Early Detection of Spots High Water Saturation for Landslide Prediction Using Thermal Imaging Analysis

Aufa Zin, Kamarul Hawari, and Norliana Khamisan

***Abstract*—Nowadays, landslide phenomenon has become a serious problem in Malaysia. Landslide can cause human injury, loss of life and economical problem. One of the factors is due to the heavy rain. Hence, to overcome this problem, this study investigates a new method to detect spots of high water saturation which is integrated with a thermal camera system to provide early detection of landslide. The thermal camera is selected because it provides accurate predict where landslide going to occur. Thermal camera can be used to detect spots of high water saturation which is a key component that contributes to landslide activity. The analysis is done using 10 images. It was tested to see the accuracy of this technique. From the observation, this technique is quite accurate but still has their weakness and error.**

***Index Terms*—Landslides, thermal camera, morphological techniques, color thresholding.**

I. Introduction

This study is to explore the Computer Vision technology in developing a system which capable in detecting high water saturation for landslide prediction by using thermal imaging analysis. Image processing analysis has been widely used in the last decade in many applications such as in agriculture engineering, face detection, electrical inspection, thermal imaging, biomedical and car driver assisted [1]-[3].

A new approach and method to detect spots of high water saturation will be developed which then to be integrated with a thermal camera system to provide an early detection of landslide. It is very important to have early warning systems on landslide prevention in natural hazards especially where mitigation strategies are not realizable.

The proposed approach and method use thermal camera provides accurate predict where landslide going to occur. Thermal camera can be used to detect spots of higher water saturation, a key component that contributes to landslide activity. Such spots of high water saturation are prime candidates for landslide activity when certain other criteria are met [4]-[6]. Thermal camera is able to identify spot of intense saturation, a red flag of a landslide, before any actual damage is done. It is because thermal camera is a device that forms an image using infrared radiation. All object emit infrared energy which is heat as function of their temperature [7], [8], Then, the device collect the infrared radiation from object in scene and create an electronic image based on info about temperature different because object rarely precisely the same temperature as other object around them [9]. For use in temperature measurement the brightest means the warmest parts of the image are customarily coloured white, intermediate temperatures reds and yellows, and the dimmest means the coolest part is black. The spots of water saturation must appear dark in colour because of different temperature between the soil and saturated water.

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II. Methodology

The thermal imaging system proposed in this paper is shown in Fig. 1. This system used a thermal camera and a laptop installed with Matlab Programming R2013a.

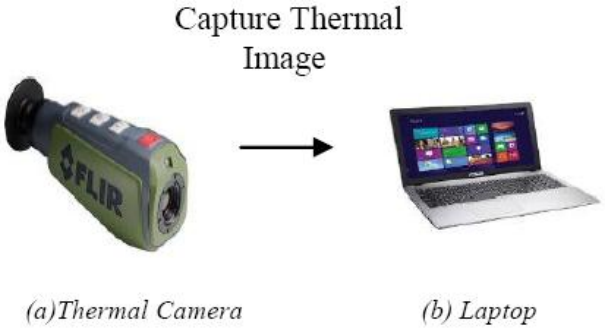


Fig. 1. Thermal imaging system.

A. Image Acquisition

The image acquired using thermal camera FLIR A655sc. The camera is placed nearest to the landslide. The maximum distance for the image captured is 50m. The position of thermal camera is not static. It is for searching the high risk spots in that area. The parameters use is focus lens, camera positioning and distances. The camera resolution is 640 x 480. The image is taken after heavy rainfall because slope saturation by water is a primary cause of landslides.

The data have been collected at Universiti Malaysia Pahang. The image acquired using thermal camera FLIR A655sc. The camera is placed nearest to the slope of the soil. The maximum distance for the image captured is 50m. The position of thermal camera is not static. It is for searching the high risk spots in that area. The parameters use is focus lens, camera positioning and distances. The camera resolution is 640 × 480. After recording the video of slope, that video was converted into image in JPEG (Joint Photographic Experts Group) image format by using Matlab coding. The video was taken about 14 second and after converted with 1 frame per second the image become 93 images. Fig. 2 below shows the general diagram of study. The steps that is required for image processing is image acquisition, image pre-processing, image processing and image segmentation.

