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Determination and Analysis of Automated Fruits Grading System Using Machine Learning Method

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Abstract: Most Exporter or fruit seller doing the grading of fruits or vegetables based on results and through experience which involves a lot of subjectivity such as cleanliness, , cost and inconsistency, labor requirements, availability, an automatic marking system needs to be developed . In this, we are designing automatic fruit grading system to combine three phases (feature extraction, sorting and grading), in which human intervention is not required. This system must be designed to eradicate the problems of manual grading of fruits which involve lot of subjectivity issues. It is designed to help all people which are connected with this like stakeholders, producers, consumer, etc in making their choices. We will capture the images of fruits. The image can be captured by using a digital camera or mobile phone camera. This image is then input to the system (Agriculture Grading system) for obtaining the quality of that fruit and then accordingly we give fruit's grade.
The Agriculture Grading system consists of various steps like feature extraction, shape- based sorting and grading. The image which is captured by any camera is processed using tools of image processing for determining its features [6]-[9]. Based on the fruit's appearance its features are extracted and these extracted features are comparing with the Rule formed with the help of genetic algorithm database of fruits. Based on this comparison fruits have been graded.

Keywords: Genetic Algorithm, Fruit Grading System, Pattern Recognition, Automatic Grading

1. INTRODUCTION

Agriculture sector has a potential of converting Government's dream of "Acchey Din" into reality. India is a Country Where 60 percent of Population dependent on Agriculture. Agriculture is a drive engine for India's economic Growth. Agriculture sector was taken a very different status in the twelfth Five Year Plan 2012-2017 (XII Plan) where the Agriculture sector is being changed a lot to become a major part of Economic Growth Engine (EGE).

Agriculture growth rate in India cannot exceed more than 4% annually despite of several government schemes and free-bye to agriculture sector.

To enhance improve market value, any agriculture product should meet quality measures. Variation from the norm fit as a fiddle speaks to a deficient natural product which can be rejected while exporting. India got First positions among world's mango creating distinctive nations representing around 46% of the worldwide territory and 40 % of the worldwide generation. As indicated by NABARD's (National Bank for Agricultural and Rural Development), the assortments popular at the universal market incorporate Langda, Tomy, Atkin, Alphonso and Dashari. Every

sending out nation has its own organic products assortments, which vary in quality parameters like shape, shading and flavor. The natural products send out assumes real part in making a remote cash.

The Implementation of Information and Communication Technology (ICT) is playing an important role in improving the status of the agriculture sector. The concept of mixing ICT with agriculture sector motivates the development of an automated system for sorting and ranking of agriculture good's produced. That Grading based on observations and with their experience which involves a lot of subjectivity.

Genuine nature of any organic product is controlled by its healthful qualities, synthetic constituents, et cetera; however shopper's buying choice relies on upon the general outside appearance of organic product. A Fruits with great appearance, all around framed in size and all around shaped fit as a fiddle will dependably be desirable over shoppers. It will have better business esteem inside Indian Market and Outside India for Export item. Along these lines quality evaluating and sorting will guarantee that organic product meet predefined quality norms and in this way help both dealers and purchasers. Because of current Technological advances in PC vision frameworks and Image preparing, Manufactures have move their concentration to programmed quality assessment frameworks [2]. Presently Days, The Digital Camera and Computer are accessible in Indian market at low cost. A PC vision framework might be utilized for investigation undertakings. Machine vision frameworks are supplanting the subjective procedure of manual review of items in various enterprises.[4]

Machine vision has several advantages over the traditional manual inspection method based on experience. It is tedious to develop computer algorithms for automatic grading of fruits system. The techniques for pattern recognition like Neural Network, fuzzy logic, and Support Vector Machine, The Automatic sorting system for fruits is done with machine vision [6,7].

Fruits like apples, mango etc. have commercial value based on their external appearance (i.e. color, sizes, shapes, presence of surface defects etc.) and hence classified into different grades. Automatic Grading system helps in achieving better standards and quality of fruits. The proposed system starts the grading process by capturing the fruit's image using a regular digital camera. Then, the image is transmitted to the processing level where feature extraction, classification and grading are done using MATLAB and Rapid Miner. In my Research work, the focus is more on agricultural produce Sorting and Grading technique.

