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ENHANCED DETECTION OF FIELD GROWN CUCUMBERS USING MACHINE LEARNING TECHNIQUES

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Abstract: **In image processing mechanism recognition of images, plays a key role and it is applied all over methods of processing with a techniques. Cucumber is broadly cultivated vegetable, due to its delicious taste and short vegetative cycle. Matured field grown cucumbers to be harvest in time of their quick maturity stage. It will harvest to reduce the quality of vegetable and it slows the mature to next one. But the problem is need of many workers for short farming, so the cucumber harvesting robot need to be utilized by our existing system. In existing system the robots are used to harvest field grown cucumbers to realize machine learning examples. In our proposed work we recognize field grown cucumbers using color difference mechanism, but in existing they have only used shape based methods, it only gives 80% of accuracy. Using of color difference mechanism with shape difference gives more accuracy.**

Keywords: **Color Difference, Image Segmentation and Multi template library.**

1. INTRODUCTION

Image handling is a technique to change over a picture into advanced frame and play out a few activities on it, with the end goal to get an improved picture or to separate some valuable data from it. It is a kind of flag control in which input is picture, like video edge or photograph and yield may be picture or properties related with that image. For the most part Image Processing system consolidates seeing pictures as two dimensional signs while applying authoritatively set banner planning methods to them.

1.1. Purpose of Image processing:

The image processing purpose is separated into 5 groups. They are:

1. Representation - Observe the articles that are not unmistakable.
2. Picture honing and reclamation - To make a superior picture.
3. Picture recovery - Seek for the picture of intrigue.
4. Estimation of example – Measures different protests in a picture.
5. Picture Recognition – Distinguish the items in a picture.

The two kinds of methods utilized for Image Processing are Analog and Digital Image Processing. Simple or visual strategies of image preparing are employed for the printed editions like printouts and photos.

In Present days, another idea of shrewd cultivating has been presented where the field conditions are controlled and observed utilizing oneself working frameworks. The self acknowledgment of the sickness depends on the recognizable proof of the indications of infection. With the goal that data about the sickness event could be rapidly and precisely given to the ranchers, specialists and analysts. This thusly lessens the checking of expansive field by individual. In ailment acknowledgment from picture the key is to separate the trademark highlight of the sick locale. As per the sickness the highlights may differ. The highlights that are removed from the picture are shading, shape, surface and so forth. In some cases for location of the ailment more highlights are removed and this separated element would build the equipment and additionally programming expense. This further causes increment in the multifaceted nature and the calculation time. Consequently it is important to diminish the element information. The event of the malady on the plant may result in huge misfortune in both quality and in addition the amount of product of agriculture. This can create the negative effect on the nations whose economies are fundamentally subject to the agriculture. Consequently the recognition of the ailment in the prior stages is essential to maintain a strategic distance from the misfortune as far as quality, amount and fund.

As a vital part of plant pathology, leaf ailment is progressively esteemed by botanists and pathologists. PC vision innovation gives new research thoughts and strategies for fast programmed recognizable proof and determination of plant ailment. As ahead of schedule as 1999, Yuataka Sasaki considered the programmed diagnostics of cucumber anthracnose from the point of view of phantom reflectance properties and shape attributes [1].Wang Shuangxi of Shanxi Agricultural University has taken the cucumber sickness leaf in nurseries for instance to do inside and out research on segmentation of images, enhancement of image and highlight extraction. In this examination, we respect the normal cucumber precise leaf spot, fine buildup and fleece mold as the principle look into items, investigating the method for accomplishing quick and exact finding of infections of cucumber through removing three trademark estimations of shape, surface and shading. It will give specialized help to the protected creation of cucumber.

1.2. Present Status of Fruit Harvesting Robotics:

The improvement of robot framework that empowers gathering independently has gotten impressive consideration in the most recent decades yet has increased slightest measure of mechanical advancement for acceptable mechanization. In horticulture robotization, the creation frameworks ought to give higher quality items at lower cost with the end goal to end up focused when the rural generation rates are essentially impacted by use of farming robots and instruments and procedures produced for choice emotionally supportive network. Among the different homestead administration activities, collecting is a critical task which needs work control as well as high vitality contribution with high assets. A large portion of the other ranch administration activities can be done by exceedingly exact and precise marketed automation methods however collecting task still has not picked up the comparative commercialization status which connected with numerous analysts to think about and build up the farming robot applications for reaping reason.

