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Banana Detection-a Scale Space Approach

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ABSTRACT

In India, agro industries provide significant contribution to the economy. Fruit are cultivated in large amount for domestic and export purposes. The sorting, classification and grading of fruit varieties like mango, banana, pomegranate and apple industries are involved in the postharvest processes of fruit industries for pulp and juice extraction. Machine vision technology can be implemented to assist the discrimination of various fruits. The separation of each fruit from others is required to automate the processes of fruit industries. In this paper, an image processing based approach is proposed to detect banana (Musa Balbisiana, Musa Accuminata etc.) from other fruits such as Mango, Apple, Citrus, and Pomegranate. The foreground region from an input image is segmented using a threshold technique. The boundary of the segmented contour is then subjected to curvature scale space (CSS) construction in order to retrieve shape information through CSS image. The generated CSS image is matched with the template using Eigen window for fruit identification. The accuracy rate of this algorithm is 82%.

Index Terms: Post Harvest Technology, Curvature Scale Space, Eigenspace

I. INTRODUCTION

Agriculture, an important part of India's economy, this sector contributes around 18.1 percent to the Gross Domestic Product (GDP). Agro industries process various agricultural produce like rice, wheat, fruits, vegetables and oilseeds etc. The operation of agro industries starts from the harvest till the products reaches the consumer in the desirable form inclusive of quality testing packaging and pricing. Technical innovations and advancements in automation have aided the agro industry worldwide. This growing agro business hub needs rapid and huge investments in channelizing the automation process.

In the current scenario of fruit industries, the process of cleaning, sorting, grading and ripening of raw fruits, extraction of juices, production of several products like jams, jellies are performed with manpower. Among all the fruits, Bananas (Musa Species) are the largest commodity in world trade with 97.5 million tones of production. India is the second largest exporter of banana in Asia. Indian bananas are exported to quench the rising demands of Gulf countries. In India, 2.8% of agricultural GDP is contributed by bananas. Banana cultivation and production ensures year-round security for food or income. Bananas are cultivated mainly in Maharashtra, Tamil Nadu, Gujarat, Assam, Karnataka, Kerala, Bihar, West Bengal, Andhra Pradesh, Odissa and Madhya Pradesh. Even though large numbers of banana export units are originated in India, only manual processes exist which are tedious, inconsistent, time consuming, less efficient, variable, and subjective. Few researches have been done to reduce the manual process. Hence the replacement of human operator with automated system is necessitated. Technology is still being geared to quench the automation process of fruit processing units. The emergence of vision technology has been enabled to automate a wide range of tasks in agro industries such as harvesting, cleaning, pre-cooling, ripening, sorting and cold storing of the raw fruits and vegetables. Enormous researches are carried out in the classification, sorting, grading, identification of ripening stages, quality testing of fruits and vegetables. In the context of these post harvest operations in fruit industry, the fruit classification is an important and a prior step of all processes. Zhang

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et al. [1] has summarized the application of traditional, hyper spectral and multi spectral computer vision system in quality evaluation of vegetables and fruits. Different methods for fruit quality inspection were analysed and found that the traditional computer vision system is a powerful tool for fruit inspection. In a fruit industry, many varieties of fruits are transported in the conveyor belt for processing. These fruits are to be segregated and directed for further operations in their respective section. The concentration of the proposed research is aimed on banana fruit. Therefore, an automation process is required to discriminate the banana from other fruits. The cost effective and non-destructive method for sorting of agricultural products is Computer vision and image analysis [2]. The contribution of the research work is to generate a scale space approach for banana using its curvature and to match the Eigen features of CSS for automatic detection of banana from non-banana fruits.

The remaining part of the paper is organized in such a way that section II summarizes few works related to the objective, section III describes the proposed methodology, section IV discusses the result and section V contains the concluding remarks.