2. LITERATURE REVIEW

Recently, Number of Researchers focusing and putting their efforts for developing the grading system for agriculture industry. The techniques extend from manual grading by men, where the features are determined manually, under laboratory conditions to machine vision systems for automated high-speed fruit sorting [2, 4].

Njoroge et al had developed an automated grading system where the focus is on the fruit's internal and external defects [3] using image processing and this automated grading system consists of six CCD cameras. The position of two cameras are mounted on the top, two on the right and another two cameras mounted on the left of the fruit for capture the image of fruit used for inspecting the biological defects. Njoroge used the concept of image processing to analyze the fruit's features; size, color, shape and bruise, and the grade is determined based on the major features of advanced designs, expert fabrications and automatic mechanical control.

Njoroge et al had built up a mechanized reviewing framework where the emphasis is on the organic product's inside and outside deformities [3] utilizing picture handling and this robotized evaluating framework comprises of six CCD cameras. The position of two cameras are mounted on the main, two on the privilege and another two cameras mounted on the left of the natural product for catch the picture of organic product utilized for examining the natural imperfections. Njoroge utilized the idea of picture preparing to dissect the natural product's components; estimate, shading, shape and wound, and the review is resolved in light of the real elements of cutting edge plans, master creations and programmed mechanical control.

Unay et al developed a machine vision system for grading specially apple using artificial neural network-based segmentation [4]. Some other artificial intelligence methods have been proposed such as linear discriminate classifier (LDC), fuzzy nearest neighbor classifier (fuzzy k-NN), nearest neighbor classifier (k- NN), adaptive boosting (AdaBoost) and support vector machines (SVM) where Ada Boost and SVM have done the defects segmentation successfully.

The Proposed AGS is designed to combine three phases like feature extraction, sorting and grading, in which human intervention is not there. This AGS is designed to overcome the problems of manual grading by men. We are expecting that it will help all stakeholders, from the producer to the consumer, in making right choices. The image is captured using a digital camera or mobile phone camera. This image is then served as input to the system (AGS) for obtaining the fruit's rank or grade. The AGS consists of several steps involving feature extraction, shape- based sorting and grading. The image which is captured is processed in the system using image processing for determining its features [6-9]. Then based on the fruit's shape size color , the fruit is classified to its class using SVMs [11, 12].The grade is determined based on fruit type and features by using Fuzzy Logic.[8,9]

Shape is also one of the important aspect for good quality evaluation during grading and classification in order to provide the user with homogeneous lots of product. Hence, it is one of the important need effectively applied in packinghouses, where experienced people judge the fruit's shape depending on whether or not it extracts from typical shape of variety [8]. Shape and size are the important features that characterize the appearance of an object. Area, parameter, major and minor axes lengths of a thing , as well as the aspect ratio are some of the most commonly measured morphological features used in this system. These Morphological features are widely used in automated grading, sorting and detection of objects in the industry. Many methods have been developed to characterize product shapes, including two major categories such as size-dependent measurements (SDM) and size-independent measurements (SIDM). Shape descriptors in SDM are formed by the proper combinations of size measurements. The SDM that have been applied [9] in the food industry includes Compactness, Elongation, Convexity and Roughness etc. For Irregular shapes, Size-independent measurements (SIM), including region-based and boundary-based methods, have consequently been developed [10].

The region-based method is based on the statistical characteristics of object regions. In boundary-based method, shape measurements are acquired by first representing the boundary with the spatial information of boundary pixels, and then analyzing and extracting measurements from the spatial information. This method include Fourier Transform, autoregressive models etc. Fourier Descriptors have been used by Currie et. al.[11] to develop apple classification system. As local and sharp irregularities of boundary are not well captured by Fourier analysis; alternatively wavelet Descriptor has been popular to catch local feature at multiple scales.

