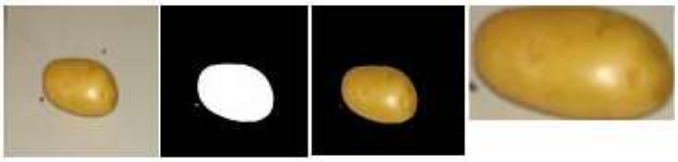

Figure3.Raw image, Background Removal, Segmentation

It is observed that *Threshold Algorithms* are quite popular in extracting object from back ground, customized *Threshold Algorithms* are used in Mango sorting machine[1,9], Date fruit classifier[14], Jatropha classification[5] and Cranberries Classification machine too[8].

In the mango sorting machine the noise was removed by applying a median filter[1,9]. The background color used was blue for mango sorting and this helped to do the segmentation easily [9].

In case of cranberries there is noise in terms of the white reflective patch in the middle of each fruit. Which are

distinguished clearly in the saturation band of the HSI colorimetric model. Once located, the reflection zones are filled by the surrounding genuine color of the fruit [8].

C. Feature Extraction

To classify the objects into proper classes, we need to extract features from the segmented object. A class is set of objects with some common features. Hence proper feature extraction only leads to justified classification of objects. Every fruit family has its own ripening process; hence different fruit families/breeds may give different features for classification. Mostly in case of color images the average Red, Blue and Green color values, total number of pixels, total of boundary pixels, length of major and minor axis etc makes feature space for classification [8, 10, 9, 1, 5, 14]. Mango sorting have used 27 features [1, 9], Date classification have used 15 features [14].

As shown below in figure 4, the various shape and color features are extracted from the RGB image.

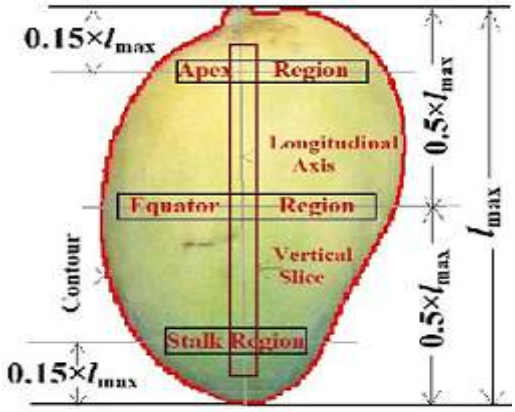

Figure 3. Various Measures of Mango for Feature Extraction

Texture also plays a vital role in classification, in case of date fruits classification gray level co-occurrence matrix was created for each image which is used as texture feature [14]. The shape and size feature extracted on the roundness measure calculated with the formula

Roundness metric= 4π area /(perimeter)^2

D. Classification

For the classification of the fruits, first the categories are to be decided, the boundaries between those categories are to be finalized based upon the values of the features extracted [15].There are various models in Pattern Recognition such as Statistical Model, Template Matching Model, Neural Network Model, Syntactic Model [7, 15] etc.; which can be used for classification of the objects. The Jatropha classification have used Fuzzy system[5], Mango classification have used are estimated using Gaussian Mixture Model [1,9], Date fruit classifies have tested almost all techniques like K-means, Linear Discriminant Analysis, Neural Networks; it was found that neural networks give the best results and accuracy up to 99% [14].

E. Post Processing

If the classifier is not able to give proper classification of the object into the desired class then it is needed to re adjust the missing features and the contexts. This learning can be supervised or unsupervised (self learning by machine)[15]. Usually the training samples are different from test samples.

Also, we can include the costs of miss-classification at this stage and improve the classifications. For ex. if a fruit is miss-classified as semi-ripe where as it is completely ripe and its life is for 3 days, and it is transported to another place which takes 4days then the fruit will be rotten by the time it reaches destination. Hence for boundary conditions we should add cost factor [15].

F. Decision

Once the system is ready after extensive testing and re-modifications in the feature sets or classification techniques; it can be used on real life machines which can sort the fruits. Based upon this classification further processing and packaging can be done.

III. Conclusion

The automated fruit and vegetable sorting machine is the need of time, as manual sorting has many draw backs. The machines developed so far have not covered all fruits, rather not even a complete fruit family. A generic design is not yet done for unsupervised machine learning. Color image processing gives results but if the infrared and X-ray imaging is used it will give the most accurate results.

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