The Innovation Development of Early Flash Flood Warning System Based on Digital Image Processing through Android Smartphone

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Abstract. Flooding is a phenomenon that almost always occurs every year in various regions throughout Indonesia with a variety of cycle variations. In the rainy season, high rainfall and narrowed watersheds and silting up are no longer able to accommodate the flow of water, causing flash floods. Flood Warning Systems operate with traditional local wisdom that is highly dependent on the availability and responsiveness of the personnel assigned to oversee the river. Therefore, the development innovation of the existing system is expected to be able to provide information and data regularly and be an early warning to flash floods in order to minimize the impact. This research was conducted to design, create and implement an image-based flash flood early warning system prototype based on an Android cellular phone so that the public is expected to be able to access information on possible flash floods through their respective cell phones. Image processing is the basis of this development innovation through the Background Substraction method which is carried out to automatically detect High Levels of Water (TMA) on the control board (Peil) via an IP Camera which is an input parameter for the system and is processed into information for interested parties. The results of analysis of the detection of water level (TMA) on the peil board carried out on the server computer, become input parameters for determining the status of the dam water level. Flood early warning application that is installed on Android smartphone devices receives data from the server computer via the internet network
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1. Introduction

Flash floods occur when rainfall is high during the rainy season, through narrowed watersheds (DAS) and siltation, unable to accommodate water flow, while water-retaining vegetation in the upstream area is decreasing. Flash floods that occur have both physical and psychological impacts. Physically, retaining embankment infrastructure along the watershed is mostly damaged and needs repair. While from the psychological side, it causes trauma to the community. However, positively psychologically the community is becoming more concerned and alert to the occurrence of flash floods in the future. So, it is necessary to develop an existing flash flood early warning system through an innovation using technology.

One of the technologies that can be utilized in flood early warning systems is digital image processing technology, digital image processing processes data captured through optical devices to be analyzed to produce information that is used to make decisions. Examples of object motion are the level of river water level that shows a certain level in the control board mounted on the dam.

The research [1] developed flood early warning prototypes using VoIP. Telemetry was built through telephone connections at two stations, namely monitoring stations and warning stations that are not in one location, to provide early warning of flood disasters. The research [2] was conducted to detect moving objects based on object tracking using the Background Subtraction method and Kalman Filter. The results obtained are the motion of objects in the video can be detected by the Background Subtraction method and object movement can be estimated with the Kalman Filter. Other research conducted to detect object motion is research [3] that uses Background Subtraction and Frame Differencing techniques to detect motion. The results obtained are able to detect the movement that occurs, by observing the threshold value and changes in light on a moving object.

Increasing the amount of water in a watershed (DAS) or a dam, is one indicator of flooding, the focus of this research is on monitoring water level and disseminating information generated as an early warning to the community. High level detection of water level can be done by comparing the level of it as a model object with the high water level designation board as a background in line with the results of the study [4], explaining that background subtraction is a technique for finding objects in an image by comparing images which is a background model. Research [5] found that IP cameras can be detected red with a success rate of 97% and the indicated success rate reaches 95%. In research [6], it shows that color level tracking based on color with background subtraction can be done by taking into account several parameters namely, the range of distance and angle of the IP Camera to the water level board height. Another parameter that influences is the level of light intensity when the IP Camera captures the object.

This research aims to develop a prototype of a flash flood early warning system by analyzing the video captured by the IP Camera which shows the level of the Water level on the height scale board using the Background Subtraction method. The output of this analysis is the level of water level information on normal conditions, standby and dangerous conditions, through an Android smartphone based application so that it becomes information for the public.