2. PRIOR WORK

Fruit Quality evaluation and classification methods can be either destructive or non-destructive. The destructive methods are non-versatile. Non-destructive measurement of agricultural produce includes the methods like optics, X-ray, Mechanics and electromagnetic [3] are applicable. In the recent years, series of researches have been conducted on the application of vision technology for the benefits of fruit industries. Abiniu et al. have proposed automatic fruits identification and sorting system with Fourier descriptors (FD), artificial neural network (ANN), and spatial domain analysis (SDA) [4]. From the two non-overlapping clusters of segmentation, the shape boundary and signatures are found and analysed using FD and SDA technique. Also the colour information obtained from the RGB fruits images are trained by ANN and used for correctly determining the colour of a fruit. The colour and shape features are fused for fruits sorting and identification purposes which achieves 99.1% of accuracy. A new approach for sorting and grading of fruits are presented in [5], where the shape based sorting and grading of fruits are performed using Support Vector Machine (SVM) and Fuzzy logic respectively. The image analysis of the fruit product is performed on the colour, shape, size, and being without fault, damage or signs of sickness. A fruit recognition system based on three features namely colour, shape and size is proposed in [6] to increase recognition rate. This method classifies and recognizes fruit based on nearest neighbours classification. Rocha et al. have proposed that a single feature descriptor is insufficient to acquire the distinctive nature of different classes [7]. Therefore, effective and efficient feature fusion policies are required. Vegetables like beans, Zucchini, broccoli are recognized based on colour, shape, size, texture and weight that are extracted and analysed in [8] to facilitate the checkout process of a supermarket or grocery stores.

The existing literature has revealed that the vision systems are increasingly implemented in industry for inspection and classification which leads to consistent, rapid, hygienic, economic, and objective assessment. Out of colour, texture and shape of the fruits, shape is most distinct feature. Yang et al. have analysed shape descriptors in [9], curvature scale space is robust to noise, translation and scaling. It captures the main feature of a shape, and retains the local information of a shape. Each concavity and convexity of the contour of the image has its lobes at the CSS image. The proposed method aims at the discrimination of banana fruit through curvature scale space.

3. PROPOSED APPROACH

The research work comprises of two phases namely training and testing phases. An input image acquired by a digital camera is segmented using an iterative threshold algorithm. The boundary of the segmented object is used in the construction of curvature scale space. Curvature Scale Space retrieves the shape

