Rice Leaf Blast Disease Detection Using Multi-Level Colour Image Thresholding

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***Abstract*—Rice diseases have caused a major production and economic losses in the agricultural industry. To control and minimise the impacts of the attacks, the diseases need to be identified in the early stage. Early detection for estimation of severity effect or incidence of diseases can save the production from quantitative and qualitative losses, reduce the use of pesticide, and increase country's economic growth. This paper describes an integrated method for detection of diseases on leaves called Rice Leaf Blast (RLB) using image processing technique. It includes the image pre-processing, image segmentation and image analysis where Hue Saturation Value (HSV) colour space is used. To extract the region of interest, image segmentation (the most critical task in image processing) is applied, and pattern recognition based on Multi-Level Thresholding approach is proposed. As a result, the severity of RLB disease is classified into three categories such as infection stage, spreading stage and worst stage.**

***Index Terms*—Rice Leaf Blast (RLB) Disease; Uncontrol Environment; Image Pre-processing; Colour Image Segmentation; Multi-level Image Thresholding.**

I. Introduction

Rice plants can become stressed mainly due to the abiotic and biotic factors. Abiotic is the non-living factors such as wind and water, while other living organisms like plants, animals, bacteria and fungi are called the biotic[1]. Rice plants' stresses are expressed in various ways. For example, plant water stress can slow down photosynthesis, reduce evapotranspiration, and raise leaf surface temperature. Other symptoms can be caused by bacteria, viruses, or fungus which include morphological changes like discolouration of leaves, wilting and plants that do not produce panicles or produce empty panicles.

Rice Leaf Blast (RLB) disease is one of the biotic stresses that contribute to the reduction of rice productivity worldwide. It has become a dominant, threatening disease in Malaysia due to its wide distribution and ability to survive in a wide range of environmental conditions.

The RLB disease is mainly caused by fungus *Pyricularia oryzae Cavara*[2] that attack rice plants which diminish rice quality. This disease can attack all stages of rices' growth as early as the seedlings, vegetative and even the harvesting stages. The experts can identify the symptoms of this disease, i.e. by looking at a leaf with lesions usually starts near the leaf tips or leaf boarder or both. These symptoms appear as brown specks and then grow to become spindle-shaped, pointed at both ends. The colour of lesions is usually pale green to greyish green, later turning yellow to grey at the centre of dead spots[3,4].

Several studies have reported that RLB disease is one of the most harmful diseases to rice and had caused yield losses. For instance, in Philippines and Japan, the yield losses were estimated to vary between 50% to 85% and 20% to 100%, respectively[5]. In 2014, [6] has reported that in Malaysia, nearly 10 thousand hectares of MADA crop area was attacked by this disease. This disease is capable of causing yield losses up to 100% which definitely affects farmers' income and national economy.

Traditionally, the RLB disease inspection is performed by trained human inspectors. However, their observations are highly variable, and their decisions are always inconsistent between inspectors from day to day basis [7]. Therefore, a more reliable technique is necessary to diagnose this diseases instantly and accurately[8].

Thus, an early detection system has been proposed in the literature based on image processing technique[8-10]. Although human eye can identify some of these symptoms, image processing system gives more accuracy and speed[11,12]. This technique will be used to reduce manual inspection and identification of common rice disease[13,14]. Unfortunately, the existing image processing system is focused only on a single leaf and unfavourable for many other aspects such as different sizes, orientations, complex background and light conditions. It is very challenging to detect the target image outdoor since it composed both the structured and unstructured objects [15].

This work presents RLB disease diagnosis system using multi-level colour image thresholding. The system includes image enhancement, image segmentation, and feature extraction. Experimental work was set up at a rice field with considering many rice leaves, different sizes, orientations and light conditions. Details of the proposed system are shown by the flowchart in Figure 1.

II. Methodology

The experiment was conducted at Rice Research Centre of Malaysian Agricultural Research and Development Institute (MARDI) Seberang Perai, Malaysia. The acquired colour images were captured by using smartphone camera in real-world conditions where the condition of crops' leaves and the environmental conditions are uncontrolled. Then, all the images will be transferred to a computer for detection of RLB by using image processing technique. The output expected data such as the severity stages of RLB disease can be used for further action by farmer or agricultural experts. This RLB disease detection system is shown in Figure 2.

