Comparison of Water Levels By Sobel Fringe Method and First Order Differential Equations

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Abstract

This research is to determine the edge of the camera image using a model to create a water barrier. CCTV images were analyzed as color images and transformed to find the edge of the image by two methods: Sobel method and first-order derivative method. The number of images to be analyzed was 1000 frames and analyzed 1:1 frames for greater resolution and accuracy, then compared with MSE, RMSE and MAD. The results showed that the first order derivative method was the most detailed and accurate with an MSE of 13.968 %, RMSE of 1.18 and MAD of 0.491 compared to Sobel method with an MSE of 919.01. %RMSE of 9.586% and MAD of 8.645.
Keywords: Sobel edge detection, First order derivatives bounding, MSE, RMSE, MAD

1. Introduction

Still images or images from the video are used to check out things of interest. Technology is developed and applied to warn of what will happen before it is used in various applications. Especially in the field of disasters, in the rainy season there will be a lot of storms or rain. Flooding is one of the most widespread disasters affecting lives and property. In addition, the use of CCTV to monitor rainwater levels requires humans to make decisions. Analysis of images that detect water in different areas may require 24-hour detection. From the problems that arise, it is found that the water level analysis from images has limitations in that it requires humans to track and monitor the increase or decrease of water levels. In addition, there may be problems from various conditions, such as having water stuck in front of the camera, causing the water level to be invisible to be notified immediately.

In this research, the images from the CCTV camera were used to find the edge of the image to find the water level that has changed. Comparison of sobel method [1] and first derivative method [2] for water level measurement by comparing MSE [3], RMSE [4] and MAD [5].

There are many ways to find the edge of an image and are used in various fields according to the literature review as follows:

Li Bin [6] has studied the comparison of the algorithm for finding the edges of objects by using aerial photographs of unmanned aerial vehicles. The obtained images were taken for the edges of the images by Robert Sobel, Prewitt, Gaussian and Canny methods and then analyzed by using the PR and PSNR indexes to test the similarity between images. The results of the Gaussian and Canny bounding experiments were able to find the edge of the object more efficiently than other methods.

Kevin R. Hutson. [7] has presented the design and development of image edge circuitry using the high-level Impulse C language, which is the development of FPGA technology to increase the efficiency of video signal processing. The high-level language and edge detection method by Robert Sobel and Prewitt using bmp images has shown that edge detection can actually be performed on FPGA technology before being implemented on the Spartan 3E board.

Sakunwutthichai, Phanuwat [8] presented a method for analyzing the size of the case study objects: Banana peeling using an image processing technique for analyzing the size of peeled bananas. In this experiment, 30 bananas were used to analyze the photographic characteristics, consisting of area, length, width, by point, line and thresholding methods. The results of the experimental method of finding edges by Thresholding were effective in finding the object size in 22 images out of 30 images, representing an accuracy of 73.33%.

Mangkorn Chenchai [9] studied the development of a model for forecasting average runoff in Nakhon Ratchasima Province by using data mining techniques. The modeling was ANN, LR, SMOreg and RBFN and predictions were performed using MAE and RMSE. The results showed that the SMOreg model had the best predictive performance of water content.

Anima Kujur [10] studied the convolutional neural networks (CNN) have shown promising results for various classification problems over the past years. However, selecting various CNN architectures is still challenging as each architecture performs differently with the same dataset.

Vibhor Kumar Vishnoi [11] studied Plant diseases are a severe cause of crop losses in the agriculture globally. Deep learning-based models provide promising ways to identify plant diseases using leaf images. Although, there exist several CNN models for crop disease detection with comparable.

In this research, the objective is to find the edge of the image to be used to measure the water level in different areas that need to be notified of the changing water level. There are many ways to find the edge of the image, but in this research, the two methods of finding the edge are used to compare the resolution of the edge finding and to find the accuracy of water level indication. Comparisons were made by both methods, Sobel and first order derivatives. The Sobel vignetting method is a widely used prototype of vignetting and is the basis for other vignetting methods such as Prewitt or Canny.