2. RELATED WORK

2.1. Cucumber cultivation:

In genuine open air cultivate settings; a solitary sensor methodology can infrequently give the required data to recognize the objective organic products under an extensive variety of varieties in brightening, halfway impediments and distinctive appearances. This presents an incredible defense for the utilization of multi-modular natural product identification frameworks on the grounds that fluctuating sorts of sensors can give correlative data with respect to a variety of parts of the organic products. Profound neural systems have just indicated extraordinary guarantee when utilized for multi-modular frameworks in areas outside agrarian robotization, for example, in [24], where sound/video has been utilized effectively, and in [25,26], where picture/profundity show a superior execution contrasted with the usage of every methodology alone. This work pursues a similar methodology and exhibits the utilization of a multi-modular area based organic product location framework and how it beats pixel-level division frameworks.

The feature descriptors gather information from the local region around the feature point. In SIFT points, the information is oriented to the sharpest gradient to add rotational invariance. This descriptor provides distinctive data regarding the type of feature the point represents. It also contains hints which may be employed to rebuild the layering of surface. The neuroscience community has studied the implications of the local region surrounding feature points. In particular, a class of point features known as junctions have been used to solve numerous geometric harms in rasterized frameworks.

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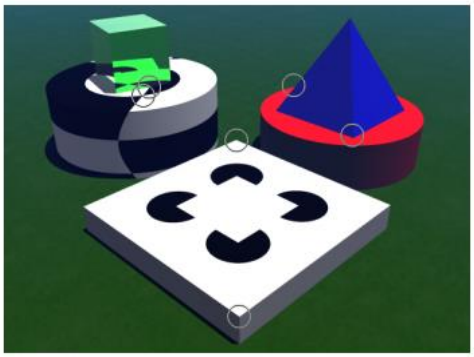

Figure 2.1: distinct Conceivable kinds of Intersection

Junctions are locations in an image where edges intersect. If a feature point does not have incoming edges, it is an impulse. Distributions of impulses can provide clues to the locations of deceptive contours in addition to the orientation of surface geometry. Junctions with one incoming gradient are line endings. Junctions with two incoming edges may be classified in one of two ways: continuous or discontinuous. If the edges leading into the junction are smooth across it, the junction can be considered an edge point. Edge points are less significant junctions than 2-way junctions with a discontinuous derivative. Junctions at locations where two incoming edges do not smoothly complete are referred to as L-junctions. The incoming edges at an L-junction need not be each other orthogonal. Tse and Albert discuss the existence of 2-way junctions with curvature discontinuities [14]. They note that these junction types demonstrate surface penetration.

2.2. Vectorization:

Vectorization is a compressive process, which reduce the complexity of a rasterized image by replacing collections of data samples with a simpler set of equations. In the edges case, vectorization allows for the conversion of a planned group of spot into a simple curve. The process also improves estimations based on the data by building up a data-sensitive region of sup-port. Early research on vectorization focused on fitting parametric polynomials to raw data. This gradually evolved into the growth of splines. Splines are curves built up through the progressive concatenation of piecewise polynomial pieces of order n. The (n - 1) st derivative of a typical spline is an impulse train. Splines therefore can be expressed using a very small amount of data [35]. Research into splines has searched for ways to reduce the data quantity required to express complex curves. Through careful selection of knot locations (impulses in the derivatives), splines can be fit to a broad selection of shapes.

If knots are poorly selected, splines will create oscillations in the output curve. If mandates on preserving monotonicity are enforced, as with MAT-LAB's implementation of Hermite splines, the splines can smooth over local extreme. The input to the vectorizing process consists of quantized samples. This means that samples located at an actual junction's location are very rare. For Lindeberg's algorithm [19], the points exist at intersections between the curves and a regular grid (Figure 2.2). If the change in slope near discontinuities is smooth enough, the vectorization algorithm may not notice them. This can result in overlooking features which could have produced perceptual completions.