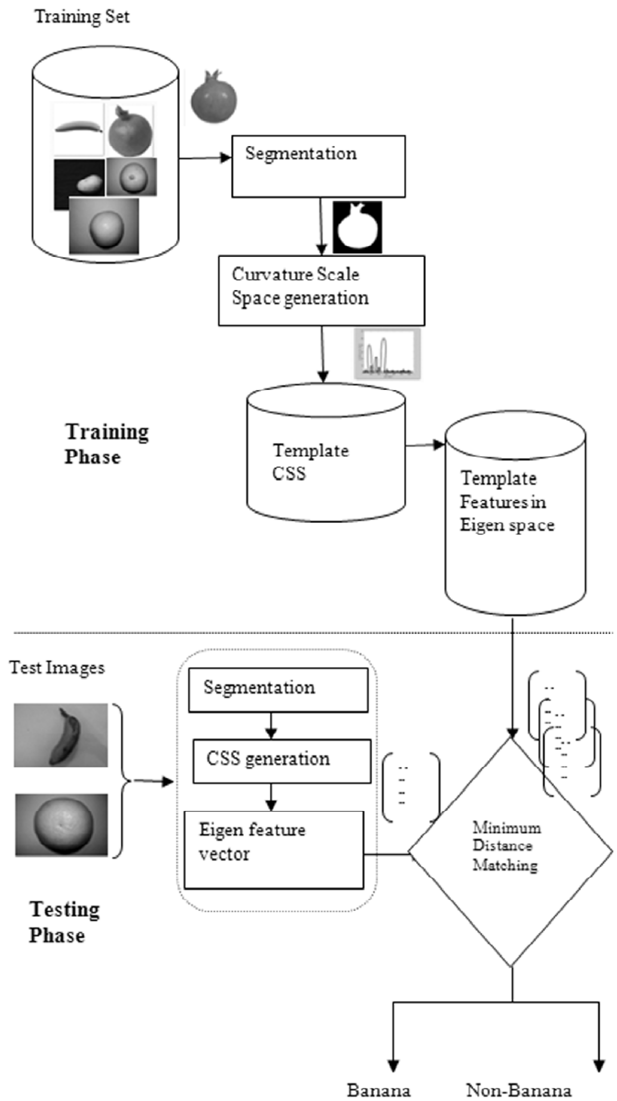


Figure 1: Proposed Methodology

information of the object. CSS image is obtained as an output of Curvature Scale space and then it is vectorized to marginal sum feature vector. The Eigen space of these vectors is used for matching. The features of the test image are matched with the template features obtained for a given training set. The metric used for matching is minimum distance measure. The flow of the proposed methodology is depicted in Fig. 1.

3.1. Segmentation

The ROI of an input image is segmented by computing a high contrast grey value image from RGB image, estimating a global threshold from the statistics of its intensity values and then extracting the contour based on a threshold and connectivity as suggested in [10] for food images

3.2. Construction of Curvature Scale Space

Curvature scale space [12] is multi scale representation of curvature to represent planar curves. Curvature scale space representation is scale, rotation, translation, and reflection invariant. So, it is implemented to find the apex structure as rounded or Bottleneck or so on. The contour is parameterized by *t* as represented in Eq.1.

$$\mathbf{L}_0(t) = \mathbf{L}_0(x(t), y(t)) \tag{1}$$

Where $x(t)$ and $y(t)$ are the x and y co-ordinates parameterized by path length 't'. The binary CSS image is computeded by convolving the closed curve $\boldsymbol{L}_0(t)$ with a series of Gaussians $g(t, \sigma)$ of increasing standard deviation σ, case given by Eq. 2.

$$\mathbf{L}(t,\sigma) = \mathbf{L}_0(x(t), y(t)) \otimes g(t,\sigma) = \mathbf{L}(X(t,\sigma), Y(t,\sigma)) \tag{2}$$

Where $\otimes$ denotes convolution. The curvature of smoothed curve is identified as Eq.3.

$$\mathbf{K}(t,\sigma) = \frac{\frac{\partial X}{\partial t}\cdot\frac{\partial^2 Y}{\partial t^2} - \frac{\partial Y}{\partial t}\cdot\frac{\partial^2 X}{\partial t^2}}{\left[\left(\frac{\partial X}{\partial t}\right)^2 + \left(\frac{\partial Y}{\partial t}\right)^2\right]^{3/2}} \tag{3}$$

The evolution of the smoothed curve is performed iteratively with varying path length and standard deviation to reduce the number of curvature zero crossings. The evolution of the curve is stopped when there is no zero crossing along the boundary of the object. CSS image is plotted with Path length versus Standard deviation (smoothing scale). This image consists of many lobe shaped contour which depicts the concavity/ convexity or point inflection of the contour.

3.3. Matching

Let the CSS image is represented as $C(i, j)$, where 'i' and 'j' are the indices of row and column of the image respectively. The CSS image is reformatted as marginal sum feature vectors m with row sum r and column sum c vectors as shown in Eq. 4.

$$\mathbf{m} = [\mathbf{r} \quad \mathbf{c}]^T \tag{4}$$

$$r = \left[\sum_i C(1, i) \ \sum_i C(2, i) \ .. \ \sum_i C(r, i)\right]^T \tag{5}$$

$$c = \left[\sum_j C(j, 1) \ \sum_j C(j, 2) \ .. \ \sum_j C(j, c)\right]^T \tag{6}$$

The phase correlated vector $\tilde{r}$ is computed as

$$\tilde{r} = \left|F^{-1}(\left|F(\mathbf{r})\right|)\right| \tag{7}$$

Where F is the 1D Fourier Transform. The marginal sum feature vector is modified as

$$\mathbf{m} = [\tilde{\mathbf{r}} \quad \mathbf{c}]^T \tag{8}$$

The Eigen values and Eigen vectors are calculated for the modified marginal sum feature vector using Singular Value Decomposition method. The Eigen space is used to reduce the curse of feature vector dimensionality. The reduced feature vectors are matched using the distance metric.