In this research, the Sobel method was used as a method to compare edge detection with first order derivatives to analyze edge detection from 1000-frame CCTV cameras. Then analyzed 1:1 frame to determine the accuracy and resolution of water level determination. After that, it was analyzed 1:1 in order to determine the accuracy and resolution of water level determination by using 3 error determination methods, MSE, RMSE and MAD were used to find the least error value.

2. Materials and Methods

The edge detection method is one of the image processing methods aiming to find the boundaries in that image that are prominent. The sharpening of the image boundaries results from the difference in light intensity at each point of one image to another that is contiguous. The sharpness of edge detection depends on the light intensity between the image pixels. The process of finding the correct edges of an image is not an easy task, especially in finding edges that are of poor quality or whose intensity may be uneven across the entire image or where there is a difference between foreground and background with different values. In some cases, there may be a large number of strokes and different resolutions, these will help to find the edges of the image more perfectly.

2.1 Digital image definitions

or discrete 2D photographs are considered as two variable functions with x-axis and y-axis. Which is the number of rows (N) and the number of digits (M). The image will be divided into small squares. Called pixels (Pixel), with coordinates [m, n]. For images obtained from photography, there are 3 types of images: black and white images, gray images and color images.

2.2 Binary image [12-16]

Black and white images have elements in the image. A small square called a pixel, in which one pixel of a black and white image is worth only 1 bit, which is the binary number 0 and 1, where the value 1 means the white point, and the value 0 means the point. Black

2.3 Grayscale[17-

A grayscale image contains an image element for each pixel. There will be different light intensity from white to black. which is different from black and white images Because the grayscale image will have a gradation. In which the intensity of the light is using the gray level value. Normally, the gray level image has resolution (Resolution) equal to the number of 8 bits, which the image will have light intensity from 0 to 255.

2.4 Color image

A color image is an image that can be seen generally with elements of the image. Is a pixel of a color image and will store the light intensity level of the primary colors, which consist of red (Red), green (Green) and blue (Blue), also known as RGB, which will have different color values. different and will show the result of the color value in each pixel According to the intensity level in each light band.

The size of the image file will differ depending on the latter two components, namely the size of the image (Size) and the number of bits used to represent the color value or the intensity of light in each pixel of the image. If the image resolution is very high will have a large number of bits Storage will require more space (Memory unit).

2.5 Edge Detection

Edge detection is a method of determining whether a line is drawn across or close to a point, which is measured by the change in light intensity in the vicinity of that point. There are several ways to find the edges of an image. In this research, two methods of edge determination are compared: the first derivative method and the sobel edge determination method.

2.6 Adjustment of colors

Most of the resulting images are color images, which must be converted to color using the Gaussian filter method, which creates a submatrix (Mask) for filtering. The Gaussian equation can be expressed as Eq.(1).

$$G(x,y)=\frac{1}{2\pi\sigma^2}e^{\frac{x^2+y^2}{2\pi\sigma^2}} \quad (1)$$

when

(x, y) is position of the members in the submatrix.

σ is the parameter value.

2.7 Gradient Magnitude and Gradient Direction

Gradient Magnitude and Gradient Direction are shown by Eq.(2) and (3), respectively.

Gradient Magnitude

$$M(i,j) = \sqrt{g_x^2(i,j) + g_y^2(i,j)} \quad (2)$$

Gradient Direction

$$\alpha(i,j)=\arctan\left(\frac{g_y(i,j)}{g_x(i,j)}\right) \quad (3)$$

when

(i, j) is the position of the pixel.

g_x and g_y is the magnitude of the color shift along the axis, x and y .