1.1. Image Processing

Digital image processing is a discipline that studies image processing using techniques in image processing. The image referred to here is a still image (for example: photos) or moving images / moving images which is a series of still images that are displayed sequentially into a frame (for example: video) [7]. A digital image can be represented by a matrix consisting of M columns and N rows, where the intersection between columns and rows is called pixels. Pixels have two parameters, namely the parameters of coordinates and intensity or color. The value contained in the coordinates (x, y) is f (x, y), which is the intensity or color of the pixel at that point. Therefore, a digital image can be written in the form of a matrix equation in equation 1

$$f(x,y) = \begin{matrix} F(0,0) & f(0,1) & \dots & f(0,M-1) \\ f(1,0) & \dots & \dots & f(1,M-1) \\ \dots & \dots & \dots & \dots \\ F(N-1,0) & f(N-1,1) & \dots & f(N-1, M-1) \end{matrix} \qquad (1)$$

Based on Equation 1 of a digital image matrix, an image of f (x, y) in a mathematical function can be written in equation 2 as follows:

$$0 \le x \le M-1$$
$$0 \le y \le N-1$$
$$0 \le f(x, y) \le G-1 \qquad (2)$$

The values of m, n and k are positive integers. The interval (0, G) is called the gray scale. The magnitude of G depends on the digitization process. Usually gray (0) denotes black intensity and 1 (one) states white intensity, for an 8-bit image, the value of G is equal to 28 = 256 colors (gray degree)

1.2. Digital video
Digital video is basically composed of a series of frames. The series of frames is displayed on the screen sequentially with a certain speed, depending on the frame rate given in units of frames per second (fps). If the frame rate is high enough, the human eye cannot capture interlocking images or frames. The characteristics of a digital video are determined by the resolution or dimensions of the image, aspect ratio, bit depth, frame rate, and pixel of the video. These characteristics determine the video quality and the number of bits needed to retrieve it.

Image processing can usually be interpreted as digital image processing. An image can be done with various image processing, as well as video. Basically the video consists of several images that change or can be called frames. On video, usually within 1 second there are 12 frames or images that take turns, these frame changes take place quickly so that the eye cannot see the changes

1.3. Background Subtraction
Several methods have been used to detect moving objects automatically. This method can be classified into three broad categories namely background subtraction, temporal different based, and possibility based approach. Each of the methods above has advantages and disadvantages

Background Subtraction is a technique that is widely used to detect moving objects from static cameras[9]. in addition, background subtraction is a technique used for automated video surveillance or analysis [10]. It is the process of finding objects in an image by comparing the existing image with a background model. Background subtraction procedure consists of 3 stages, namely pre-processing, background modeling and foreground detection [6].

2. Discussion
Based on previous studies, then in this research, red tracking was carried out on the Water Height Designation Board using Blob Detection [9] and the Background Subtraction method to track the Water Level Height on the Peil Board. The use of these two techniques is combined with determining the threshold value that has been determined. Other parameters that influence include the distance and angle of the IP camera to the scale designation level and the intensity of light and height of the position of the IP camera.

2.1. Design of high water boards and IP cameras
Water level shows the level of water level which is divided into 3 parts, each of which is 300 cm high. Each of each section shows the level of safe, alert and hazardous conditions. In the analysis the system will track the level of water level, with the provisions of the analysis:
1. If the water level is still at the 1st part and maximum covers 1 part from the bottom, then the status is SAFE
2. If the water level is still at the 2nd part and the maximum cover 2 parts from the bottom, then the ALERT status
3. If the water level is still at the 3rd part and the maximum cover 3 parts from the bottom, then the status of DANGER

2.2. Tracking the Red Color on the High-Water Board
The flow of the analysis system to track water level can be seen in figure 1:
1. Capturing Image from IP camera. Recording objects is done manually with the camera's IP resolution in the settings first.
2. On the video image that has been made, then tracking the scale designation red.

3. In the color tracking process, tracking this color object uses blob detection which detects a collection of pixel dots that have different colors from the background and unites them in a region. In tracking the level of water level also carried out background substraction techniques