Slamet et. al develop wavelet based shape descriptor [12]. Improvement in wavelet based function for affine and invariant shape representation is discussed by Rube et. Al.[13]. Generally, shape classification develops the co-efficient for wavelet that represent boundary of the object.

3. PROBLEM STATEMENT

In general we can say that, quality means meeting all the expectations of the consumers those are investing a lot of money in that regarding safety, storability and sensory properties of products. Sensory properties are appearance (color, shape and defects), texture (crispness, juiciness, firmness, toughness etc.) and flavors (taste and aroma). Currently, Most Exporter or fruit seller doing the grading of fruits or vegetables based on observations and through experience which involves a lot of subjectivity. It is very difficult to develop computer algorithms for automatic grading of fruits system.

Manual grading has its own inherent problems such as subjectivity, cleanliness, Man power requirements, cost incur and inconsistency of human, An automated grading system overcome from these inherent problems of manual Grading.

As per latest newspaper reports in January 2015, Indian Fruits rejected in outside market contains 5 % - 10 % of total export fruits item. Recently, Many researchers focuses on developing such a fruit grading system which is beneficial for all users. The methods extend from manual grading by human, where the features are determined manually, under laboratory conditions to machine vision systems for automated high-speed fruit sorting. Now we have number of Pattern Recognition techniques like neural network, fuzzy logic, and Support vector machine can be used to develop automated sorting system for fruits.

4. OBJECTIVE OF STUDY

As we discussed in problem statement that manual grading system involves lot of subjectivity issues. The main objective of this study is to eradicate these issues and come up with the solution of better grading system of fruits. Proposed automatic grading system of fruits is capable of analyzing more efficiently the quality of fruits and rates them according to their quality and standards based on irregularity in shape and their size grading.
This requires efficient Pattern matching approach to analyze the shape of fruits and to detect misshapen fruits. The deformed fruits will be rejected and the good one should be ranked and separated by various parameters like size, good appearance and well-formed shape. These parameter will always be preferable to consumers and will have better commercial value inside Indian market as well as outside India as export commodity. As per latest newspaper report in January 2015, Indian fruits rejected in outside market contain 5% to 10 % of total export fruit item. Automatic grading system has better chances to lower the rejected item graph and hence enhance India's foreign currency and god will in the outside world.

This study is also synchronous with as per government commitment of "Digital India Program" launch recently. As this Automatic grading system bound to shift from manual to automatic grading of Fruits which may resolve many inherent problem of manual grading of fruits.

5. METHODOLOGY

This works will aims at efficient automatic grading of four different fruits. The fruits we choose are Mango, Banana, Apple and Carrot. The Entire Automatic Grading system is divided into four major sub processes are as follow:
(A) Segmentation and classification of fruits.
(b) Feature extracted from fruits.
(c) Sorting based on extracted features.
(d) Automatic grading.

Various Machine learning and pattern recognition techniques such as Fuzzy Logic, SVM and Fuzzy Logic, Neural Network and Genetic Algorithm have been applied to determine which techniques perform better under these different set of fruits. Comparative study shows which technique is most suited for Automatic Fruits grading System.

5.1 Software & Hardware Requirement

(a) MATLAB and RAPID MINER for Mathematical and the relevant image processing analysis on window platform.
(b) Different standard database from Agriculture University Gwalior for testing and classifying our result.
(c) Digital camera for capturing fruit images.

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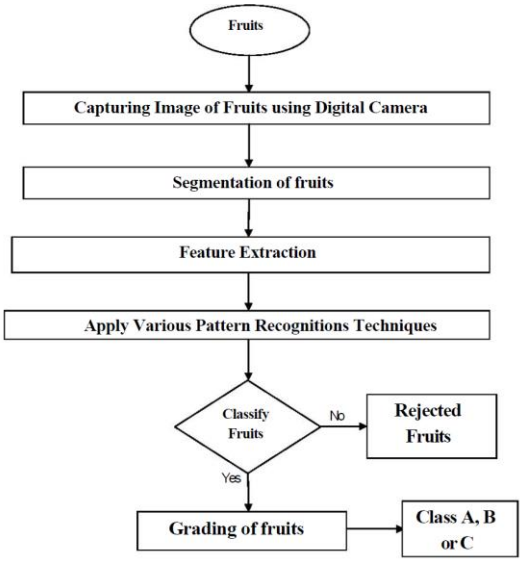
5.2 System Architecture for Proposed Automatic Grading System



