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THERMAL DETECTION OF WATER SATURATION SPOTS FOR LANDSLIDE PREDICTION

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ABSTRACT

Nowadays, we heard many serious issues about landslide phenomenon in Malaysia. It became serious when landslide phenomenon affects human's life. It causes human injury, loss of life and economical problem. There are a few factors that caused landslide but the main factor is heavy rain. Hence, to solve this issue, 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 technique of neural network is used to classify the image of water saturation. The analysis is done using 40 samples. It was tested to classify the data into two groups which are low water saturation and high water saturation.

Keywords: thermal camera, landslide, morphology, and feature matching.

INTRODUCTION

Image processing and computer vision have presented a massive growth in the previous years. They develop an outstanding technology in certain important areas such as telecommunication, internet, medical imaging, remote sensing and intelligent sensing [1]. A new technique to detect spots of high water saturation is developed using a thermal camera to provide an early detection of landslide. The importance of the early warning systems is to prevent landslide from occur and save human life.

The proposed technique is to predict the area of landslide going to occur accurately using thermal camera. Thermal camera can be used to detect high water saturation spots which are key component that contributes to landslide activity [2-4]. Thermal camera is able to identify spot of intense saturation, a red flag of a landslide, before any actual damage is done. It is happen because thermal camera is a device that forms an image using infrared radiation. As mention in [5-6], all object emit infrared energy which is heat as function of their temperature. 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 [7].

For the measurement temperature usage, the brightest means the warmest parts of the image and its colour is white, intermediate temperatures reds and yellows. The dimmest means the coolest part is black. The spots of water saturation must appear in green colour because of the different temperature between the soil and saturated water.

THERMAL IMAGING FOR LANDSLIDE

Radiation occurs when all objects have temperature above absolute zero. When the radiation increases, the temperature also increases [8]. The total amount of thermal of thermal radiation is expressed by the Stefan-Boltzman law as mention in [9]. Refer to the equations in the text as Equation (1).

$$E = \varepsilon\sigma T^4 \quad (1)$$

MATERIALS AND METHODS

The system of thermal imaging proposed in this paper is shown in Figure-1. This system used a thermal camera and a laptop installed with MATLAB Programming R2013a.

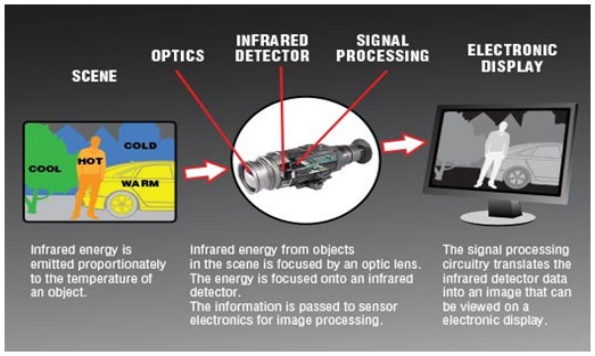

Figure-1. Thermal imaging system.

Materials and equipment

Image acquisition system

Thermal image were using thermal camera FLIR A615sc. 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.

Thermal image processing software

The thermaCAM Researcher (FLIR Systems Inc., MA, USA) was developed for infrared camera image

analysis. For this study, the software was used to compensate the acquired thermal images for emissivity and convert the thermal images to a format appropriate for image processing.

Methods

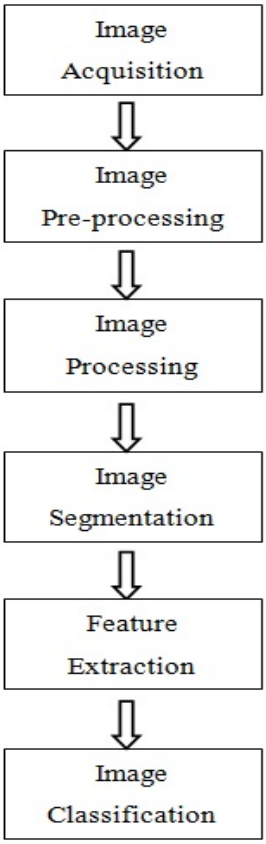

Figure-2. Block diagram of image processing

Data acquisition

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 x 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. Figure-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.

Pre-processing

After the image acquisition, the next step is pre-processing. Pre-processing is important to improve the image which is increasing the chances for success of other processes [10]. In the pre-processing stage, the images were loaded and then applied using feature matching method. The purpose of using this technique is to detect a specific object based on finding point that match between the reference and the target image. The image detected is grayscale in color. To make the next step become easier, the image is converted to RGB.

Image processing

As mentioned earlier, the image is converted into the RGB before the color thresholding is applied. The purpose of using this technique is to detect greenish color in the image. The green color in the image indicates the water that saturate in the soil. A threshold value needs to be set in order to detect the greenish area. The objects that lie outside the selected range will be rejected. Table-1 below shows the range of color which is to detect the greenish area in the image.

Table-1. Threshold value for color processing.

