Detection of Object Changes in Low Contrast Image Using Template Matching Method

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Abstract. This research uses a contrast stretching method to improve the detected object image. This process is needed because of the lack of lighting in the room so it is difficult to identify properly. This research develops an image object change detection system to detect the movement of objects contained in a room through a Closed Circuit Television (CCTV) camera which is conducted simulations using a webcam camera using a template matching method with normalized cross-correlation techniques. The results of detecting changes in image objects are then made to compare between the reference image and image before there is an object change with the image after the object changes. System testing is carried out at a certain time, namely 07.00-17.00 WIB. The level of accuracy to identify the detection of changes in image objects using the template matching method with normalized cross-correlation technique is 85% for the category of no change in min (0.01025) and max (0.02088) and changes in min (0.01640) and max (-0.00513).

1. Introduction

Current technological advances, especially in the field of digital image processing technology (Digital Image Processing) cannot be separated from the role of humans, as happened with the detection of changes in image objects. Currently detecting changes and classification in image objects is still a large percentage of its success is still low [1] [2].

This is due to the lack of lighting in the room or lighting that is less stable, so the dimensions of the change in the object image captured in the program cannot be properly defined. Generally, low light conditions can be overcome with some technologies such as image processing. In low light, the video becomes blurred or experiences noise, causing a much greater video flow. The ability of Closed-Circuit Television (CCTV) to capture images more cleanly over long distances and capture changes in the object image that is moving current constraints [3]. With the condition of nighttime CCTV or lack of lighting can cause noise, the results are not clear, thus doing the wrong processing. Monitoring is still manual that is only monitoring using the eyes of a practicum assistant in the room. In the basic computing laboratory room, there have been various events with poor lighting conditions in the basic computing laboratory room, such as frequent unconsciousness about changes in objects that have occurred, changes in the object in question include the layout of computers, desks, chairs in each basic computing laboratory room and the location of the practitioners' seats in the room. With these constraints, we need a system that can improve the results of capturing changes in image objects so that the desired results can be obtained easily and simply so that users can define the desired object change in a more modern way without the need to use the naked eye to supervise practitioners.
2. Method

2.1. Contrast Stretching Method

Improvement of the digital image is a stage that is subjective, optional, and experimental because there is no standard algorithm in improving image quality. Operations in improving image quality include point operations, spatial operations, and transformation operations. The purpose of improving the image of an image, among others, is highlighting certain aspects of the display to be more easily understood or interpreted by human vision, as well as reducing or eliminating the display aspects of an image that is not needed such as noise.

This method serves to improve the quality of the image in contrast to the image that was previously still not good which is caused by poor lighting or image experiencing noise. In a contrasting image affected by lighting, errors in the settings of the camera during the process of image acquisition and the dynamics of the image sensor. The following is the formula for contrast stretching in equation (1).

\[ O(i, j) = \frac{u(i,j) - c}{d-c} (L1) \]

In equation (1) where \( O(i, j) \) and \( u(i,j) \) are pixels before and after being transformed to coordinates \((i,j)\), \( c \) and \( d \) state that the maximum and minimum values obtained from the input image pixel, and \( L \) are maximum grayscale value. If the pixel value is less than 0 then the pixel value becomes 0 and if the pixel value is greater than \((L-1)\) then the pixel value becomes \((L-1)\). The grayscale color sequence where each pixel represents a gray degree with the lowest intensity value from 0 (black) to the highest that is 255 (white). In this grayscale color sequence, the pixels have a size of 8 bits or 1 byte [4] [5].

2.2. Template Matching Method

The template matching method is one of the techniques in digital image processing that functions to match each part of an image with an image that becomes a template (reference) [8]. An input image containing a particular template is compared to a reference template. The template is placed at the center of the image to be compared and counted how many points best fit the template. This step is repeated for the entire input image to be compared. The greatest point of conformity between the input image and the template image indicates that the template is the template image that best matches the input image.