I. Feature Extraction

With the help of MATLAB image processing tool box the feature extraction process is done [5]. Initial this extraction process converts the original image into gray scale image and then again converted into binary image. The boundary of each and every object is detected before the image features such as area, major axis length (length), minor axis length (width) and perimeter are determined. The image boundary is then traced from the binary image using the MATLAB function *bwboundaries*. This function traces all the exterior boundaries of an object and also the holes marks or dark patches that are present in the object.

The holes present in the object are filtered using the MATLAB function *imfill* so that the function r*egionprops* can be used to calculate the area enclosed by each of the boundary. Now, this labeled region will be represented in a two-dimensional array which accepts only non-negative integers. The *bwareaopen* function is used for removing the „dark patches" that may be connected to the fruit [6,7].

II. Rule Formation based on Extracted Features

Features of Captured Image have been segregated and rule has been formed based on these features.
The sample rule has been taken as-

If Surface = Smooth and dark_patches = None then Fruits = 'Class A'

The fitness of these rules has been tested using fitness functions. Based on these rule set fruits have been classified into various grades.

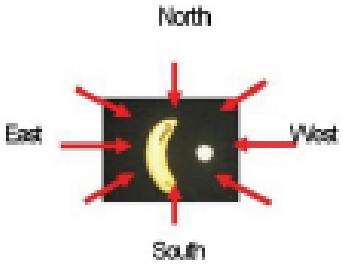


Fig 2:- Various Position of Image Capturing of Fruits

III. Rule Formation based on Extracted Features

Genetic Algorithm has been applied on extracted Features and these rule set has been compared with the database. Based on these rule formed fruit have been classified into various graded A, B or C.

6. RESULT

Now Consider, different (4) types of fruits like Apples, Bananas, Carrots and Mangoes are used for classification process. These result would clearly tell us that among various pattern recognition techniques Genetic Algorithm is better and secondly it reduce the tedious task of Manual grading of fruits.

For Better Accuracy and efficiency results have been tested on two standards Data base gathered from Agriculture University. Metrics used for result Analysis are as shown below:-

For Test Dataset 1

Pattern Recognition Techniques		
Fruits	**SVM/Fuzzy Logic**	**Neural Network**
Apples	96.25	90.65
Banana	81.25	76.25
Carrot	0	40
Mangoes	98.75	92.45

For Test Dataset 2

Pattern Recognition Techniques		
Fruits	**SVM/Fuzzy Logic**	**Neural Network**
Apple	**94.65%**	**91.50%**
Banana	**79.28%**	**73.23 %**
Carrot	**4%**	**33%**
Mango	**93.68%**	**89.30%**

Detection rate (DR) is computed as the ratio between the number of correctly detected fruits(Number of True positive) and the total number of fruits(Number of false Negative + Number of True Positive), that is

$$\text{Detection Rate} = \frac{\text{True Positive Rate}}{\text{False Negative rate + True Positive rate}}$$

False positive Rate (FP) can be computed as the ratio between the numbers of normal fruits that are incorrectly classifies as rejected fruits and the total number of normal fruits.

$$\text{False Positive Rate} = \frac{\text{False Positive Rate}}{\text{True Negative rate + False Positive rate}}$$

6.1 Analysis of Result using Genetic Algorithm-

Types of Fruits	Condition	Correct	False Positive	Reliability
Apples	Normal	400	390	97.5
	Rejected	50	42	84
Banana	Normal	400	387	96.7
	Rejected	50	41	82
Carrot	Normal	400	360	90
	Rejected	50	34	68
Mangoes	Normal	400	378	94.5
	Rejected	50	43	86

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