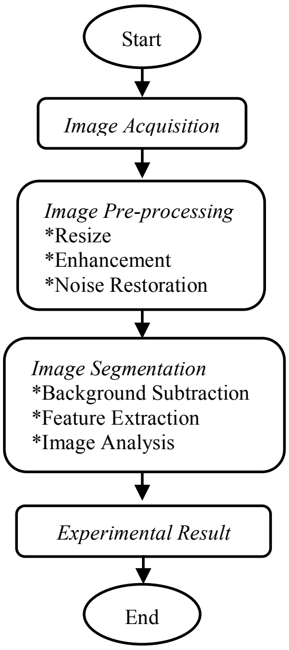


Figure 1: The system flowchart

Figure 2: The developed rice blast diseases detection system.

III. IMAGE PRE-PROCESSING

The colour images need to enhance before it can be analysed by the pattern recognition technique. The image pre-processing is used where the original images will be transformed into new colour space, This new image fundamentally similar to the source image, but differs in certain aspects. This process involves image resize, image restoration (filtering) and image enhancement.

A. Resize

The original images will be resized to a fixed resolution to improve the memory storage capacity and to reduce the computational complexity. The resizing image will reduce to the dimension of 640 x 480 pixel.

B. Noise Restoration

Noise is one of the undesirable nuisances in the acquired images. It may be caused by motion between camera and object, improper shutter opening, atmospheric disturbances and misfocusing [19]. Generally, it can be considered as a random variable with zero mean. Consider a noisy pixel;

$$P = P_0 + n \tag{1}$$

where P_0 is the true value of pixel and n is the number of noise in that pixel. These noisy pixels need to be removed to produce a visually high quality image before further process of retrieving the original images. Ideally, after image restoration, the new image should get;

$$P = P_0 \tag{2}$$

where the mean of noise is zero. Image restoration or denoising includes the process of changing, correcting, or moving of the image data to produce noise-free image while preserving the edges. This step should be processed before the segmentation stage without loss of information for RLB disease diagnoses to avoid from false feature selection during background subtraction.

C. Image Enhancement

This process will improve the low intensity of original image by reducing its dynamic range and/or increasing its contrast. This process will enhance the quality of the image that suits the image processing analysis. The Histogram Equalization (HE) method is used to enhance the contrast of the acquired image. This method will be equalising the intensity distribution of an image or flattening the intensity distribution curve. This method is the most useful method for enhancing the quality of image[16-18]. The original Red, Green and Blue (RGB) colour image is transformed into Hue Saturation Value (HSV) colour space.

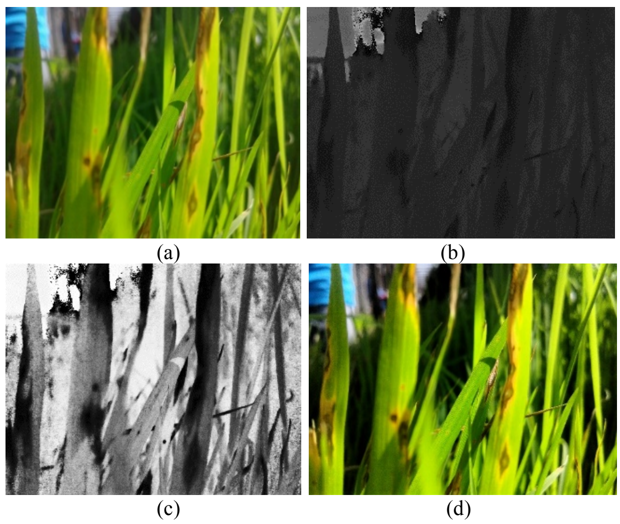


Figure 3: (a) Original RGB image. (b) *V* channel before enhancement. (c) After enhancement. (d) Convert back to RGB.

Then, it will be split into a single component which Hue (H), Saturation (S) and Value (V) from HSV respectively. Only V component is enhanced while other components remain in its coordinates. After enhancement, the new V component is merged back to it colour space. Figure 3(a) and Figure 3(b) shows the original image and enhancement process for V channel. Figure 3(c) and Figure 3(d) shows the result after merging and convert back to RGB colour space.

IV. IMAGE SEGMENTATION

Image segmentation is a process to divide an image into significant regions or segments and extract out the interested target used for image processing. The process will partition a colour image into discrete regions which contain information which generally very challenging. The suitable segmentation technique depends on the type of image and problem facing. Every region has similar pixel according to some homogeneity image characteristics such as colour, intensity or texture[20].