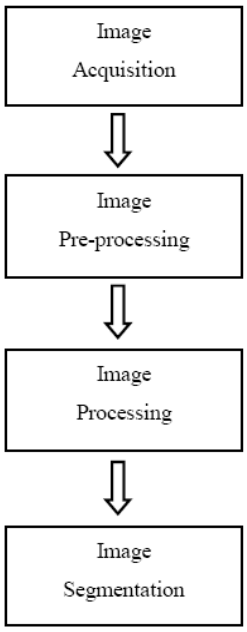


Fig. 2. General diagram of study.

B. Pre-processing

After the image acquisition, the next step is pre-processing. The purpose of pre-processing is to improve the image which is increasing the chances for success of other processes [10]. In the pre-processing stage, the images taken were loaded and then applied using color processing technique. The purpose of using this technique is to detect greenish color in the image. The green colors in the image indicate the water which is saturated in the soil. A threshold value needs to be set in order to detect the greenish color. The objects that lie outside the selected range will be rejected. Table I state the range of color which is to detect the greenish color in the image.

TABLE I: THRESHOLD VALUE FOR COLOR PROCESSING

Color	Digital image representation
Red	0 - 200
Green	2 - 224
Blue	0 - 80

Based on the Table I, the pixel value that in the range in Table I will be remain, while the pixel value that out of the range will set to logic '0'. After the greenish color is detected, the image is converted into black and white image (BW). The im2bw is used in the image because binary image gives better efficiency in processing. It only consists of two values which is '0' and '1'.

C. Image Processing

As mentioned earlier, the image is converted into the binary image before the morphological operation is applied. The 1's which is white denoted the foreground pixels and 0's which is black is background pixels. The morphological technique that used is erosion. The operation of erosion is to shrinks the image because it removes pixels on object boundaries. The number of pixel that removed is depends on the size and shape of structuring element when process the image. The structuring element used is line, the length is 3 and the angle is 45˚.

D. Image Segmentation

Image filtering is applied to remove noise from the previous image that has been eroded. This step is used because to make the image more appear. As the image captured, it also contain of noise such as the tree and the grass. So the function 'fspecial' and 'imfilter' are used.

E. Data Collection

The data have been collected at Universiti Malaysia Pahang. The image acquired using thermal camera FLIR A655sc. The camera is placed nearest to the slope of the soil. The maximum distance for the image captured is 50m. The position of thermal camera is not static. It is for searching the high risk spots in that area. The parameters use is focus lens, camera positioning and distances. The camera resolution is 640 × 480. After recording the video of slope, that video was converted into image in JPEG (Joint Photographic Experts Group) image format by using matlab coding. The video was taken about 14 second and after converted with 1 frame per second the image become 93 images.

III. RESULT AND DISCUSSION

The analysis about this project will be discussed under this topic.

A. Color Thresholding

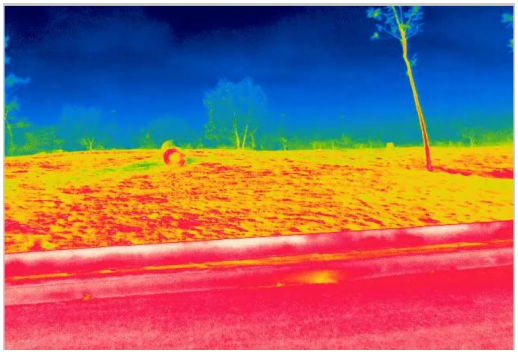


Fig. 3. Original image.