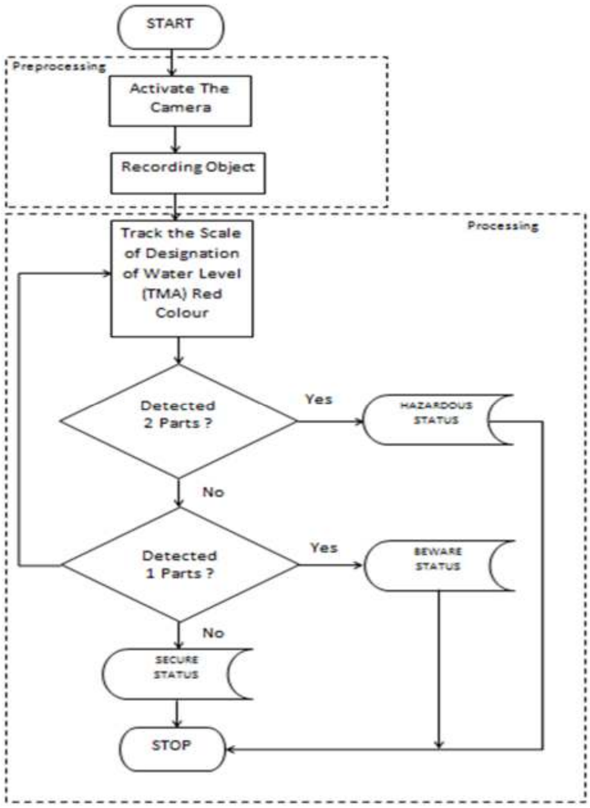

Figure 1. Flow track of high levels of water face on a red color TMA peil

2.3. Testing parameters of distance and angle of ip camera against peil water level

Measuring range and angle distances are also tested to get the minimum range and angle range and the range and maximum angle range. The minimum range and angle distance is the closest threshold distance the IP camera can still detect the appointment scale and the maximum range and angle distance is the furthest distance and the maximum angle where the IP camera cannot detect the elevation level designation scale

The first test is in the form of testing the minimum distance of an IP camera. The steps for testing the minimum distance search, namely:
- Direct the IP camera to the water level designation scale.
- The IP position of the camera is moved closer to the elevation level designation scale to a minimum distance.
- Then analyzed the Mathlab program that was made first.
- This process is carried out as much as 20x

From the search for the minimum distance recognition of water level markers on Peil, the minimum distance is 200 cm (2 m). Testing the maximum IP camera distance to the water level designation scale is done by moving the IP camera away from the designation scale and done repeatedly as much as 20x. The maximum distance obtained from this test is 600 cm (6 m)

The range and angle distances based on the identification of the IP camera's recognition of the appointment scale are found in the IP Camera's Image Distance and the IP Camera's Angle Image. The range of the IP camera's range against the Peil's water level scale that is less than 200 cm and more than

600 cm is the IP camera's range that cannot track the height of the water level, while the angles used are 15, 30, 45 and 60 degrees. At a distance of 200 cm with an angle of 30, 45, and 60 degrees, the Peil water level scale can be detected and can be analyzed, at a distance of 400 cm the angle that can be detected and tracked is 45 and 60 degrees, the distance of 600 cm is the angle that is detected and tracked only 60 degrees, but at a distance of 800 cm angles are not detected and tracked.
The results of testing the IP camera distance and angle can be seen in Table 1 below.

Table 1. Test results of ip camera distance and angle to peil water level

Sudut (º)	Distance (Cm)			
	200	400	600	800
15	×	×	×	×
30	√	×	×	×
45	√	√	×	×
60	√	√	√	×

information: √=Detected, ×=Not Detected

2.4. Testing of light intensity parameters and altitude of ip camera against peil water level
Testing the IP camera's height and light intensity varies, to determine the effect of the placement of the right position on the light intensity. Testing the position of the IP camera placement is done by dividing the height of the IP camera position into two height levels:
a. Low Level is the height level of the IP Camera position where the IP camera can detect and track the Peil water level scale
b. High level. Is the level of the position of the IP Camera where IP Camera is difficult to detect and track the scale of the Peil water level, so the analysis shows that it cannot detect it

In this study, the IP camera height position is limited to a height of 1000-1500 cm (10-15 meters) while the light intensity is limited between 500-2000 lux. The results of testing the IP camera's position height and light intensity are shown in Table 2. If the IP camera's height with sufficient light intensity, analysis in detecting and tracking the scale of the water level designation can be done. IP camera position height level of more than 1250 cm is a high level so that the analysis of Peil water level Scale is difficult to obtain, because the size of the appointment scale is small and the color area is also difficult to capture by the IP camera. Thus, the level of the IP Camera's position from 1150 - 1250 cm is an area that can be captured by the full IP camera so that in detecting and tracking it can be done well

Table 2. Results of measurement of light intensity and ip camera height to peil water levels

