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MACHINE VISION BASED APPROACH FOR VEGETABLE QUALITY EVALUATION

Venkat Kumari N,
Student,
Department of Computer Science and Engineering,
University College of Engineering,
Kancheepuram, Tamilnadu,India.

Kumar V,
Student,
Department of Computer Science and Engineering,
University College of Engineering,
Kancheepuram, Tamilnadu,India.

JennathPirthouse B,
Student,
Department of Computer Science and Engineering,
University College of Engineering,
Kancheepuram, Tamilnadu,India.

Dr. K. Selva Bhuvaneswari,
Assistant Professor,
Department of Computer Science and Engineering,
University College of Engineering,
Kancheepuram, Tamilnadu,India.

Abstract: Agriculture is the backbone of India. By introducing automation into the agriculture sector, the production increases with less production time and minimal labour. In this project, the potatoes are graded based on their attributes such as the size, shape and the external defects. For this purpose, the static image is obtained from the video stream. Several Image processing techniques are applied to collect features such as the Gray level co-occurrence matrix method (GLCM). Multi Attribute Decision Making (MADM) have been adopted for quality evaluation. K-nearest neighbour algorithm (KNN) is used in the classification. The grading accuracy achieved through this scheme is over 90%.

Keywords: quality evaluation, grading, GLCM, MADM, KNN

I. INTRODUCTION

Potatoes are grown in more than 125 countries and more than a billion people consume potatoes in their daily diet. Countries like China, India and Russia are the top exporters of potato. The export trade contributes to the nation's gross output. The potato plants are susceptible to at least 75 diseases and nonparasitic disorders. It is one of the reasons why grading of potatoes is essential. However, manual grading can be very time-consuming and sometimes erroneous. When this grading can be done automatically through a machine vision based system, the accuracy is achieved in minimal time.

The inspection and grading is quite common in the industries and manufacturing sectors for quality evaluation. This is because it is way much easier to develop a software and produce an algorithm as the products are standard in their size and shapes and any defect can be easily identified. But, when it comes to natural fruits and vegetables, they differ in their features and the algorithm used becomes complex. When the defects are accurately identified, the grading is effective.

The proposed system combines two important processes such as the feature extraction and the classification. The system is designed over the Matlab software to inspect the grade of the potatoes.

II.LITERATURE REVIEW

This section provides some past works done to grade and classify fruits using various techniques and algorithms.

A machine vision system has been developed for grading mangoes based on criteria such as the actual days-to-rot and the quality by adopting techniques such as the Support Vector Regression (SVR) and Multi Attribute Decision Making(MADM) and finally the fuzzy incremental learning Algorithm for classification

- The achieved accuracy was around 87%.In another work, the features of the fruit Orange are extracted using the method of Gray level co-occurrence matrix and then the classification is done by RBPNN (Radial Basis Probabilistic Neural Network) –based classifier. The accuracy achieved was up to 88%
- In order to classify fruits based on external defects
- features such as the mean and standard deviation is calculated for each pixel in the image. A threshold value is set and the threshold of the image is compared to the standard threshold value and the defects are identified.
- In this paper, a system has been developed to automatically inspect and grade fruits by determining the size, colour and shape through edge detection and OpenCV. The distributed network architecture was employed to interface the camera unit to a computer system through LAN. The various methods and techniques to detect the diseases in vegetables in the field of image processing has been discussed. The type of improvements that can be done and the research gap is also discussed in brief [6]. It gives an overall idea about the existing researches in the field of detecting diseases in vegetables.
- The efficiency of fruit defect detection can be improved when the glare (or) uneven lighting in the image is removed. The author uses anisotropic diffusion techniques and optimal Gabor filtering to remove glare.
- have developed classifier system for detecting blemishes in potatoes by adaptive boosting algorithm

which automatically selects the best features to discriminate between blemishes and non-blemishes. So far, all the above papers have discussed about a particular fruit or vegetable, but in [9] multiple fruits and vegetable are sorted using machine vision techniques such as the fuzzy logic and K – means clustering technique. The colour and shape are the determination factors based on which the sorting is done. Fuzzy logic based on the colour and size of the fruits is used in the classification and grading of fruits. Boundary extraction, geometric features and colour extraction are the important parameters derived here [10].

- imposes various techniques and methods that can be used in the classification of fruits including the fuzzy logic, artificial neural network, support vector machine, genetic algorithm technique, histogram based method etc.
  The conversion of three dimensional colour space into one dimensional colour space and the size grading based on the normalized second central moment is used in the fruits sorting and grading. [12]
- provides an overview techniques that can be used in the fruit grading process. KNN, Artificial Neural network, Deep Learning, Support Vector Machine are the machine learning algorithms that are discussed.