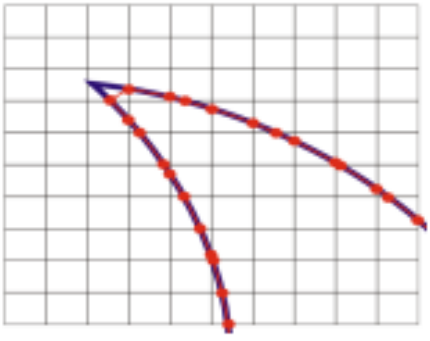

Figure 2.2: Connection between edge and distinguished points

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2.3. Color-Mapping Technique:

This study shows an organic product estimate distinguishing and reviewing framework dependent on picture handling. The early evaluation of natural product quality requires new instruments for size and shading estimation. The side view pictures of products in natural have caught. After that some organic product characters have extricated by utilizing identifying calculations. K. Parvati et al. [24] have proposed picture division utilizing dim morphology in scale and marker restricted watershed change. Division, another strategy, for shading, dim scale MR medicinal pictures, and aeronautical pictures, has proposed. Edge recognition calculation incorporates work edge and marker-controlled watershed division. Miss. Anuradha Gawande et al. [25] have depicted usage of organic products reviewing and arranging framework by utilizing picture handling and information classifier.

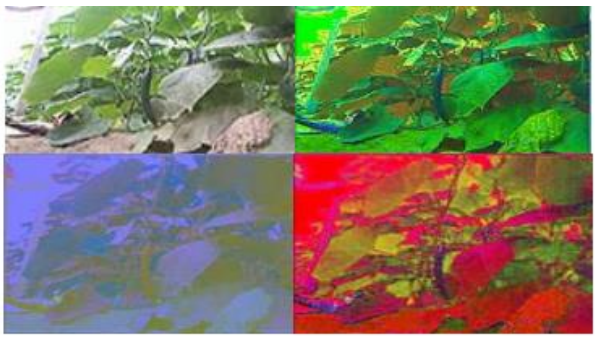

Figure 2.3: Color space

After examination, the contrast between the foods mature from the land base of the HSL was self-evident, so this paper picks HSL as the preparing space. HSL is a sort of shading space display, in which the HLS is tone brightness and saturation. The relationship among RGB and HSL:

$$H = \begin{cases} \theta & (G \geq B) \\ 2\pi & (G < B) \end{cases}$$

$$\theta = ar\ cos\left[\frac{0.5(R-G)+R-B}{\sqrt{(R-G)^2+(R-B)(G-B)}}\right]$$

$$S = 1 - \frac{3}{R+G+B}\min\ (R,G,B)$$

$$L = \frac{1}{3}(\mathrm{R}+\mathrm{G}+\mathrm{B})$$

2.4. Image segmentation based on region growing:

Initially, the picture is put into the shading histogram, and the shading focuses and the shading histogram of the organic product are extricated by utilizing PS programming. Select the 6*6 pixel territory, set the limit, and checks the quantity of pixels inside the area not as much as the edge. In the event that more noteworthy than 20 might be viewed as the organic product class of articles, it is sifted to under 20. The development point is chosen by utilizing the above technique to partition the products of the soil foundation shading; however, because of the nearness of organic product shading like the pixel squares, it should be additionally prepared. Sifting and development factor division results are appeared in Fig. (2.4).