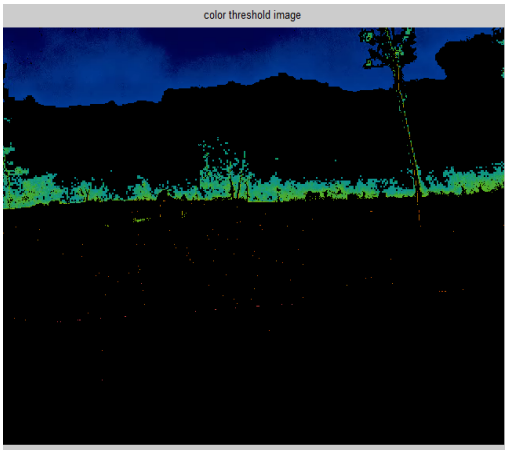


Fig. 4. The result from the thresholding value in Table II.

The threshold value has been set based on the RGB value of the image. This threshold is to detect the coolest region on this image which is indicates the greenish color. To detect the green color, the value is set to the highest. Meanwhile, blue color is set to the lowest because to remove it from the image.

If the range set is too large, then the greenish color area is not detected. The first value for the color thresholding is shown in Table II and the second value is shown in Table III. Fig. 3 and Fig. 4 are shown the table of the thresholding value.

TABLE II: THRESHOLD VALUE FOR THE COLOR THRESHOLDING

Color	Threshold Value
Red	0 – 200
Green	2 – 180
Blue	0 - 150

Based on the analysis of Fig. 4, there are no greenish areas because the range of the blue color is high while the range of green color is low. So, the water spot in this image is not detected.

TABLE III: THE THRESHOLD VALUE FOR THE COLOR THRESHOLDING

Color	Threshold Value
Red	0 – 200
Green	2 – 224
Blue	0 - 80

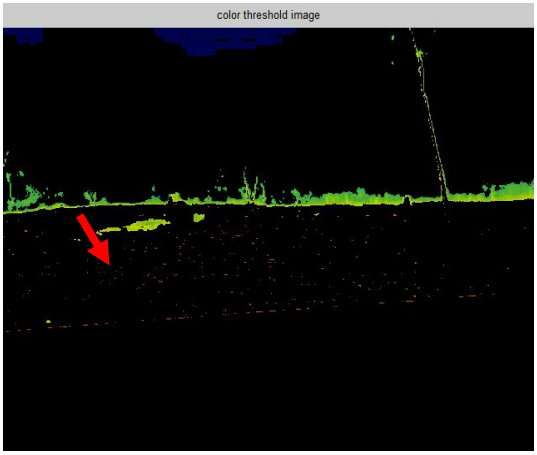


Fig. 5. The result from the thresholding value in Table III.

Based on the analysis from Table III, the range of the green color is set to highest and blue color is the lowest. As a result, the image become more reliable compare to the Fig. 5. Area for detection greenish color is more than Fig. 4. The optimum color of greenish is needed because the water spot is marked as green in color. The arrow in the image above shows the water spot.

B. Morphology Analysis Using Erosion Technique

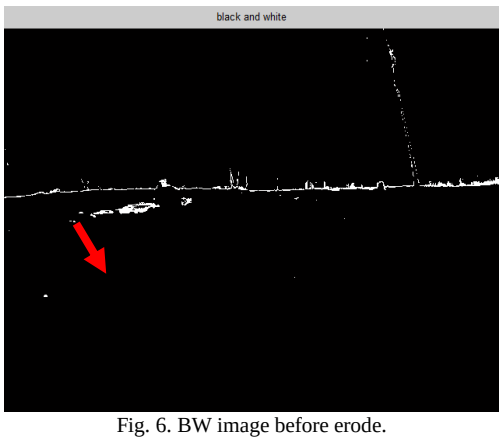


Fig. 6. BW image before erode.

After the greenish area in the image is detected, the image is converted to black and white (BW). Using the black and white image, the erosion technique is applied. The purpose of using erosion is to shrink the image and get the best shape. The structuring element used is line, the length is 3 and the angle is 45˚.