4. EXPERIMENTAL RESULTS

Fruits are placed on the conveyor belt and transited to each processing sections of a fruit industry. The images of the fruits are acquired by a camera installed at the top of the image acquisition chamber with its field of view on the conveyor. In this research, a database with the set of images of citrus, pomegranate, banana and Mango fruits are collected using a digital camera. The images are acquired at the controlled illumination and uniform background. Nikon 5200 camera is used for image acquistion at different views and positions of the fruit. Matlab 2012b simulation software is used for implementation of proposed algorithm. The size of the input images are 256×256. The banana database includes the finger samples of Morris, Red, Wild, Rasthali variety acquired at different position and views. A non-banana database comprises of mango, orange and pomegranate. Sample images of the database are shown in Fig. 2 respectively. The proposed algorithm is tested on the database images to discriminate banana fruits from other fruits.

The size of the database is 119 comprising of bananas, pomegranate, mango and citrus fruits. The images used for training and testing are mutually exclusive to each other. The object is segmented from an image by converting the image to a high contrast image, so that the between class variance is maximized to get better

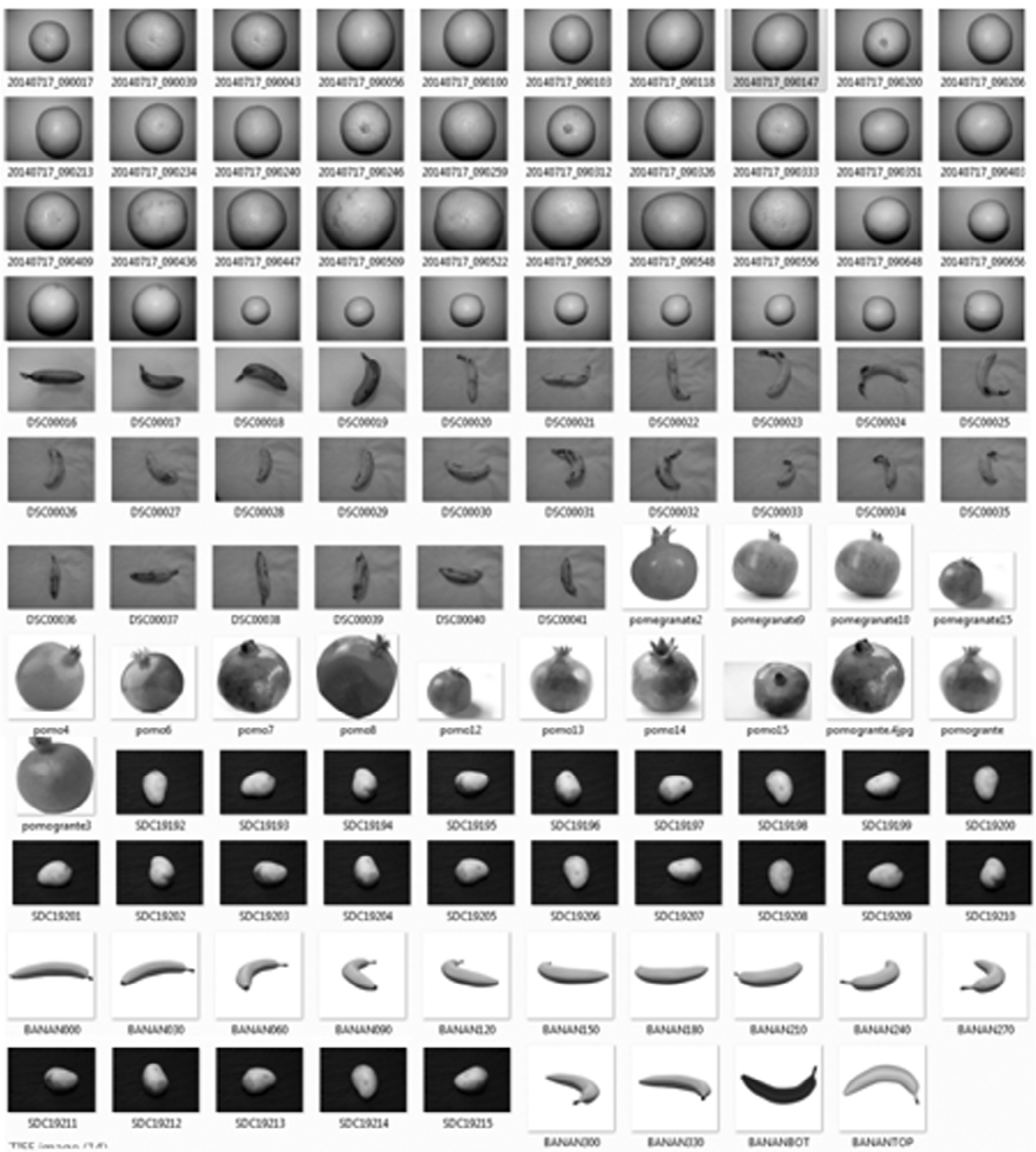


Figure 2: Database

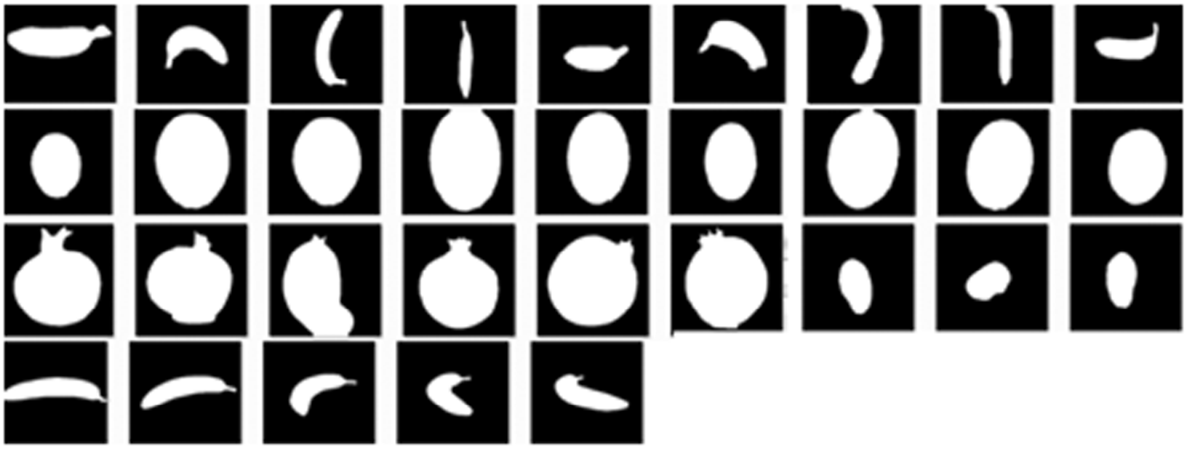
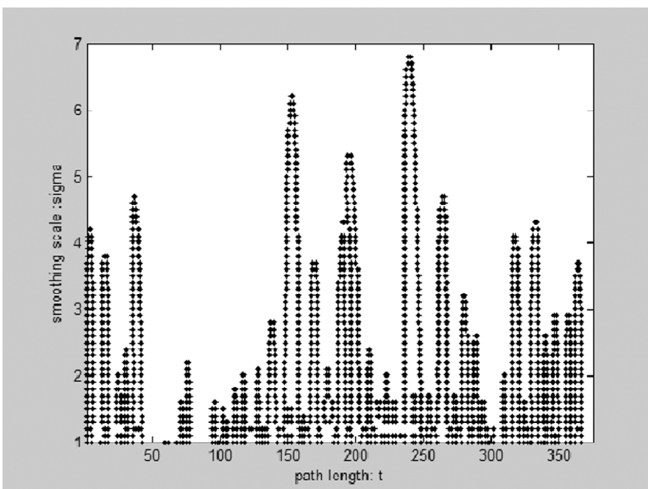
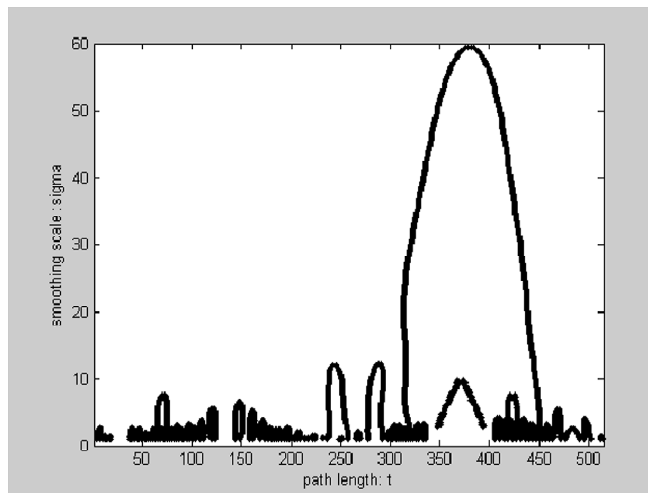