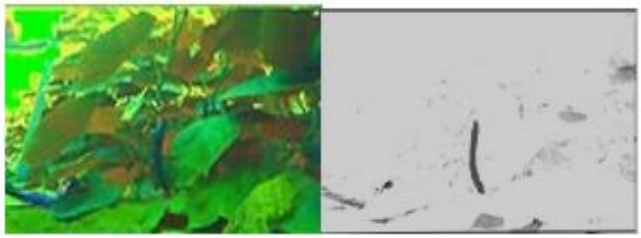

Figure 2.4: Image filtering and split the growth area

3. BACKGROUND STUDY

As made reference to by Jimenez et al. to get the programmed natural product reaping framework in horticulture part, preferably, three primary issues should be comprehended: (1) the direction of the robot through the harvests, (2) the area and portrayal of the organic product on the trees, and (3) the getting a handle on and separation of each piece. The main issue isn't basic and can be fathomed utilizing one administrator to manage the robot through the yields or receiving line following moving base framework. The other two issues have gotten exceptional consideration amid the most recent thirty years, albeit no business gathering robot is accessible. To take care of issues of area and portrayal of organic product on trees, an effective acknowledgment framework is required that can find the natural products on trees with their positional data i.e. the area and introduction of the natural product. Further, the acknowledgment framework ought to have the capacity to find the impeded or natural products mostly shrouded by leaves in the variable field condition. Additionally, to tackle the issue of getting a handle on and separation of organic products, a powerful grasping and cutting framework is required that can reap the natural products under different conditions without making any physical harm the organic product. Besides, the picking framework ought to have the capacity to deal with the delicate, fragile organic products amid reaping time as for their different shape and size without making any harm trees and could ready to play out the gathering activity at higher speed absolutely. To maintain a strategic distance from the physical harm to delicate and fragile natural products, manual collecting is favored which essentially builds add up to cost of organic product creation. Likewise, this sort of reaping strategy is exceedingly work serious and wasteful as far as both economy and time. To perform the intensive manual harvesting, need more labor power. If the labor population in the agriculture is taken into consideration, then since last few decades, the labor population is decreasing rapidly.

3.1. Recognition System:

1. The recognition system should be able to identify and place the fruits under conditions like: single fruit, fruits with leaves, fruits with leaves and stem.

2. The procedure ought to be material in the circumstances where certain territories of the natural products are not noticeable because of incomplete impediment by leaves or by covering organic products.

3. The recognition system should be robust enough for operating in the presence of difficult and variable field conditions like bright light reflections, shadows, variable lighting conditions, night operations and noisy background.

4. The recognition system outcome must bring the 3D place of the recognized fruit.

5. The developed algorithm must operate in real-time in a general purpose sequential processor the support of special image processing boards.

6. To estimate the performance of algorithm used for recognition of green sweet peppers and recognition rate by using same recognition system.

7. To develop multi-spectral recognition system to detect the sweet peppers under various selected conditions such as single fruit only, fruits with leaves, partially overlapped fruits and partly covered and partly overlapped fruits.

8. To extend and examine the algorithm for multi-spectral recognition system to determine the maturity stage of detected fruits so that only matured fruits should be harvested.

4. PROPOSED METHODOLOGY

The automatic detection of cucumber focus inside its developing condition is important technique for the robot for the cucumber harvesting. Since cucumber develops in the mind boggling condition and its shading is like that of branches and abandons, it is very testing to accomplish high ID precision while utilizing calculations dependent on shading highlights, image division and shape highlights. Receiving spectroscopy can streamline the calculation. Anyway it builds the multifaceted nature and cost of the robot framework. The multi-format coordinating strategy was proposed to pay attention of this issue in this paper. A multi-layout coordinating library, which contained 65 cucumber images, was set up dependent on the measurable parameters of the developed Field grown cucumber, by corresponding scaling the standard cucumber image with venture of 0.1 in the scope of [0.8, 1.2] and pivoting with venture of pi/36 in the scope of [pi/6, pi/6]. To identify the cucumber in the robot to the visual field, cucumber formats in the library are utilized to figure the grid of normalized correlation co-efficient (NCC) with the objective image, in a steady progression.

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4.1. Detection Methodology:

4.1.1. Object cucumber:

The subject of this examination is Field grown cucumber, or, in other words be developed in nursery in late-winter and pre-winter. The Field grown cucumber is parthenogenesis and floriferous. Each branch can hold up under 3– 4 foods grown from the ground developed cucumber is long of 12– 18 cm. The Field grown cucumber is broadly supported on account of its high efficiency, top notch, style shape and appearance.

4.1.2. Construction of multiple-template library:

Regardless of whether every one of them is sufficiently developed for collecting, they are not reliable with one another in size and redirecting point. Considering the development point and size contrast of cucumbers, the cucumber standard image was acquired through insights from a lot of tests, by image improvement, thresholding and morphological tasks, appeared progression of cucumber formats were produced through the change of scale and edge from the cucumber standard image, which established the various layout library.