III. METHODS

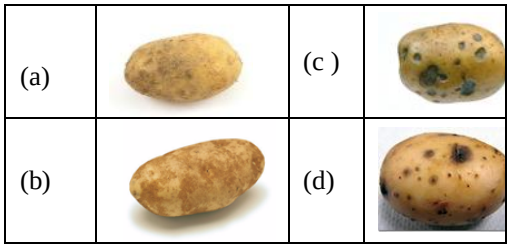
1) Material and Pre-processing:
   A dataset collection of 50 images of potatoes are collected. These images can be extracted from the video stream of potatoes moving in a conveyor belt. The image pre-processing techniques are applied to the static image in order to remove the noise and distortion. For this purpose, Median filter is used. Also, the image is converted into grayscale. The background is eliminated for the further process.
2) Manual Grading Process
   Generally, humans perform grading manually. By just seeing and touching the potatoes, the experts can grade them almost correctly. Manual process is erroneous.
3) Automated Grading Process
   In the proposed project, there are two main process that can be divided as feature extraction and quality evaluation. Finally, the grading is done. The table 1 contains the list of grades and their attributes for gradation.
   In previous work [1], MADM technique is used successfully in quality evaluation and fuzzy incremental algorithm in grading. The classification is from G1 to G4 with G1 being poor to G4 being very good grade.

TABLE 1

Grade	Attributes for gradation
G1 (very good)	Only 5% defect tolerance is allowed
G2 (good)	Almost like G1 except 10% defect tolerance is allowed
G3 (medium)	Exhibiting slight external defect but consumable while
	fresh
G4 (poor)	Exhibiting both external and internal defects

Firstly, the features are extracted by using the gray level co-occurrence matrix. From the features extracted, the quality evaluation is proceeded using the Multi Attribute Decision making technique. This technique in which of the attributes are given highest weightage and the lowest. The grading is completed by the K-nearest neighbour Algorithm. The sample images of different grades of potatoes are shown in fig 2.The fig 3 shows the flow diagram for the entire grading process. The 5 major steps in the flow diagram.

Figure 2: Sample images (a)G1- very good (b)G2- good (c)G3- medium (d)G4- poor



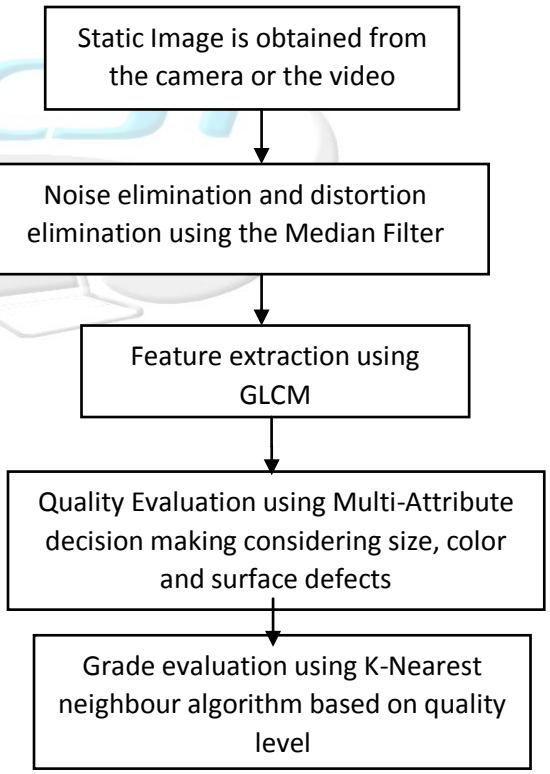


Figure 3: Flow diagram of potato grading machine vision process

1) FEATURE EXTRACTION USING GLCM
The Gray Level Co-occurrence Matrix(GLCM) and associated texture feature calculations are image analysis techniques.

The features that are extracted using GLCM are Energy, Entropy, Contrast, Homogeneity, Correlation, Shade and Prominence. These features are further used in quality evaluation. The formula for each features are listed below in Table 2.

