Ripeness Evaluation of Mangoes using Image Processing
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Abstract:
Mangoes are delicious seasonal fruits grown in the tropical region. They are harvested from its grove, the mangoes present in each batch are not uniformly matured. So ripeness evaluation should be done before transporting into different locations. Most farmers use manual experts for ripening evaluation of the mangoes which is time consuming, inconsistent and inaccurate. To avoid manual effort, an automated Computer vision technique is introduced in this paper. This includes preprocessing, Segmentation, Feature extraction and classification. Here 24 color features are extracted from the mango image. Classifying the mango into two different classes according to their maturity level using k-NN Classifier and proposed system resulted in the accuracy of about 93% in ripeness evaluation of mangoes.

Keywords: Segmentation, Feature Extraction, k-NN classifier

I. INTRODUCTION
Agriculture is one of the largest economic sector and it plays a major role in the development of our country. The ever-increasing population demands for higher quality of mangoes with good appearance. There is a need for the development of accurate, fast and focused quality determination of mangoes. Harvesting of mangoes is performed in several steps like cutting of fruits from the farm, washing, sorting, grading, packing, transporting and finally storing. Out of these sorting and grading are major processing tasks associated for preserving the quality of mangoes.

Sorting of mangoes is done based on appearance of fruits, whereas grading is done based on the overall quality features of fruits by considering a number of attributes like shape, size, color and texture etc.

Classification is necessary for the quality evaluation of mangoes. Fruit industry for its excellent trading purpose goes for highly selective ones in quality and standard. It demands the suppliers and the distributors the fruits of high standards of quality, packaging and presentation. So there is a increasing need to supply quality fruits within a short period of time has given rise to the development of Computer Vision Techniques to improve the quality.

In present scenario, sorting and grading of fruit according to maturity level are performed manually before transportation. This manual sorting by visual inspection is labour intensive, time consuming and suffers from the problem of inconsistency and inaccuracy in judgement by different human operators and provides an opportunity to apply Computer Vision based system to assess this problem.

II. PROBLEM STATEMENT
For exports, presently grading is done manually by the experts which is very time consuming and subjective. So, farmers need alternatives for sorting and grading of mangoes. An automated mango sorting system could be more preferable as it can be cheaper, consistent and could result in better overall quality. Thus the scope of the project is to develop an automated computer vision system for sorting of mango based on maturity level.

III. LITERATURE SURVEY
Chandra Nandi et al. (2012), implemented a computer vision based system for automatic grading and sorting of mangoes based on maturity level from its RGB image frame, collected with the help of CCD camera. Parameters of different classes of mangoes are estimated using Gaussian Mixture Model. Graph contour tracking method based on chain code is adapted for finding the boundary of the mango. This automated technique is good but is further affected by ambient light intensity. Response time of system is on the order of 50 ms [1].

CCD camera was used to collect video image of Mangoes and several significant features of maturity level of Mango was obtained. Colour of Mango was estimated using Gaussian Mixture Model. Accuracy can be improved by using Support vector machine and neural network. Gaussian Mixture Model (GMM) and fuzzy logic was combined for size based grading of Mango. Size of Mango was calculated using pixel area covered by Mango [2].

Tajul Rosli et al. Proposed and implemented methodologies and algorithms to determine the grade of local mango production in Perlis. The main contribution for this study is on a design and development of an efficient algorithm for detecting and sorting the mango at more than 80% accuracy in grading compared to human expert sorting. This work proposes a mango grading technique for mangoes quality classification by fuzzy logic based image processing [3].

P. Sudhakara Rao et al. (2009) have adopted HSI model for sorting and grading of fruits by color and developed a system for on-line sorting of Apples based on color, size and shape. Images are captured by a color CCD camera and frames are separated by a frame grabber card and it produced the image in RGB model. The image is analyzed by using advanced image processing techniques to estimate the color of image. Using image processing system achieved around 98 % accuracy in color inspection of apples [4].

Suzanawati Abu et al. Proposed and implemented Automated Mango Fruit Assessment Using Fuzzy Logic Approach. This work developed a new method of automated mango Size and
grade assessment using RGB fiber optic sensor and fuzzy logic approach. The calculation of maximum, minimum and mean values based on RGB fiber optic sensor. To analyse the data and make the classification for the mango fruit uses the minimum entropy formulation method. The automated mango grading system using fuzzy logic achieved 77.78% accuracy in overall categories [5].