The cucumber shape limit (x ; y) changed over to (x* ; y*) by the scale change can be communicated by:

$$\begin{bmatrix} x* \\ y* \end{bmatrix} = S\ X \begin{bmatrix} x \\ y \end{bmatrix}$$

Scale transformation is connected on standard cucumber shape, in which S changes from 0.8 to 1.2 with venture of 0.1. So there will be five scale change coefficients, appeared in Table 1. The cucumber limits under various scales are appeared in Fig. 4.1.

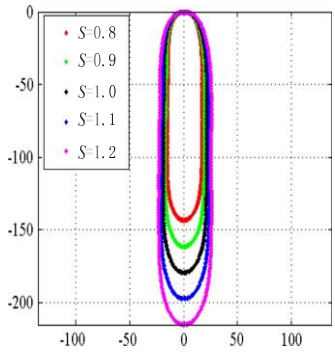

Figure 4.1: Cucumber in Various scales

4.1.3. Angle Transformation:

The factual consequences of 100 Field grown cucumber images demonstrated that there were just 2 cucumbers going astray more than. The likelihood was just 2%, or, in other words to be overlooked. So we set the going astray edge extends as. (- (∏/6),(∏/6)). The point is 0° when the cucumber is vertical descending. The edge revolution change for the standard cucumber limit in the spatial area is:

$$M_{rotate} = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} M$$

Where M remains for the standard cucumber image; M turn signifies the shape after the point change; h is the revolution edge, going in (- (∏/6),(∏/6)). The cucumber shape limit (x,y) changed over to (x**,y**) by the edge change can be spoken to as a grid :

$$\begin{bmatrix} x** \\ y** \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

The edge change will be connected on standard cucumber shape. The edge θ changes from (-∏/6) to (∏/6) with venture of (∏/36). So there will be 13 edge changes co-efficient, as appeared. The cucumber shapes delivered by the edge change from the standard cucumber limit are appeared in conditions.

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4.1.4. Cucumber Template Library:

The change consolidating scale and edge was connected on standard cucumber limit. So there were 5 X 13 = 65 cucumber limit images with various scales and avoiding points. The procedure of layout age is demonstrated as follows. A portion of the cucumber limits after the change are appeared in beneath. Every one of the limits ought to be appeared as cucumber. At that point, the cucumber matching of image multi-layout library was manufactured, which will be connected in cucumber coordinating and identification. A few layouts from the cucumber format library were appeared in Fig. 6. The final format library included 65 cucumber images.

Format k to the following pixel (I +1, j) in target image and figure the NCC R(i+1; j). The NCC framework R will be acquired by navigating the entire images.

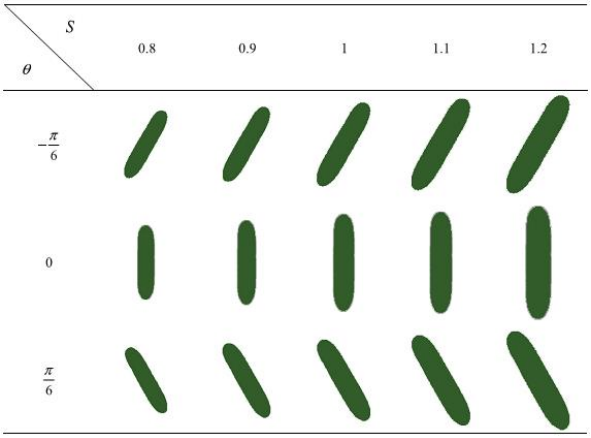

Figure 4.2: Template Library

Locate the greatest Rmax (i,j) from the NCC grid R. On the off chance that Rmax (i,j)>Th, the coordinating succeeds. The point (i,j) is the start of the targeted cucumber and the coordinated cucumber can be situated in the objective image outline, as appeared in Fig. 10. At that point the coordinating procedure exits. On the off chance that Rmax (i,j) < Th, hop to step (5). Here Th is edge. (5) Select format k + 1 from the layout library. Rehash ventures from (1) to (4). Anyway that every one of the formats is utilized and the program never exits from step (4), it implies that there is no cucumber in the objective image.