Image segmentation is an essential step for image interpretation, analysis process, object representation and visualisation. The colour image segmentation technique s include pixel-based, edge-based, region-based, model-based, physics-based, and section surveying hybrid-based[22].

There are no rules in selecting the image segmentation technique suitable for an image. It is also difficult to select a various approach for a specific type of image. Most researchers will diligently try to resolve the uncertainty difficulties encountered while trying to model the human visual system[21]. Therefore, selecting the suitable image segmentation technique remains a challenging problem in image processing[22].

The image segmentation process consists of, background subtraction, feature extraction and image analysis.

A. Background Subtraction

The objective for background subtraction is the region of leaf affected by RLB disease and define as a foreground. Segmentation is performed by choosing suitable thresholds range to extract the infected area from the background.

Thresholding is an important method for image segmentation which is based on image space regions, i.e. the characteristics of the image. This image segmentation technique has an advantage compared to others due to it is smaller storage space, fast processing speed and easy manipulation[20].

The values of the threshold are chosen from the lower and upper of the image histogram. Since the colour of RLB diseases region is not uniformly distributed, a single process of thresholding is not efficient. Therefore, multi-level thresholding based on pixel-based segmentation techniques for a colour image is proposed. This is illustrated by Equation (3)

$$T_h(x,y) = \begin{cases} v_1, if\ T_1 \leq T(x,y) < T_2 \\ v_2, if\ T(x,y) \geq T_2 \\ v_3, if\ T(x,y) \leq T_1 \end{cases} \quad (3)$$

where T_1 and T_2 is the lower and upper range of thresholding values, respectively. A point (*x,y*) is classified as object of class 1 (v_1) if the threshold value is between T_1 and T_2 . If the threshold value is greater than or equal to the upper range T_2 , a point (*x,y*) is classified as object of class 2 (v_2), and it is classified to the background if the threshold is not more than the lower range T_1. The HSV is used according to the rate of high luminance points and white luminance points in the image.

The H channel is selected for its ability to accommodate the variable lighting conditions and to distinguish between rice and non-rice leaf colour efficiently. For every pixel, the H channel will be checked that allow only values above a specific range to be realised based on the selected threshold value. Figure 4 shows the example of RLB disease colour extraction using this technique.

B. Feature Extraction

The image analysis that based on edge detection is unaffected to change in the overall illumination level[23]. From Figure 5, the image result is observed as in the disconnected white regions which influence the decision in image interpretation. Therefore, the regions of RLB disease in the image should be completely solid before the image suitable to analyse. A morphological closing is performed by using a *7* x *7* rectangular structuring element to join all the disconnected regions together as shown in Figure 5(a).

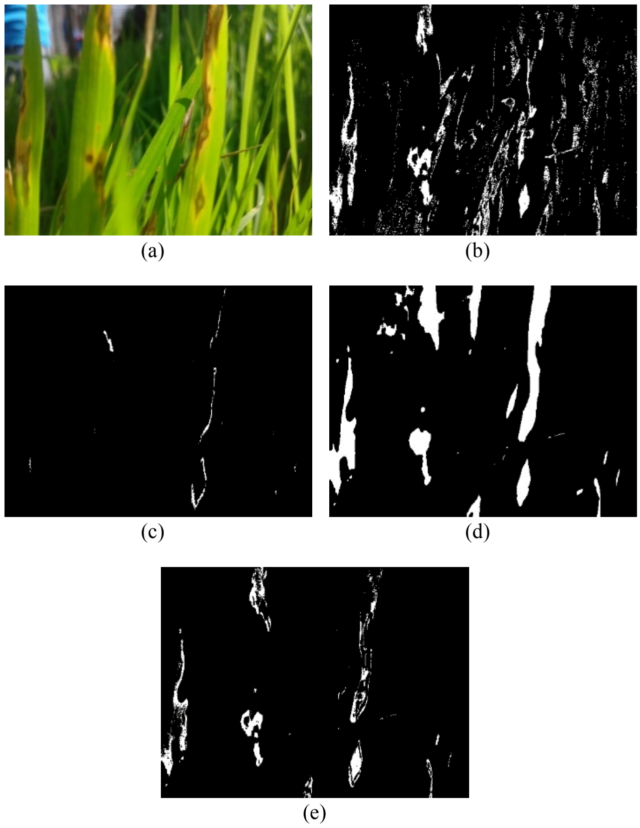


Figure 4: (a) Original input Image. (b) 1st level thresholding. (c)2nd level. (d) 3rd level. (e) Result of total image thresholding.