IV. METHODOLOGY
The following steps are to perform the ripeness evaluation of mango

1. Select the mango image.
2. Crop the area of mango.
3. Thresholding
4. Find and calculate the major axis.
5. Align the mango image.
6. Divide it into 3 regions.
7. Extract the color features from the 3 regions.
8. Use K nearest neighbour classification algorithm for database features \([k=10]\).
9. Output results based on the ripeness.

![Flow chart of proposed system](image)

**IMAGE SEGMENTATION**
Thresholding is the simplest method of image segmentation. It creates binary images from the gray scale image.

The choice of the threshold value is the key parameter in thresholding process. Maturity of mango can be determined by its color feature. The average color value of a whole mango should be taken for further processing, so the region of mango is necessary.

To find the region, thresholding process is used. In this step thresholding \((T=0.5)\) operation is performed on the color component. Otsu’s Method is a global threshold level computes used to convert an RGB or intensity image to a binary image.

**FEATURE EXTRACTION**
In order to predict the maturity level with the help of computer, some suitable measures collected from the images of the mangoes need to be investigated, which are most correlated with the maturity level.

A. Average R, G and B value
This represent the average R, G and B value of the entire mango and was calculated from the following equation:

\[
A_{K-R,G,B}=\frac{1}{r} \sum_{i=1}^{r} \sum_{j=1}^{c} (I_{k}^{*}\text{BW})
\]

Where, BW is the binary image acting as a mask set the region outside the contour of the mango to 0, and Ik is the captured RGB image, \(r\) and \(c\) represent the total number of rows and columns of the image.

B. Average R, G and B value of the Apex, Equator and Stalk region
For collecting the average R, G and B value for these three regions, slice images along the horizontal axis were extracted from the RGB image of the mango, the width of the each slice (along the longitudinal axis) is \(0.05 \times l_{\text{max}}\) and length is in between the end points of boundary along the horizontal axis cutting the centre point of each region.

C. Derived Features
From these principal highlights other derived elements were computed, these are as per the following:

Difference of average R, G and B estimation of the entire mango that is \((A_{R} - A_{G}), (A_{G} - A_{B})\) and \((A_{R} - A_{B})\)
Difference of corresponding average value \(R, G\) and \(B\) value for the apex, equator and stalk region, that is \((A_{\text{Apex}}R - A_{\text{Stalk}}R), (A_{\text{Apex}}G - A_{\text{Stalk}}G), (A_{\text{Equator}}R - A_{\text{Stalk}}R)\) and essentially for \(G\) and \(B\) too.

**K-NN ALGORITHM**
The K-nearest-neighbour (KNN) algorithm measures the distance between a query scenario and a set of scenarios in the data set.

**Distances**
- Euclidean distance measuring:

\[
d_{E}(x, y) = \sqrt{\sum_{i=1}^{n} (x_i - y_i)^{2}}
\]

Flow chart of K-NN Algorithm:
KNN Algorithm perform mango classification by using the distance between the feature value of unknown mango with the feature value of stored mango examples after that algorithm will find out the nearest examples to unknown mango.
The proposed methodology uses the dataset of 60 mangoes, out of which 30 mangoes are taken for training and 30 mangoes for testing which is shown in the figure 2.

The major axis is calculated using distance formula and dividing the three regions such as apex, equator and stalk regions based on the major axis which is shown in the figure 3.

The confusion matrix for the datasets

<table>
<thead>
<tr>
<th></th>
<th>Training</th>
<th>Testing</th>
<th>FP</th>
<th>FN</th>
<th>TP</th>
<th>TN</th>
<th>ACC</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>15</td>
<td>30</td>
<td>13</td>
<td>2</td>
<td>15</td>
<td>0</td>
<td>93%</td>
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<tr>
<td>M2</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

V. RESULTS

VI. CONCLUSION AND FUTURE WORK

In this proposed work, global thresholding segmentation method has been used to segment the mangoes from the background. We successfully estimated the ripeness of mangoes by extracting 24 color features with 93% of accuracy using K NN Classifier.

For future scope of work need to evaluate the mango ripeness by combining color and texture features using video processing.

REFERENCES