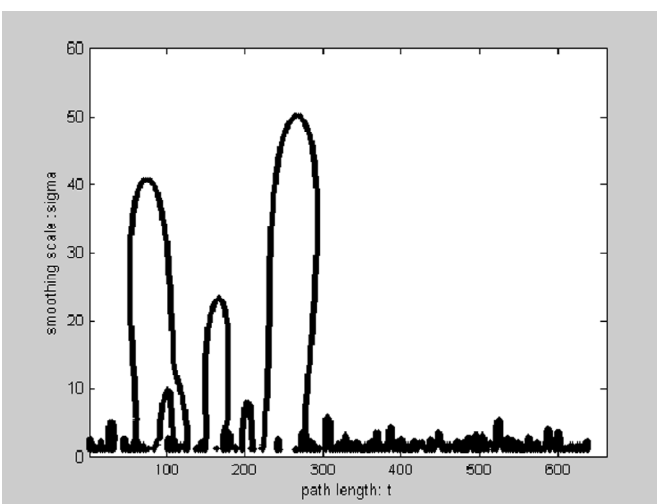
Figure 3: Segmentation output



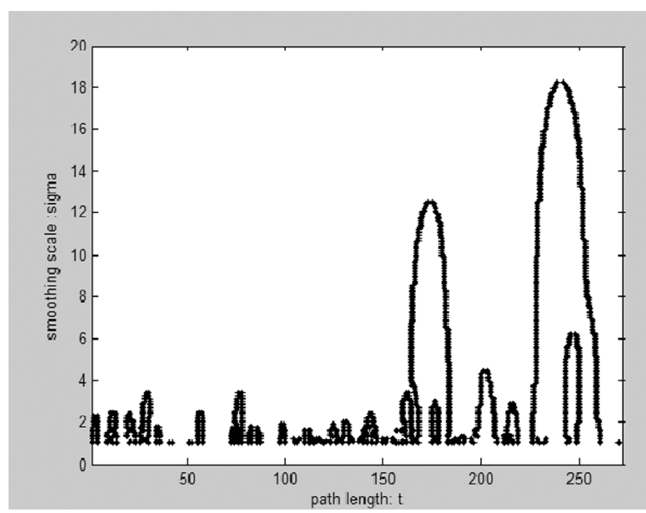
(a)



(b)



(c)



(d)

Figure 4: CSS image for a) Citrusb) Banana c) Pomegranate d) Mango

segmentation. The threshold value is found in an iterative manner based on the input image. The resultant of the segmentation process is more important to regulate the accuracy of the proposed shape based algorithm. Few segmentation results are shown in Fig 3. The boundary points of the foreground region are acquired and used for curvature scale space construction. The curvature scale space image for citrus, banana, pomegranate