2.8 Non – maxima suppression

Non – maxima suppression is likely to be the edges of the image and eliminate pixels that are not at the edges of the image which will be calculated as follows:

Consider the non – maxima suppression from the value $\arctan\theta$, which is from range $[-90^0, 90^0]$ to sub-range in the color adjustment as follows:

$-22.5^0<\alpha(i,j)\leq 22.5^0$ adjusted to $\alpha(i,j)=0^0$

$22.5^0<\alpha(i,j)\leq 67.5^0$ adjusted to $\alpha(i,j)=+45^0$

$-67.5^0<\alpha(i,j)\leq -22.5^0$ adjusted to $\alpha(i,j)=-45^0$

$\alpha(i,j)\leq -67.5^0$ or $\alpha(i,j)>67.5^0$ adjusted to $\alpha(i,j)=90^0$

Comparing the size and gradient Magnitude of an image pixel considers two neighboring pixels in the direction of the change, which in turn defines it as a potential margin. The magnitude of the chromatic aberration of a pixel is greater than or equal to the magnitude of the chromatic aberration of its two neighboring pixels.

2.9 Double thresholding

In order to identify edge of pixels, high threshold values (T_h) and low threshold values (T_l) are required to take into account only possible pixels as follows:

- The gradient magnitude is greater than or equal to (*Th*), that pixel is called dark edge.

- The gradient magnitude between (T_l) and (*Th*) is called light edge. The light edge can only be an edge as the neighboring pixel value is at least 1 dark edge.

- The magnitude of the pixel's color change is less than (T_l), so that pixel is not borderless.

2.10 Finding edges from intensity data

Edge detection using Intensity data is a way to convert color images, known as RGB, to grayscale images. This grayscale detection technique will be used to find the edge of the image that is considered by changing the gray intensity of one pixel called pixel intensity [12] to another pixel with consecutive channels. Edge detection using Intensity in this research is ranked first compared to Sobel.

2.11 The Edge Detection Methods

The Edge Detection Methods with the first derivative is one of the most popular methods like Sobel or Prewitt, etc. The edge of the image obtained from the first derivative is characterized by a thick line called (Thick Line) because the edge of the image obtained is compared with the threshold.

Edge determination using the first derivative is a discrete gradient transformation on numerical image data. Therefore, discrete partial derivatives must be used along the direction perpendicular to the x-axis and y-axis, which can be determined by the following method:

$$\nabla_x g(x,y)=g(x,y)-g(x-1,y) \quad (4)$$

$$\nabla_y g(x,y)-y(x,y)-y(x,y-1) \quad (5)$$

The magnitude of the gradient g(x,y) can be determined from

$$|\nabla g(x,y)|=\sqrt{\nabla_x g(x,y))^2-(\nabla_y g(x,y))^2} \quad (6)$$

The magnitude of the gradient along the direction perpendicular to the x-axis and y-axis combined as the equation

$$|\nabla g(x,y)|=|(\nabla_x g(x,y))|-|(\nabla_y g(x,y))| \quad (7)$$

2.12 Finding edges by Sobel Convolution Mask method [13]

Sobel edging is a non-linear edging method that can change the discontinuity according to the scaling with the value of , which is the original image. The value of is the position value of each of the 8 pixels that will rotate counter-clockwise by giving:

where the magnitude of the edge detection by sobel will be $m \in R^x$ by

$$m(i,j)=\sqrt{u^2+v^2} \quad (8)$$

The direction of the gradient of image d is

$$d(i,j) = arctan\left(\frac{u}{v}\right)$$

$$S=\begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \quad (9)$$

$$T=\begin{bmatrix} 0 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & 1 \end{bmatrix} \quad (10)$$

$$\theta= \tan^{-1}\left(\frac{S}{T}\right) \quad (11)$$

where

S is the mask of the x axis.

T is the mask of the y-axis.

θ is the direction of the vector.