Figure 5: (a) Example of disconnected regions image. (b) Canny edge detection after applied Gaussian Smoothing filter.

Edge detection is used in most image analysis which the outlines of the object in the image will detect the boundaries between regions of objects and background. The canny edge detector is selected since it produces thin lines, continuous edges and much better detection compare to others algorithm especially in various lighting conditions. Figure 5(b) shows an example of edge detection after applying 5 x 5 Gaussian smoothing filters that will reduce speckle of high-frequency noise.

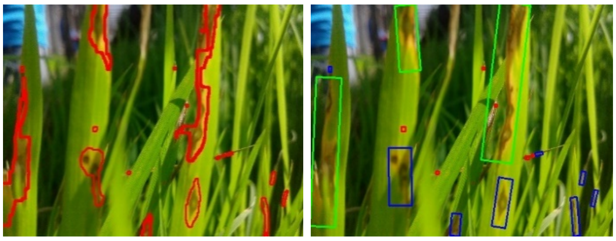
C. Image Analysis

Then the image contour and region boundary of interest will be trace. A contour is defined as a segment that is one pixel wide, and one or more pixels in length and a boundary is an unbroken contour[24]. This feature extraction finding represents the region of RLB disease. The border tracing algorithm is used to extract the contours. Figure 6(a) shows the result of this disease detection where the area of infected are marked with red colour. Then, the infected area of the disease is calculated using the Green's theorem as in the following [25];

$$\int_C Pdx + Qdy = \iint_D \left(\frac{\partial Q}{\partial x} - \frac{\partial P}{\partial y}\right) dA \quad (4)$$

where C is positively oriented a simple closed curve in the plane, D the region bounded by C, and P and Q are functions with continuous partial derivatives in an open region containing D.

The RLB disease infected area in an image is based on the calculated boundary region as shown in Table 1. It also shows the suggested three-stage disease severity. Figure 6(b) illustrate the suggested severity stage; stage one is for early infection phase (red), stage two is for spreading phase (blue), and stage three is for worst phase (green).



(a) (b)

Figure 6: (a) Boundary of rice disease region on leave. (b) The severity stage.

V. FIELD EXPERIMENT

Figure 7 shows seven more experiments of RLB disease detection where the first row is the input image captured under uncontrolled environment, i.e. multiple rice leaves, the different sizes, orientations, light conditions and complex background.

The first row shows various background conditions in uncontrol environment of the captured images due to uncontrolled environment. The first column from left shows the healthy rice leaf and the other column of the images consisting unhealthy rice leaf. The second and third row shows the result of image transformation and pre-processing stage, respectively. The fourth and fifth row illustrates the image segmentation and analysis stage. The sixth row shows the result of image analysis where the region of RLB disease boundaries with red in colour. The final row illustrates the result of this disease detection which the severity stage of each image is summarised in Table 2.

Table 1
The Experimental Result of Rice Disease Detection.

No. of detected disease region	Area in Pixel	Stage of Severity
1	172.5	2
2	27	1
3	333.5	2
4	50.5	1
5	705.5	2
6	99	1
7	14.5	1
8	21.5	1
9	81	1
10	1762.5	3
11	16	1
12	2398.5	3
13	16	1
14	1108	3
15	95	1
16	443.5	2
17	384.5	2

Table 2
The Experimental Results in a Varoius Uncontrolled Enviroment.

Image No.	No. of detected disease region	Stage 1	Stage 2	Stage 3
1	0	0	0	0
2	36	14	22	0
3	8	5	3	0
4	13	6	7	0
5	28	16	9	3
6	3	2	1	0
7	36	19	16	1

VI. CONCLUSION

This paper has discussed a technique to detect RLB disease using multi-level colour image thresholding. The technique successfully detects the disease based on the images taken in uncontrol environment. The technique is not suitable for detection of other diseases which may have similar features. However, this technique can be further enhanced by having the capabilities to measure the incidence of RLB disease in the field.