Confusion matrix of the proposed method

Overall Accuracy(82%)	*Target Classes*	
	Banana	*Non-Banana*
Banana	84 %	16 %
Non-Banana	20%	80 %

and mango are shown below in Fig. 4. Each of these has different pattern of CSS image depending on its inflection points. The Eigen features obtained for Marginal sum features of CSS Image matrix is used for matching. The test image matches with the minimum distance measure of the banana template features resulting that the given fruit is banana. If it is maximum for banana template features, then it is Non-banana fruit. The confusion matrix of the proposed method is given below in table I. The overall accuracy rate is 82%.

5. CONCLUSION

In this paper, a vision approach has been developed for the detecting banana fruit from other fruit varieties. This research finds its application in the automation process of fruit industries. The input images of the fruit are acquired when the fruits are transported via the conveyor belt. The region of interest of the given input image is segmented using threshold technique. From the boundaries of the segmented blob, the CSS is evolved. The Eigen features of the CSS image are used for matching with the help of distance metric. The accuracy rate is 82%. The future work can be extended to address the occlusion problem of samples on the conveyor and also with the banana hand.

REFERENCES

[1] Baohua Zhang, Wenqian Huang, Jiangbo Li, Chunjiang Zhao, Shuxiang Fan, JitaoWu, Chengliang Liu, “Principles, developments and applications of computer vision for external quality inspection of fruits and vegetables: A review”, Elsevier, Food Research International, vol. 62, pp.326-343, 2014.

[2] Raji A.O and A.O. Alamutu, “Prospects of Computer vision automated sorting systems in agricultural process operations in Nigeria”, Agricultural Engineering International: the CIGR Journal of Scientific Research and Development. Vol. 7. Invited Overview. February 2005.

[3] Kyu-Hong Choi, Kang Jin Lee,Giyoung Kim, “Non -Destructive Technology for Evaluating Qualities of fruits using NIR Spectroscopy”, Second International Seminar on Non-Destructive Evaluation Tech, pp. 5-17, 2001.

[4] A. M. Aibinu, M. J. E. Salami, A. A. Shafie, N. Hazali and N. Termidzi, “Automatic Fruits Identification System Using Hybrid Technique”, IEEE Proceedings 2011 Sixth IEEE International Symposium on Electronic Design, Test and Application, 2011.

[5] Nur Badariah Ahmad Mustafa, Syed Khaleel Ahmed, Zaipatimah Ali, Wong Bing Yit, Aidil Azwin Zainul Abidin Md Sharrif, “Agricultural produce sorting and grading using support vector machines and fuzzy logic”, IEEE Proceeding International conference on Signal and image Processing, 2009.

[6] Woo Chaw Seng, Seyed Hadi Mirisaee, “A New Method for Fruits Recognition System”, International Conference on Electricak Engineering and Informatics, August 2009.

[7] Anderson Rocha, Daniel C. Hauagge, Jacques Wainer, Siome Goldenstein, “Automatic Fruit and Vegetable Classification from Image”, Elsevier/ computer and Electronics in Agriculture, 2010.

[8] Hridkamol Biswas, Faisal Hossain, “Automatic vegetable recognition system”, International Journal of Engineering Science Invention, 2013.

[9] Yang Mingqiang, Kpalma Kidiyo, Ronsin Joseph, “A survey of shape feature extraction techniques”, Pattern Recognition, 43-90, 2008.

[10] Domingo Mery, Franco Pedreschi, “Segmentation of color food images using a robust algorithm,” Elsevier-Journal of Food Engineering, vol. 66, pp. 353–360, April 2005.

[11] Sai Anand C, Tamilarasan, M., Arjun P., “A study on curvature scale space”, International Journal of Innovative Research in Computer and Communication Engineering, Vol. 2., Special Issue 3, July 2014.

[12] Tim K. Lee, Mark S. Drew, “3D object recognition by Eigen scale space of contours”, ACM, pp. 883-894, 2007.