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Foreword

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Last, we are sorry for any shortcomings. Thanks.

Yogyakarta, October 2014

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Image Processing-based Flood Detection for Online Flood Early Warning System

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Abstract

This paper will discuss the design of an online flood early warning system. This system will use a single board computer Raspberry-PI as the main controller, and a webcam to capture image. This system is integrated to Twitter. In hardware section, Raspberry-PI has main tasks as an image processor and do an update request to Twitter. In software section, OpenCV will be used as Image Processing software. Some method which used in this system is: 1) Region of Interest: this method is to create a portion of an image that you want to filter or perform some other operation on. Brightness and contrast: these methods are used in order to get brighter and better image before next process. 3) Grayscale and threshold: this method is to create an object segmentation. Otsu-thresholding is used on this step. 4) Edge detection: edge detection algorithm to find edge points on a (relatively) horizontal water line and point of dam's height. By using these methods, the system can read and monitor the water level in the dam. If the water level exceeds the specified threshold, this system will generate an early warning of impending floods by doing update time line (text and image) of water level conditions to Twitter. The public will get the information if they following early warning system's Twitter. Simulation test results show the system can read water level with an accuracy nearing 96%.

Keywords

Early warning system, flood, image processing,, opencv, raspberry-pi, twitter

1. Introduction

Flood is a nature phenomenon that can occur due to the volume of water in the dam exceeds the dam's capacity itself, a non standard drainage system in the region is one of the problem. There are various ways have been done either by the government or by non-government community to understand and solve this problem. To give an early warning, many electronics systems have been developed by using a microcontroller or microprocessor and sensors for detecting the level of the water surface elevation. In [2] a water level control system is made by using water as a conductor of the sensor systems, this is the same method as in the automatic water pump. When the water reaches a certain level, then the sensor will be connected by water and the water pump will stop (or turn on the alarm in case of detection of flood). Other systems were developed using ultrasonic sensors for measuring the depth of water by calculating the time when sensors transmit ultrasonic waves until the signal is received back by the

sensor [6]. The ultrasonic system is not efficient if the bottom of the river is not stable. Unstable river's bottom will cause the signal refracts, so it will not received properly.

Based on the conditions described above, we are interested to use image processing method to generate an early warning system. This system will use a microprocessor module Raspberry-PI as the main-processing, OpenCV (Open Computer Vision) as an image processing software, and a webcam to take a picture of the water surface it is shown in Fig. 1. Some method which used in this system is: 1) Region of Interest: this method is to create a portion of an image that you want to filter or perform some other operation on. 2) Brightness and contrast: these methos is used in order to get brighter and better image before next process. 3) Grayscale and threshold: this method is to create an object segmentation. Otsu-thresholding[4] is used on this step. 4) Edge detection: edge detection algorithm to find edge points on a (relatively) horizontal water line and point of dam's height. This edge detection scheme was both effective and fast at finding the water edge. A success edge-detection will generate a segmentation which separate the water image and the other.

Figure 1. System working block diagram

2. Study Area

Area of interest is on Manggarai Dam, Central Jakarta. The depth of dam is 1000 centimeter or 10 meters. The normal water surface height is up to 750 centimeters. The warning water surface height is between to 750 and 850 centimeters. The danger water surface height is between 850 and 950 centimeters. Above 950 centimeters, is a critical level. Water surface level is described on Table 1.

Table 1. Water surface level

State	Water surface level [cm]
Normal	750
Warning	750-850
Danger	850-950
Critical	> 950

We create a simulation to test methods which used to measure the water surface level. The simulation is created based on these data shown on Fig. 2 (b). The design of simulator itself is shown on Fig. 3.

Figure 2. (a) Manggarai Dam; (b) Simulation system

Figure 2. (a) Sketch design; (b) Simulator design

3. Methods

The method presented in this paper is about how to read the water surface level using image processing methods. Some method which used in this system is: 1) Region of Interest. 3) Brightness and contrast 2) Grayscale and threshold. 3) Edge detection.

3.1. *Region of Interest*

Region of Interest (ROI) is used to create a portion of an image that you want to filter or perform some other operation on. ROI is like do a crop in image, take the interest area, eliminate the rest. By using ROI, the noise or unwanted image which outside the ROI can be eliminated, so the process will be faster and easier. The image before Region of Interest operation is shown in Fig. 3(a) and image after Region of Interest operation is shown in Fig. 3(b)

Figure 3. (a) image before ROI operation; (b) image after ROI operation

3.2. Brightness and Contrast

Brightness and contrast is one of basic operation of image processing. Brightness is often used to get a brighter image[3]. Increasing brightness means increase a value of pixel in a coordinate(x,y) with a constant α . If α is in positive value, the brighter image will be generate otherwise the darker image will be generated. Image before and after this operation is shown in Fig. 4.

$$g(x, y) = f(x, y) + \alpha \quad (1)$$

Figure 4. (a) image before Brightness operation; (b) image after Brightness operation

The contrast in an image stating bright color distribution and dark colors. A gray-scale image is said to have a low contrast, if the distribution of color tend to narrow the range of gray levels. Conversely, if the image has a high contrast gray level range widened more distributed. Contrast can be measured by the difference between the value of the highest intensity and lowest intensity values that make up the pixels in the image. Image with low contrast lighting conditions often occur because of poor or non-uniform. Image before and after this operation is shown in Fig. 5.

$$g(x, y) = \alpha \cdot f(x, y) \quad (2)$$

Figure 5. (a) image before Brightness operation; (b) image after Brightness operation

3.3. Grayscale and Threshold

Grayscale is an image in which the value of each pixel is a single sample, that is, it carries only intensity information. Images of this sort, also known as black-and-white, are composed exclusively of shades of gray, varying from black at the weakest intensity to white at the strongest.[3] The intensity of image is shown on Fig. 6.

Figure 6. Grayscale image intensity

Threshold is a point which can be used to convert a grayscale image into binary image. The intensity below this point, will be converted into black and the other will be converted to white[3]. The grayscale image is shown in Fig. 7(a) and binary image is shown in Fig. 7(b)

$$b(i) = \begin{cases} 0, & i \geq a \\ 1, & i < a \end{cases} \quad (3)$$

Figure 7. (a) image grayscale; (b) image binary

3.4. Edge Detection

Edge detection algorithm to find edge points on a (relatively) horizontal water line and point of dam's height. This edge detection scheme was both effective and fast at finding the water edge. The result of edge detection is a segmented image, which separate water image and the others. The segmented image after edge detection is

shown in Fig 8. The red rectangle is Region of Interest area, the green rectangle is the edge detected and connected by line.

Figure 8. Segmented image

A success edge-detection will generate a segmentation which separate the water image and the other. System will compare the edge pixel coordinate (in this case y coordinate) to calculate current water surface level. If the water surface level is increase, the value of y pixel will be decrease and the green rectangle will be shorter. The pixel to water surface level conversion used in this simulation is shown on Table 2. To get an accurate calculation, the system has to be calibrated first to get pixel/cm value.

Table 2. Conversion Pixel to Water surface level

Pixel	Water surface level [cm]
160	200
150	250
140	300
130	350
120	400
110	450
100	500
90	550
80	600
70	650
60	700
50	750

4. Conclusion

From the research that has been done, it is possible to build a early warning system based on image processing. By processing an image captured by camera, the system can calculate the water surface level. The advantage of this system is the captured images can be uploaded to Twitter, or the other social network . The image can be used as an evidence which indicate the alarm is not a fake alarm, or sensor miss-reading. The accuracy of this system is nearing 96% running on simulation.

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