2.13 Euclidean distance [14]

The Euclidean distance is a method for calculating the distance between two points along a straight line using the Pythagorean theorem.

$$d_{x,y}=\sqrt{\sum_{i=1}^{N}(x_i-y_i)^2} \quad (12)$$

$$x=[x_1 x_2 \ldots x_m]^T \quad (13)$$

$$y=[y_1 y_2 \ldots y_m]^T \quad (14)$$

where

$d_{x,y}$ is the j-dimensional intersects.

x is the first set of data

y is the second set of data

m is the size of the data

2.14 Tolerance values

2.14.1. Mean Squared Error: MSE [15]

$$u=(a_5+2a_6+a_7)-(a_1+2a_2+a_3) \quad (15)$$

$$v=(2a_0+a_1+a_7)-(a_3+2a_4+a_5) \quad (16)$$

$$MSE=\frac{1}{n}\sum_{t=1}^{n}(Y_t-\hat{Y}_t)^2 \quad (17)$$

2.14.2. Root mean Squared Error: RMSE [16]

$$RMSE=\sqrt{\frac{1}{n}\sum_{t=1}^{n}(Y_t-\hat{Y}_t)^2} \quad (18)$$

2.14.3. Mean Absolute Deviation: MAD [17]

$$MAD=\frac{1}{n}\sum_{t=1}^{n}|Y_t-\hat{Y}_t| \quad (19)$$

where

n is the amount of data used

Y_t is the true value at any time t.

$\hat{Y}_t$ is the value predicted at any time t.

3. Results and Discussion

From video images obtained from CCTV cameras and converting color images to grayscale images to find the edge of the image, shown in Fig.1. A converting the color images to grayscale images as shown in Fig.2.

Fig 1. Image from camera or CCTV.

Fig 2. Grayscale image.

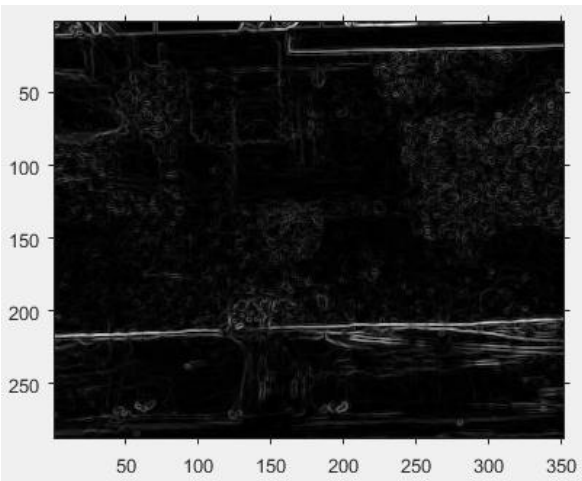


Fig 3 Process of finding edges with Sobel method.

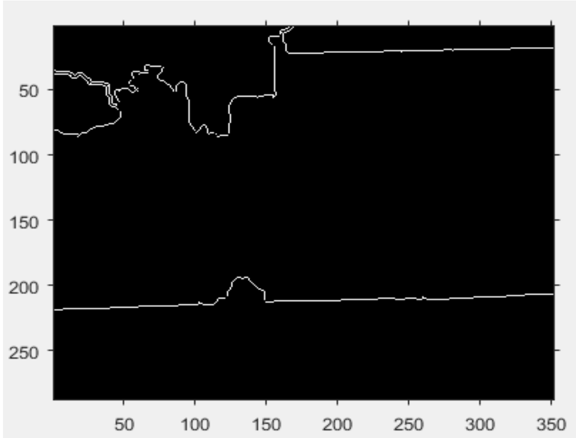


Fig 4 Finding the edge of the line with Euclidean distance.