5. RESULTS AND DISCUSSIONS

The pictures contained diverse cucumber shapes and deflecting points were tried with the five-advance multi-format coordinating calculation depicted in this results and analysis chapter. In the analysis, the edge Th was observationally set as 0.9 as threshold to pick up the edge value. That is, if the NCC C(i,j) is greater than 0.9, there exists cucumber like the format in the objective image. Five coordinating pixels outcomes were chosen for discussion appeared in below figure. For the standard scale and edge cucumber in the objective picture, it very well may be effortlessly coordinated by the standard layout. The shades of cucumber and the branches in below figure are similar to the point that they can't be effortlessly isolated from one another fair by shading highlights. While the layout from the library appeared in results, could coordinate the objective effectively. The objective natural product is 0.9 times of the standard Field grown cucumber

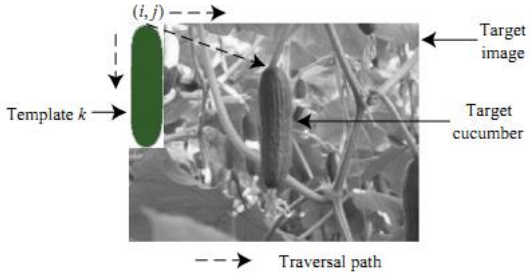

Figure 5.1: Detection traversal path of cucumber

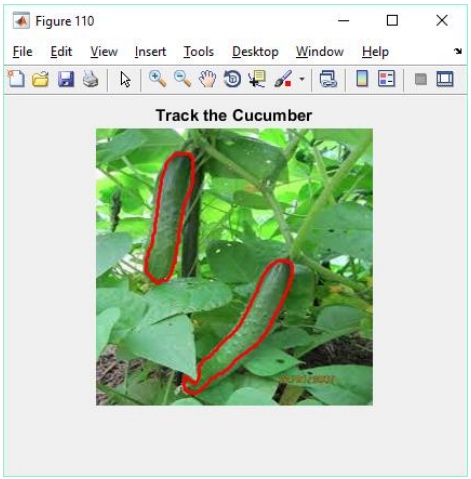

Figure 5.2: Cucumber Tracked out from plant image

From the above figure 5.2. Result (cucumber) is taken tracked out through every traversal done by our proposed approach.

6. CONCLUSION

According to the mathematical parameter of field grown matured cucumbers the proportional scale technique and operation of rotation gives and exact cucumber image that is applied to main multi template matching library. The template matching system is developed to make ease of color difference mechanism, those experimental results shows us target image of field grown cucumber is matched with accuracy of 99%. In our future work, color difference mechanism we need to detect plant disease with help of machine learning methods. Speed and accuracy of color difference mechanism is need improved more. Development of hybrid algorithms based on Neural networks and machine learning algorithm to enhancement of classifier recognition rate Implementations with robot make manual flaws, so we need to given with tested results using simulators.

REFERENCES

[1] Aitkenhead MJ, Dalgetty IA, Mullins CE, Mcdonald AJS, Strachan NJC, 2003. Weed and crop discrimination using image analysis and artificial intelligence methods. Computers and Electronics in Agriculture 39(3): 157-171.

[2] K. Padmavathi, and K. Thangadurai, "Implementation of RGB and Gray scale images in plant leaves disease detection –comparative study," Indian J. of Sci. and Tech., vol. 9, pp. 1-6,Feb. 2016.

[3] Sonal P Patel. Mr. Arun Kumar Dewangan "A Comparative Study on Various Plant Leaf Diseases Detection and Classification" (IJSRET), ISSN 2278 – 0882 Volume 6, Issue 3, March 2017.

[4] V. A. Gulhane, Dr. A. A. Gurjar, "Detection of Diseases on Cotton Leaves and Its Possible Diagnosis". 2011 International Journal of Image Processing (IJIP), Vol.5, Issue (5), pg.no.590-598.

[5] Santanu Phadikar and Jaya Sil, "Rice Disease Identification using Pattern Recognition Techniques", Proceedings of 11th International Conference on Computer and Information Technology (ICCIT 2008), 25-27 December, 2008, Khulna, Bangladesh, pg.no420-423, (IEEE).