Color	Digital image representation
Red	0 - 200
Green	2 - 223
Blue	0 - 80

Refer to Table-1, the pixel value that in the range in Table-1 will be remain, while the pixel value that out of the range will be set to logic '0'. After the greenish area 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 consists of two values which is '0' and '1'.

Image segmentation

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 morphology technique 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. Next is operation of dilation. It is to expand the shape and filling holes and gaps.

Feature extraction

Algorithms were developed using MATLAB R2013a programming language to extract features of the water saturation spots. The following features were extracted from the water saturation spots:

Area (mm^2): The area of the water saturation spots.

Perimeter (mm): The perimeter of the water saturation spots.

Image classification

Neural network perform a variety tasks, for example, prediction and object classification [11]. Neural network have proven themselves as proficient classifiers. It can solve problems once they are trained. They are good at pattern recognition problems and with enough elements called neurons can classify any data with arbitrary accuracy [12]. The two characteristics act as inputs to a neural network and the conditions of water saturations, low water saturation and high water saturation act as target.

Feature matching

Feature matching is a method that can be seen from two arbitrary viewpoints for matching features in images based on the similar physical point of an object [13]. The kinds of feature that can be notice are specific locations in the images, for example mountain peaks or building corners. These kinds of features are called keypoint features. Another types of image features are edge, corners and ridges [14].

RESULT AND DISCUSSION

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

Feature matching

There are a few steps using this Feature Matching technique. Firstly, the reference image containing the object of interest is interpreted. After it read the target image, feature points in both images is detected. Figure-3 below shows 300 strongest feature points found in the target image.

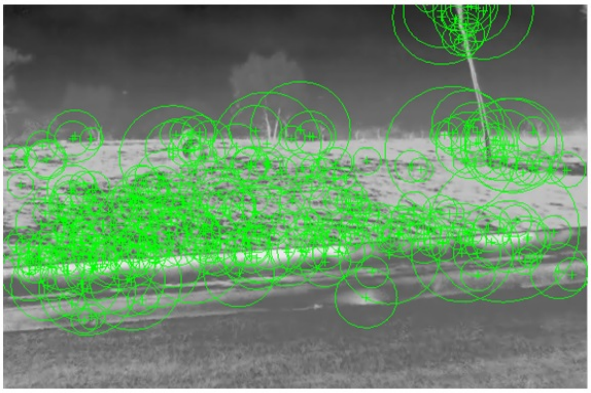

Figure-3. 300 strongest feature points from scene image.

The next step is the feature descriptors at the interest points in both images are extracted and the features are matched using their descriptors. Figure-4 below displays the putatively matched features.

Figure-4. The putatively matched features image.

Figure-5. Object detected in rectangle box.

Figure-5 above shows the detected object which is the image of water saturation spots.

Color threshold

The threshold value has been set based on the RGB value of the image. The image is converting to RGB before the thresholding method is applied shown in Figure-6. 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. Figure-7 has shown the result of the image using the value as stated.

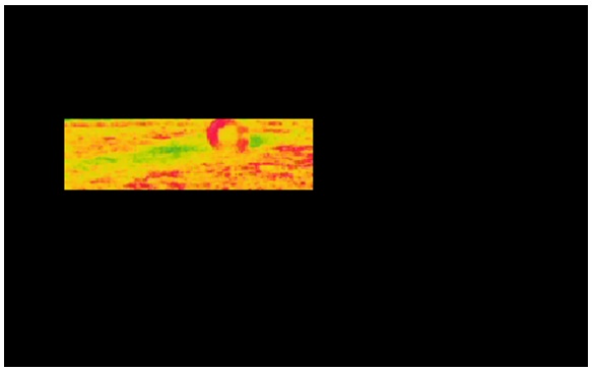

Figure-6. The RGB image.

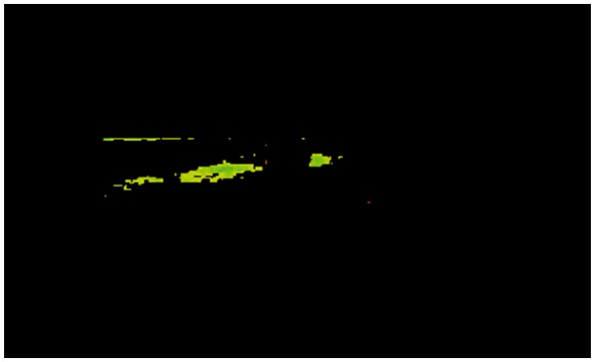

Figure-7. The image after threshold technique applied.

The range of the green color is set to highest and blue color is the lowest. The optimum color of greenish is needed because the water spot is marked as green in color.

Morphology technique

After the greenish area in the image is detected, the image is converted to black and white (BW). Using black and white image, the erosion and dilation technique is applied. The purpose of using erosion is to shrink the image and remove some noise in the image as shown in Figure-9.

Figure-8. The BW image before morphology technique applied.

Figure-9. The image after erosion technique applied.

Figure-8 shown before erosion technique is applied, there are some noise at the back of image. Using line as structuring element, the noise is being removed.

Figure-10. The image after dilation technique applied.