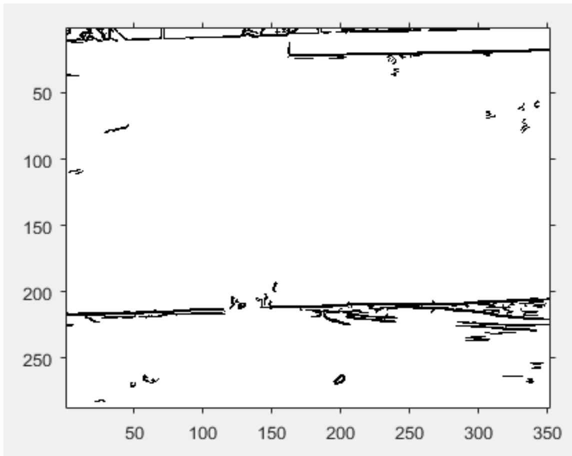


Fig 5 Process of finding edges using First derivative methods.

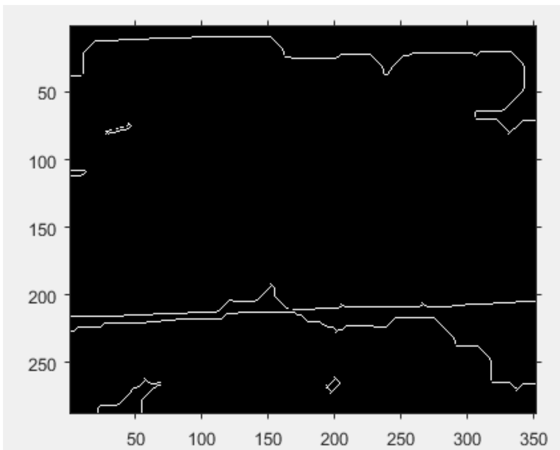


Fig 6. Finding the edge of the line with Euclidean distance.

After obtaining the image in grayscale and finding the edge of the image using 2 methods to compare with the first derivative Sobel method to determine the change in water level in each frame by the Euclidean distance method.

Sobel method for determining image edges and water levels.

For Fig.3, after converting a color image to a grayscale image, it can be entered into the equation of finding the edge by Sobel method.

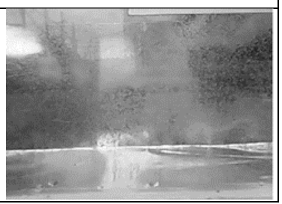
For Figure 4, it will find the edge of the water level line that has changed by checking from Figure 3 and enter the Euclidean distance equation to find the water level to check the accuracy of the image for Sobel method.

First derivative methods for determining image edges and water levels.

For Figure 5, after converting a color image to a grayscale image, it can enter into the edge finding equation by first derivative methods.

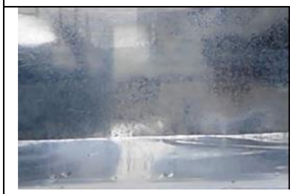
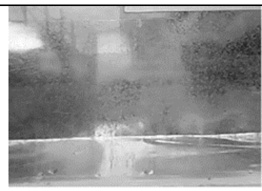
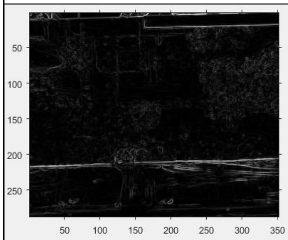
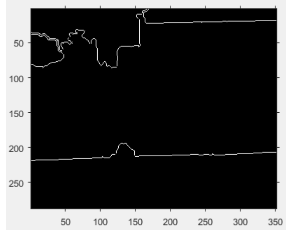
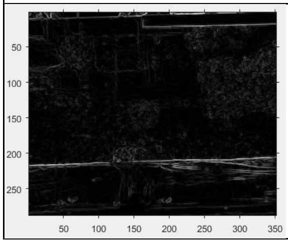
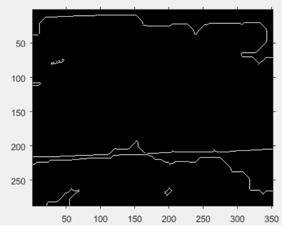
For Figure 6, it will find the edge of the water level line that has changed by checking from Figure 5 and enter the Euclidean distance equation to find the water level to check the accuracy of the image for First derivative methods.