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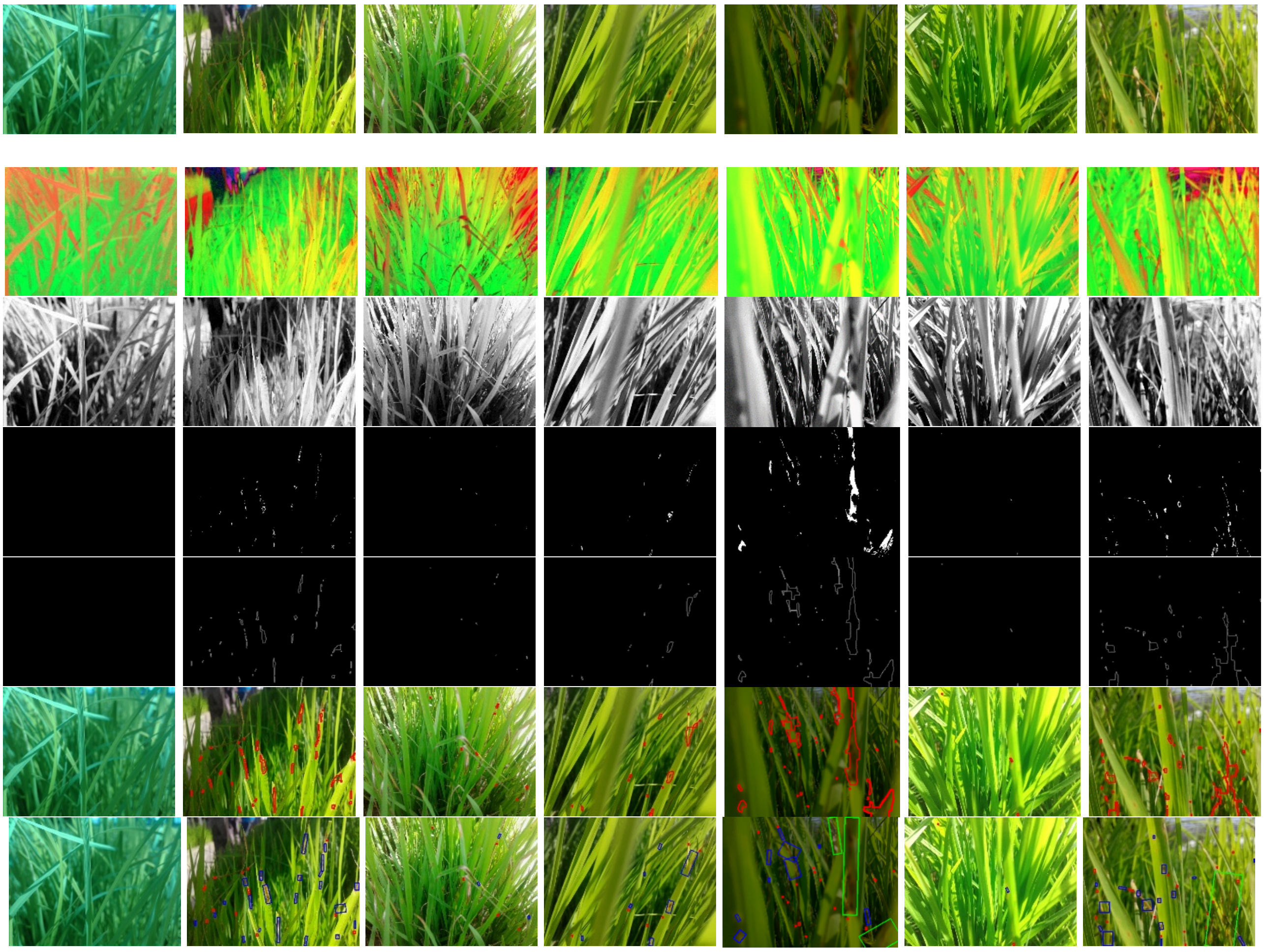

1) 2) 3) 4) 5) 6) 7)

Figure 7: The results of seven experiments (by column) shows a different condition and each row represents intermediate results of image processing step for the proposed method. From left to right: healthy rice plant, image include another object, the image captured from the top, focus image, dark image, blur image and high intensity image. (These figures are best viewed in colour)

REFERENCES

[1] S. Phadikar, A. Das and J. Sil, "Classification of Rice Leaf Diseases Based on Morphological Changes," *International Journal of Information and Electronics Engineering,* vol. 2, 2012.

[2] C.M. Vera Cruz, I Ona, N.P. Castilla and R. Opulencia, http://www.knowledgebank.irri.org, 2016.

[3] https://blogmardi.wordpress.com/2017/02/07/blb-kurangkan-berat-biji rin-padi, 2017

[4] G. Miah, M. Y. Rafii, M. R. Ismail, A. B. Puteh, H. A. Rahim, R. Asfaliza, M. A. Latif, "Blast resistance in rice: a review of conventional breeding to molecular approaches", *Molecular Biology Reports*, Vol. 40, Issue 3, pp 2369–2388, 2013.