The purpose of dilation technique is to thickening the object and makes the objects more clear as shown in Figure-10.

Neural network

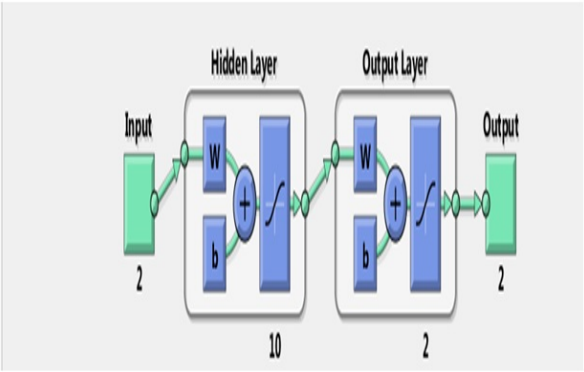

Figure-11. Neural network.

The Figure-11 showed a two layer feed-forward with sigmoid hidden and output neurons [15]. The neuron number of the input layer is two and the neuron number of hidden layers is 10. In general, more difficult problems require more neurons. Simpler problems require fewer neutrons. The neuron number of output layer is two which is high water saturation and low water saturation.

The sample is divided into three sets, called the training set, validation set and test set. It is divided in the ratio 70%, 15% and 15% and the samples is 28, 6, 6 respectively.. Figure-12 shows neutral network training performance. From the plot, the test curve had decreased while train and test curves are almost similar. The best and fitted model is where validation error has global minimum. Mean Squared Error (MSE) in Table-2 is the average squared difference between outputs and targets. The MSE value for testing is 8.55605e-11. Lower values are better.

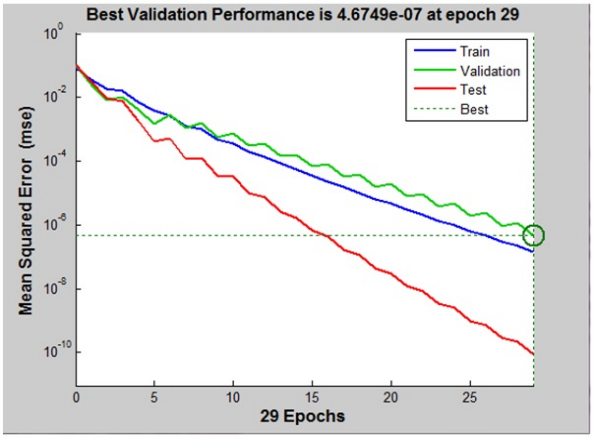

Figure-12. Neural network training performance.

Table-2. The result of neural network.

	Samples	MSE
Training	28	1.38882e-7
Validation	6	4.67490e-7
Testing	6	8.55605e-11

Table-3 below shows 40 samples of input which contain 2 elements. The elements are area and perimeter of water saturation spots.

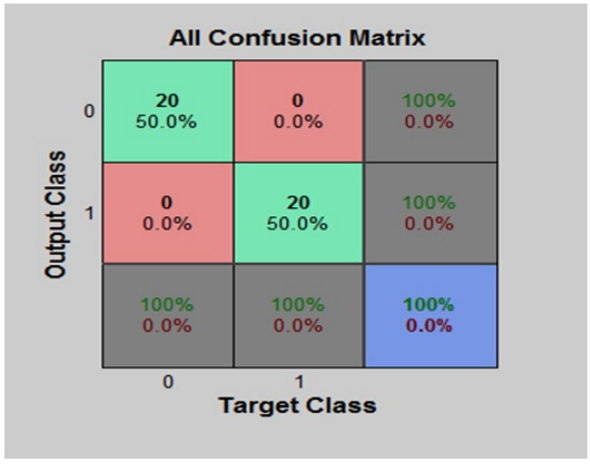

Figure-13. The confusion plot.

Table-3. The input in neural network.

Samples	Area (mm^2)	Perimeter (mm)
1	401	102.4
2	869	235.3
3	441	103.5
4	449	106.7
5	410	101.3
6	369	95.3
7	278	77.1
8	328	89.3
9	440	109.5
10	474	121.6
11	458	120.7
12	458	121.9
13	458	121.9
14	468	121.3
15	454	121
16	455	120.7
17	452	119.9
18	446	121.9
19	439	117.6
20	467	122.5
21	109	53.3
22	101	51.2
23	100	45
24	104	65
25	200	63.4
26	123	55
27	141	57.8
28	111	69
29	123	69.4
30	124	56.1
31	112	61.1
32	155	62.2
33	167	68.2
34	177	69.9
35	132	51.5
36	144	53
37	176	61
38	133	46
39	186	48.9
40	190	57

One measure of how well the neural network has fit the data is the confusion plot which is shown is Figure-13. The confusion matrix shows the percentage of correct and incorrect classifications. Correct classifications are the green squares and incorrect classification form the red squares. From this plot, there are 20 samples are high

water saturations and 20 samples are low water saturations.

CONCLUSIONS

The benefits of propose method of landslide prediction and detection using thermal imaging analysis 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.

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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