Table 1 Summarizes methods and procedures

Image from camera or CCTV.	Grayscale image.
	

From Table 1, there are 2 methods for finding edges, namely Sobel method and first order differential equation by bringing images from 1,000 VDO frames that have been analyzed 1: 1, the resulting image frames will be color images and converted into grayscale images. This image will be the original image and will be taken to the edge of the image in both ways to find the water level using the Euclidean distance equation.

Table 2 Summarizes methods and procedures.

Image from camera or CCTV.	Grayscale image.
	
Sobel method	Euclidean distance for Sobel method
	
First derivative methods	Euclidean distance for First derivative methods
	

4. Conclusions

From the experiment using VDO images of the changing water level from the canal in Nakhon Pathom Province, Bang Len District to test the water level. The image was adjusted by 10 frames and the MSE, RMSE and MAD values were determined for the error value from the test. The test results were as shown in the table.

Table 3 Error test results.

method	Sobel method	First derivative methods
MSE	919.01 %	13.968 %
RMSE	9.586 %	1.18 %
MAD	8.645 %	0.491 %

Table 3 is the three methods for determining the error value, MSE, RMSE and MAD. In this research, 1,000 frames of captured VDO images were analyzed at a 1:1 frame rate. Comparing the error values of these 3 methods, it was found that the Edge Detection method with Filters Edge Detection had the lowest percentage of error values.

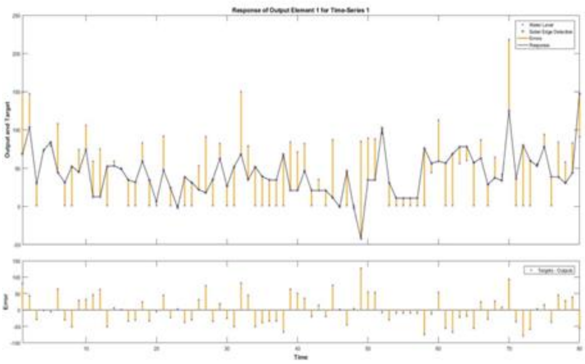


Figure 7. Error determination by Sobel Edge Detection method.

From Figure 7 shows the error value of edge detection by Sobel Edge Detection method. By comparing the water level detection value by edge detection with the actual measurement value.

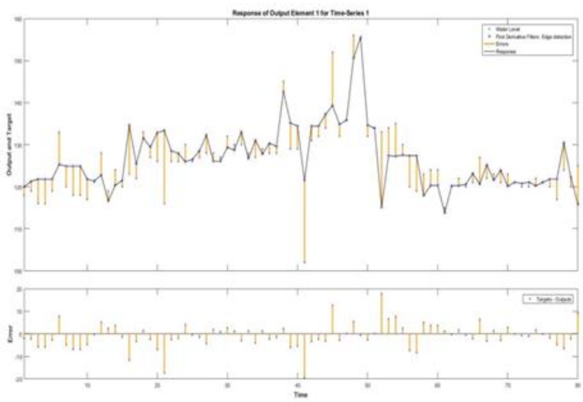


Figure 8. Error determination by Fist Derivative Filters Edge Detection method.

From Figure 8, it shows the error in finding the edge of the image by Filters Edge Detection method. By comparing the water level detection value by finding the edge of the image with the actual measurement value.

From the experimental results of finding the edge between the method of finding the edge by Sobel Method and first derivative bounding method were analyzed from VDO images taken with water level in the water level measurement model to compare the accuracy. The analysis of edge detection from a basic method by examining frame by frame for water level accuracy can be concluded that the first derivative edge determination is more accurate than the Sobel method when comparing MES, RMSE and MAD error determinations.

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