[5] C.J. Chuwa, R.B. Mabagala2, M. S.O.W. Reuben," Assessment of Grain Yield Losses Caused by Rice Blast Disease in Major Rice Growing Areas in Tanzania", *International Journal of Science and Research*, Vol. 4, Issue 10, 2015.

[6] http://madainfo.blogspot.my/2015/02/taklimatkepadamediaberkaitanp erosak.2017.

[7] S. Sankarana, A. Mishraa and R. Ehsania, "A review of advanced techniques for detecting plant diseases," *Computers and Electronics in Agriculture,* vol. 72, pp. 1-13, 2010.

[8] S. Phadikar , J. Sil and A. K. Das, "Rice diseases classification using feature selection and rule generation techniques," *Computers and Electronics in Agriculture,* vol. 90, p. 76–85, 2013.

[9] J. G. A. Barbedo, "Digital image processing techniques for detecting, quantifying and classifying plant diseases," *Springerplus,* vol. 2, no. 1, pp. 660-671, 2013.

[10] E. Singh and M. L. Singh, "Automated Colour Prediction of Paddy Crop Leaf using Image Processing," in *IEEE International Conference on Technological Innovations in ICT for Agriculture and Rural Development*, 2015.

[11] R. A. D. Pugoy and V. Y. Marianoa, "Automated rice leaf disease detection using color image analysis," in *Third International Conference on Digital Image Processing*, 2011.

[12] C. -L. Chung, K.-J. Huang, S.-Y. Chen, M.-H. Lai, Y.-C. Chen and Y.-F. Kuo, "Detecting Bakanae disease in rice seedlings by machine vision," *Computers and Electronics in Agriculture 121 (2016) 404–411,* vol. 121, pp. 404-411, 2016

[13] G. Bhadane, S. Sharma and V. B. Nerka, "Early Pest Identification in Agricultural Crops using Image Processing Techniques," *International Journal of Electrical, Electronics and Computer Engineering ,* vol. 2, no. 2, pp. 77-82, 2013.

[14] A. Vibhute and S. K. Bodhe, "Applications of Image Processing in Agriculture: A Survey," *International Journal of Computer Applications ,* vol. 52, no. 2, pp. 0975-8887, 2012.

[15] E. S. Sama and A.K. Prabhavathy and J.D. Shree, " A Survey on Outdoor Scene Image Segmentation," *International Journal of Computer Applications,* vol. 55, no. 9, 2012.

[16] J. Purushothaman, M. Kamiyama and A. Taguchi, "Color image enhancement based on Hue differential histogram equalization," *International Symposium on Intelligent Signal Processing and Communication Systems (ISPACS)*, Phuket, pp. 1-5, 2016.

[17] T. K. Agarwal, M. Tiwari and S. S. Lamba, "Modified Histogram based contrast enhancement using Homomorphic Filtering for medical images," *2014 IEEE International Advance Computing Conference (IACC)*, Gurgaon, 2014, pp. 964-968.

[18] R.Garg, B.Mittal, S.Garg," Histogram Equalization Techniques for Image Enhancement", *International Journal of Electronics & Communication Technology,* Vol. 2, Issue 1, 2011.

[19] Archana, Sheenam, A. Cchabra, "Comprehensive Review of Denoising Techniques in Image Restoration", *International Journal of Innovative Research in Computer and Communication Engineering*, Vol. 2, Issue 6, June 2014.

[20] W.Khan, "Image Segmentation Techniques: A Survey", *Journal of Image and Graphics,* Vol. 1, No. 4, 2013.

[21] R.Harrabi and E.B.Braiek, “Color image segmentation using multi-level thresholding approach and data fusion techniques: application in the breast cancer cells images”, *Journal on Image and Video Processing*, 2012.
[22] R.Dass, Priyanka, S.Devi, “Image Segmentation Techniques”, *International Journal of Electronics & Communication Technology* ,Vol. 3, Issue 1, 2012.
[23] M.S. Nixon, A.S. Aguado, “Feature Extraction and Image Processing”, Second edition 2008.
[24] W.A. Mcqueen, “Contour tracing and boundary detection for object identification in a digital image”, *U.S. Patent 6674904*, 2004.
[25] https://www.whitman.edu/mathematics/calculus_online/section16.04.html.