TABLE 2

S. no	Feature	Formula
1	Energy	$Energy = \sum_{i,j=0}^{N-1} (P_{ij})^2$
2	Entropy	$Entropy = \sum_{i,j=0}^{N-1} -\ln(P_{ij}) P_{ij}$
3	Contrast	$Contrast = \sum_{i,j=0}^{N-1} P_{ij}(i-j)^2$
4	Correlation	$Correlation = \sum_{i,j=0}^{N-1} P_{ij} \frac{(i-\mu)(j-\mu)}{\sigma^2}$
5	Homogeneity	$Homogeneity = \sum_{i,j=0}^{N-1} \frac{P_{ij}}{1+(i-j)^2}$
6	Shade	$Shade = \mathrm{sgn}(A)\lvert A\rvert^{1/3}$
7	Prominence	$Prominence = \mathrm{sgn}(B)\lvert B\rvert^{1/4}$

2) THEORY OF MULTI ATTRIBUTE DECISION MAKING (MADM)

This technique is used to decide how the quality is evaluated. The attributes are processed in order to arrive at a choice. The attributes are assigned weights and according to the weights, the overall score is determined. Based on this score, grading process is to be proceeded.

$$P_i = \sum_{j=1}^{n} (w_j(m_{ij}))_{normal}$$

Where w_j is the weight of the attribution j, $(m_{ij})_{normal}$ is the normalized value of m_{ij} of the attribution j alternatives i,n is the number of indices.

The main advantage of using Multi Attribute Decision Making technique is that it overcomes the problem of considering multiple attributes at the same time.

The attributes to be evaluated for quality checkingare:

i. Size calculation

The size of the potato in the image can be determined by finding the length of the maximum major axis (l_{max}) and the maximum minor axis (w_{max}). The total size is nothing but the addition of (l_{max} and w_{max}).

$$l_{max} + w_{max} = \frac{Number\ of\ pixels}{A}$$

For a smaller weight, least weightage is assigned to them in the MADM technique.

ii. Colour and Surface defects

The RGB values of the image is determined. By comparing the RB and GB values, the difference in the colour can be evaluated. While the difference is huge, the attribute is given the least weightage in MADM technique.

IV.THEORY OF K-NEAREST NEIGHBOUR ALGORITHM

The KNN algorithm is a non-parametric method used for classification and regression. The input consists of the k closest training examples in the feature space.

In KNN classification, the object is graded/classified by the majority vote of its neighbours, with the object being assigned to the class most common among its k nearest neighbours.

The formula for KNN algorithm is

$$\frac{1}{k}\sum x_i \epsilon N_k(x)\, Y_i$$

(x,y) are the pixel points in the image. x_i And y_i are the normalised values of the input pixels.

Both for classification and regression, a useful technique can be to assign weight to the contributions of the neighbors, so that the nearer neighbors contribute more to the average than the more distant ones.

V. RESULT AND DISCUSSION

The last section presents the obtained results for the estimation of quality using Multi Attribute Decision Making and K-nearest neighbour Algorithm based on three attributes.

Fig 4 and Fig 5 shows the original image, image labelled by cluster index and the grey image. The defects are identified by comparing the values determined with the standard values in the attribute database.

Based on their qualities, the potatoes are graded into G1, G2, G3 and G4 (Refer TABLE 1)

Class/ Grade	Condition	Number Of Samples	Number of potatoes wrongly graded
1	Very good	10	-
2	Good	10	-
3	Medium	10	1
4	Poor	10	2
	Number of Samples	Correctly Classified	Overall error
	40	35	7.5%

The result images are listed below

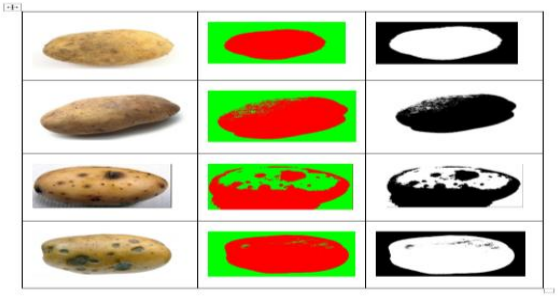


Figure: 4

Hence, the accuracy achieved is 92.5% in the grading of vegetable process.

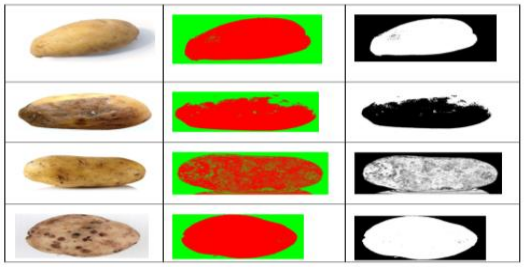


Figure: 5

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