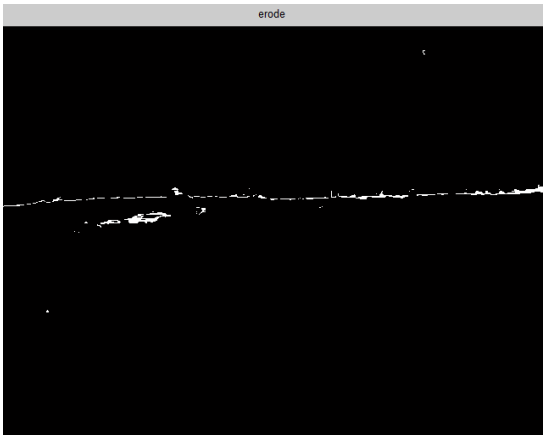


Fig. 7. BW image before erode.

The Fig. 6 and Fig. 7 above shows Black and White (BW) image before and after erosion technique respectively. Fig. 7 shown before erosion technique is applied, there are a noise at the back of image such as the trunk of a tree and grass. Using line as structuring element, the noise which is trunk of a tree is being removed as shown in Fig. 7.

C. Image Segmentation

The purpose of image segmentation is to represent the image become more meaningful and easy to analyze. In image processing, there are few types of filter that can be used to analyse the image. Two type of filter had been used to get the best filter to enhance the image which is motion filter and disk filter. This filter is chooses to make the image clearly and detect the water spot.

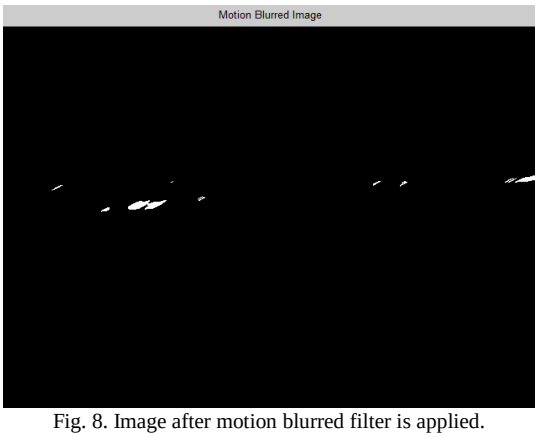


Fig. 8. Image after motion blurred filter is applied.

As shown in Fig. 8, the noise which is grass is eliminated. There are small scales of noise need to remove in order to detect water spots in the image. The linear motion of a camera by len pixels that have been use is 20 and an angle of theta degrees in a counter clockwise direction is 30. Next, the disk filter is used. This filter used radius of 9. Only water spot is detected.

Fig. 9 shows the final results after the image processing is applied. There are 10 images was tested to see the accuracy of

this technique shown in Table IV. From the observation, this technique is quite accurate but still has their weakness and error. The error maybe due to image is not clear and still has noise inside the image.