[6] Ganesh Bhadane , Sapana Sharma and Vijay B. Nerkar, "Early Pest Identification in Agricultural Crops using Image Processing Techniques", International Journal of Electrical, Electronics and Computer Enginering 2(2): 7 - 82(2013),ISN No. (Online): 27-2626.

[7] S. Arivazhagan and R. Newlin Shebiah et al., "Detection of unhealthy region of plant leaves and classification of plant leaf diseases using texture feature", CIGR, 2013, 15(1), 211-217.

[8] NiketAmoda, Bharat Jadhav, Smeeta Naikwadi,"Detection And Classification Of Plant

[9] Diseases By Image Processing", International Journal of Innovative Science, Engineering & Technology, Vol. 1 Issue 2, April 2014.

[10] WY Ma, BS Manjunath ,"EdgeFlow: a technique for boundary detection and image segmentation" on Image Processing, IEEE Transactions, 2000.

[11] Jaun M, Pilar G,Vicente A, "FPGA-Based Educational Platform for Real-Time Image Processing Experiments".

[12] Basu, J. K., Bhattacharyya, D., & Kim, T.-h. (2010). Use of Artificial Neural Network in Pattern Recognition. International Journal of Software Engineering and Its Applications, 4(2), 23-34.

[13] Samantaray, R. K., Panda, S., & Pradhan, D. (2011). Application of Digital Image Processing and Analysis in Healthcare Based on Medical Palmistry. IJCA Special Issue on Intelligent Systems and Data Processing, 56-59.

[14] Trier, O. D., Jain, A. K., & Taxt, T. (1996). Feature extraction methods for character recognition- A survey. Pattern Recognition, 29(4), 641-662.

[15] S. M. Smith, J. M. Brady, "SUSAN-a new approach to low level image processing," International Journal of Computer Vision, vol. 23, 1997, pp. 45—78.

[16] M. Yasmin, S. Mohsin, I. Irum, and M. Sharif, "Content based image retrieval by shape, color and relevance feedback," Life Science Journal, vol. 10, 2013.

[17] W. Zhao, J. Zhang, P. Li, and Y. Li, "Study of image segmentation algorithm based on textural features and neural network," in International Conference on Intelligent Computing and Cognitive Informatics (ICICCI), pp. 300-303, 2010.

[18] Heggere S. Ranganath, Govindaraj Kuntimad, "Iterative segmentation using pulse-coupled neural networks," Proc. SPIE, Vol. 2760, 543–554 (1996); doi:10.1117/12.235943.

[19] N. Senthilkumaran and R. Rajesh, "Edge Detection Techniques for Image Segmentation - A Survey", Proceedings of International Conference on Managing Next Generation Software Applications, (MNGSA-08), December 2008. pp.749-760.

[20] Eitel, A.; Springenberg, J.T.; Spinello, L.; Riedmiller, M.; Burgard, W. Multimodal deep learning for robust RGB-D object recognition. In Proceedings of the 2015 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), Hamburg, Germany, 28 September–2 October 2015; pp. 681–687.

[21] Wang, Q.; Nuske, S.T.; Bergerman, M.; Singh, S. Automated Crop Yield Estimation for Apple Orchards. In Proceedings of the 13th Internation Symposium on Experimental Robotics (ISER 2012), Québec City, QC, Canada, 17–22 June 2012.

[22] McCool, C.; Sa, I.; Dayoub, F.; Lehnert, C.; Perez, T.; Upcroft, B. Visual Detection of Occluded Crop: For automated harvesting. In Proceedings of the International Conference on Robotics and Automation, Stockholm, Sweden, 16–21 May 2016.

[23] Cheein, F.A.A.; Carelli, R. Agricultural robotics: Unmanned robotic service units in agricultural tasks. IEEE Ind. Electron. Mag. 2013, 7, 48–58.

[24] Regunathan M, Lee WS 2005. Citrus yield mapping and size determination using machine vision and ultrasonic sensors. ASAE Paper No. 053017.

[25] Xiong Xuemei, Wang Yiming, Zhang Xiaochao, et al. Locust detection by image segmentation based on pulse-coupled neural network [J] Journal of Agricultural Mechanization Research, 29(1) : 180 ～ 183,2007.