Height (cm)	Light Intensity (lux)						
	78 6	126 3	119 3	138 6	169 5	175 0	198 0
1000	×	√	×	×	×	×	×
1050	×	×	×	√	×	×	×
1100	×	×	×	×	×	√	×
1150	√	√	√	√	√	√	√
1200	√	√	√	√	√	√	√
1250	√	√	√	√	√	√	√
1300	×	×	×	×	×	×	×
1350	×	×	×	×	×	×	×
1400	×	×	×	×	×	×	×
1450	×	×	×	×	×	×	×
1500	×	×	×	×	×	×	×

Information: √=Detected, ×=Not Detected

2.5. Planning System

The output of this analysis is the information on water level at normal, standby and hazard conditions, presented in an Android smartphone-based information system so that it becomes information for the public.

Figure 2. System architecture developed

2.5.1. System architecture design

Broadly speaking the system to be developed includes five parts, are Peil; as an object to measure the dam's water level; Control devices; consists of a microcontroller; IP camera, Wifi Module, and Power supply; Computer server; as a center for data storage and processing (digital images and measurement results of water level by sensors) connected to the internet network; Smartphone devices; as an application user communication media, related to dam water level data and as a medium for flood notification / early warning for the community.

2.5.2. Use Case Diagram

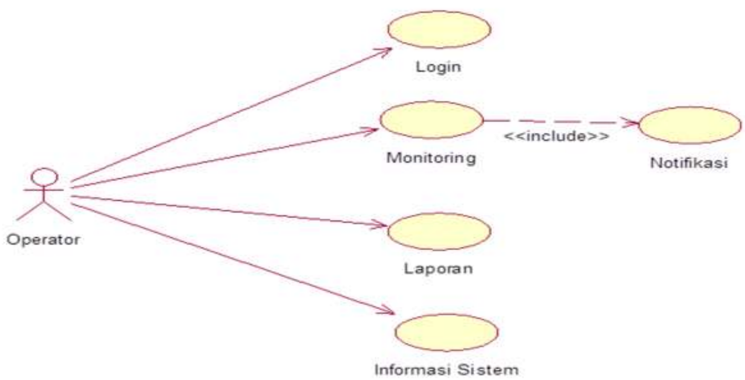

Figure 3. Use case system

2.5.3. *Prototyping testing fast flood early warning system application on an android smartphone* device Based on the results of trials on the application, the data of the dam's water level can be displayed on an application that is already installed on Android smartphone device. The data displayed is the result of the measurement of Water Level in two dams by sensors sent to the server computer through the internet network in real time. In the application of this flood early warning system also displays data such as water level and altitude status which are parameters of the dam's water position, namely in the conditions of SAFE, CAUTION, and DANGER. The status of the water level that is displayed on the android application is the result of Peil digital image processing.

On the server computer also made a web-based application, which serves not only to store digital image data from the IP Camera, as well as storing data (log data) from the measurement of water levels on the two dams by sensors. The admin (manager) has full access rights to manage monitoring data and water level reports regularly

The developed webserver application can also provide information related to water level in both dams in realtime, as well as the status of the water level measurement results within a certain timeframe, according to the data stored in the system database. Log data processing results on the database server can be displayed in the form of daily, monthly or yearly and can be downloaded in pdf format,

The prototype of an Android-based application for a flood early warning system that has been made can run well in accordance with the initial design, can display data on the measurement of dam water levels and status of dam water levels based on the results of processing and digital image analysis on the dam peil. Dam water level information that is displayed on the android application can provide information on dam water level conditions in real time that can be accessed by the public as information.

3. Conclusion

The result that can be concluded from this research is that prototype application of flood early warning system based on digital image processing has been developed through an android smartphone. The application can provide the latest information related to dam conditions in the form of water level and dam status in real time. Based on several test results on the prototype system, there are several obstacles, namely in the process of sending data to the server caused by a break in internet communication from the controller module, resulting in data not being recorded and cannot be displayed. Data on the water level of the dam due to the measurement of the sensor still occurs some errors, the data sent is not in accordance with the actual conditions. This needs a modification of the tool for measuring dam water level so that the results of the measurement are more precise.

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