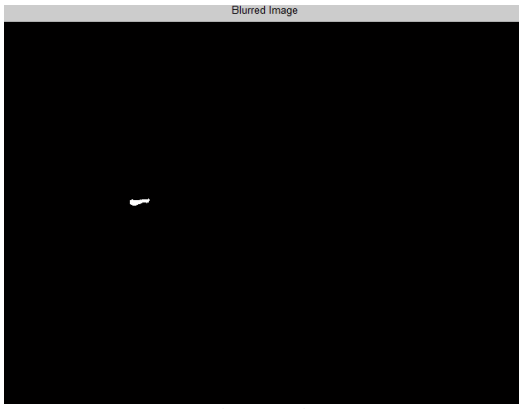
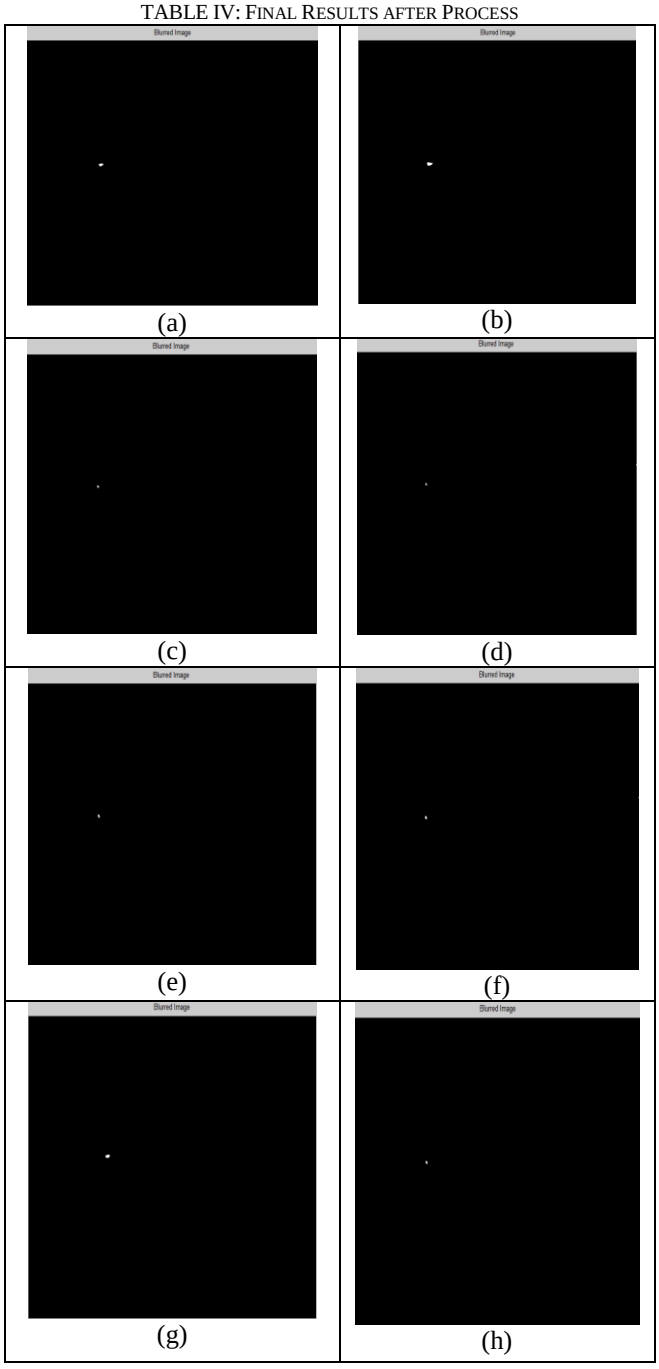
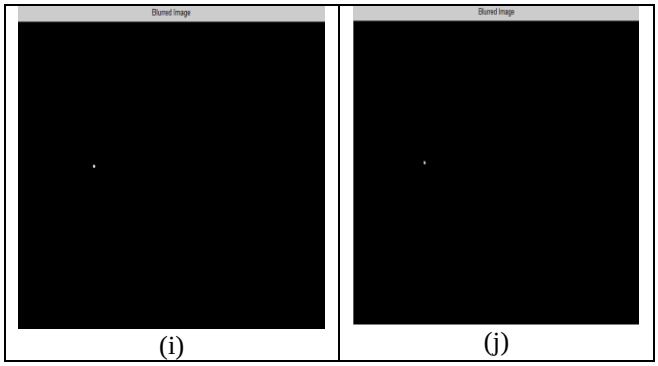


Fig. 9. Image after Disk filter is applied.

TABLE IV: FINAL RESULTS AFTER PROCESS





IV. CONCLUSION

The propose method of landslide prediction and detection using thermal imaging analysis will benefit many parties and could become an early warning system of landslide. By using a thermal imaging camera, it can save lives and suitable for variety of applications. It can be used in places where other system is difficult to deploy and also can be used as a compliment to other existing system for early detection and prediction.

In order to analyze the thermal image, the need of understanding in image processing must be strong. Thus, this project concentrates on the image analysis methods which are color thresholding and morphological operation using erosion.

The performance of the system can be improved using many factors. One of the factors is pre-processing. It is the key for getting better result. Besides, the lighting and generate new image such as noise removal and resizing also the factors that need to be considered.

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