2.3. Normalized Cross-Correlation Method

Normalized Cross-Correlation (NCC) is a technique in photogrammetry to measure the conjugation point. In the Normalized Cross-Correlation process, the first image is determined beforehand the reference image (template) that has pixel points inside it that the partner will look for in the second image. In the second image, it is determined in advance the search area (search window) which has a larger size than the reference image area (template). Therefore, the virtue of the Normalized Cross-Correlation technique is to find pairs of pixel titles between the first image and the image/pair with NCC value limits between -1 and +1. The size of the distance (Euclidean distance squared) is very influential in the use of cross-correlation for template matching.

\[ d^2_{f,t}(u,v) = \sum_{x,y} [f(x,y) - t(x-u,y-v)] \]

Where in equation (2) \( f \) is the target image, \( t \) is a feature and \( d^2 \) is the Euclidean distance squared. Equation (3) is an extension of \( d^2 \).

\[ d^2_{f,t}(u,v) = \sum_{x,y} [f^2(x,y) - 2f(x,y)t(x-u,y-v) + t^2(x-u,y-v)] \]

Equation (3) has the form \( \sum t^2(x-u,y-v) \) constant. If \( \sum f(x,y) \) it is constant, then use equation (4) to measure the equation between the target image and the feature.

\[ c(u,v) = \sum_{x,y} f(x,y)t(x-u,y-v) \]

If the image energy varies in position, equation (4) can fail, not invariant because it is caused by changes in lighting conditions at the image collapse when there is a change in image amplitude [8].
In equation (5) is a correlation coefficient to overcome difficulties by normalizing image vectors and features or called NCC where $\bar{t}$ feature mean (ROI) and $\bar{f}_{u,v}$ average of image templates under the feature area (ROI)[6][7]. The flow of the normalized cross-correlation technique is shown in Figure (1).

\[
    r(u,v) = \frac{\sum_{x,y}[f(x,y) - \bar{f}_{u,v}][t(x-u,y-v) - \bar{t}]}{\left(\sum_{x,y}[f(x,y) - \bar{f}_{u,v}]^2 \sum_{x,y}[t(x-u,y-v) - \bar{t}]^2\right)^{1/2}}
\]  

(5)

In Fig. 1 the flow of the normalized cross-correlation technique explains that in process 1 runs the input process of cropping the image and original image from the database, then in process 2 the binary values of the two images are calculated. In process 3 the process of calculating the value of cross-correlation is done, then at stage 4 calculate the mean. At stage 5 is determine the minimum, maximum value and calculate image values. And in the last process that is display information changes or not.

3. Results and Discussion

The original image before processing is a video image with *.mp4 extension with a size of 1080x1920 pixels which is then captured in the template, then the image enhancement method used in this study is tested on the captured image obtained from the video image that changes the image object with a pixel size of 1080x1920 with a *.png image extension and converted to a grayscale image to facilitate processing. In the template matching method used to identify the object image that has been preprocessed in the form of image images with a size of 174x270 pixels compared to the original image in the database. Both images are identified in binary image format to facilitate processing. In the System Analysis Results, detection of changes in image objects is carried out by the system and Expert Judgment as in

| No | Cropping image | Template | NCC   | Expert  | System conclusion |
|----|----------------|----------|-------|---------|-------------------|
| 1  |                |          | 0.01025 | Not changed | Not changed        | correct           |
| 2  |                |          | 0.01033 | Not changed | Not changed        | correct           |
| 3  |                |          | 0.01143 | Not changed | Not changed        | correct           |
| 4  |                |          | 0.01094 | Not changed | Not changed        | correct           |
After the system and Expert Judgment analyzes the detection of changes in image objects, there are 3 images that do not match between the system and Expert Judgment. Where the value of N is the total number of images tested, that is 20 images consisting of 10 images that have not changed the image object and 10 images that have changed the image object. The following calculations to determine the level of accuracy: Known: \( N = 20 \), Matching results = 17, results not matching = 3 then obtained the level of accuracy to identify the detection of changes in image objects using the template matching method with normalized cross-correlation technique that is 85%.

4. Conclusion
The results of the identification of 20 test data using the Template Matching method with Normalized Cross-Correlation technique produce NCC values for the category of no change in min (0.01025) and max (0.02088) and changes in min (0.01640) and max (-0.00513). Lighting is very influential at all on the value generated using this method, so the accuracy obtained is 85%. This method is not suitable for use in this research.
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