Mobile Application Detection of Road Damage using Canny Algorithm

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Abstract. Edge detection is one of the most frequent processes in digital image processing for various purposes, one of which is detecting road damage based on crack paths that can be checked using a Canny algorithm. This paper proposed a mobile application to detect cracks in the road and with customized threshold function in the requests to produce useful and accurate edge detection. The experimental results show that the use of threshold function in a canny algorithm can detect better damage in the road.

1. Introduction

One of the image processing techniques used is edge detection [1]. Edge detection is standard in digital image processing because it is one of the first steps in segmenting the image, which aims to present the objects contained in the picture [1] [2] [3] [4]. Edge detection serves to identify the boundary of an object over an overlapping image. So that if the edge line in the picture could accurately identify, all objects could found and the fundamental properties such as area, shape, and size of the object can be measured [5] [6]. Image edge is the position where the pixel intensity of the picture changes from low value to high value or vice versa [1] [5]. Currently, several algorithms could use for edge detection, for example, Sobel [7], Canny [7], Prewitt [7], frei-chen [7] and Laplacian algorithms [8]. In this research taken canny algorithm, Edge is a change of intensity value of gray degree quickly or suddenly in a short distance [5] [8]. The purpose of detecting the edges themselves is to group the objects in the image, and also be used to analyze the picture further [9] [10] [11] [12].
In addition to the use of canny algorithm, this research also uses threshold function in application which is a parameter to determine the level of image clarity of edge detection results done, the crack examination on the road is very important to detect the condition of the road that is used because of the effect on the safety of the street drivers, fracture on roads could be taken seriously by repairing the road.

Chitra [4] applies the gradient calculation of magnitude and gradient of direction to improve edge detection in the image, then Biswas [13] enhances edge detection by applying fuzzy sets to reduce non-noise in the picture so that the accuracy level is higher, in principle improvisation edge detection canny algorithm is possible done, only by using the threshold function applied to the mobile application contained in the experimental results in this paper.

2. Methodology
The canny algorithm is an algorithm that performs the examination with the minimum error rate to produce the optimum edge image, but the canny algorithm process is not sufficient to reduce the picture that has many edges or strokes which is really an edge or not, for that canny algorithm in improvised by adding a threshold function so that edge detection errors on the image can be reduced well by providing the minimum and maximum values at the time of edge detection processing.

Results of this research was conducted to detect cracks in the road which is the beginning of damage to the road, to facilitate the process of detecting road cracks directly designed a mobile-based applications to detect road damage with processors using canny algorithms and threshold functions, with applications designed policy makers can take a direct solution to fix the road or just do maintenance only.

The selection of canny algorithm as edge detection process because ease of implementation in the language of various programming language especially Java besides also easy to be developed by applying various function especially threshold function.

There are some of the most optimum edge detection criteria that can be met by canny algorithm [3] [10] [11]:
1. Detect well, Ability to put and mark all existing edges under the selection of convolution parameters performed. It also provides very high flexibility regarding determining the level of edge thickness detection as desired.
2. Localize well with Canny; it is possible to produce a minimum distance between the edges detected with the original edge.
3. The response is clear, there is only one response to each edge so easily detected and does not cause confusion on subsequent image processing.

There is five step in performing canny edge detection [5] [7] [14]:
1. Eliminate the noise present in the picture by implementing the Gaussian filter. This process will produce an image that looks a bit blurry, and this is intended to get the edge of the actual picture. If not performed then fine lines will also be detected as an edge. Here is one example of a Gaussian filter with $\sigma = 1.4$.

$$\begin{array}{cccc}
2 & 4 & 5 & 4 \\
4 & 9 & 12 & 9 \\
5 & 12 & 15 & 12 \\
4 & 9 & 12 & 9 \\
2 & 4 & 5 & 4 \\
\end{array}$$

$$\frac{1}{159}$$

2. Perform edge detection by searching horizontally (Gx) and vertically (Gy).
3. Determining the edge direction found using the following formula.

$$\theta = \arctan \frac{Gy}{Gx}$$
Next, divide into four colors so that the lines with different directions and have different colors. The division is 0 - 22.5 and 157.5 - 180 degrees yellow, 22.5 - 67.5 are green, and degrees 67.5 - 157.5 are red

4. Minimizes the edge line that appears by applying non-maximum suppression to produce a slimmer edge line.

5. The final step is binary by applying two thresholds, the following figure will show the image shape before processing (a) and after processing (b). The image used is a grayscale image with threshold value 0.05.

Thresholding is used to adjust the amount of gray degree present in the picture. By using Thresholding the gray degree can be changed as desired, e.g. desired using the level of gray 16, then live to divide the value of a gray degree with 16. The process of Thresholding is a process of changing the quantization of the image, so to do Thresholding with the gray degree can be used the formula:

\[ X = \frac{W}{B} \]

Where:
W is the gray degree value before Thresholding
B is the desired number of degrees of gray
X is the gray degree value after Thresholding

![Figure 1. Before and After Edge Detection](image)

The results of this research is a smartphone application that can be used to detect cracks in roads with canny algorithms and threshold functions, apps designed using Android Studio and Android API 24 SDK.

3. Result and Discussion

The Canny algorithm is one of the operators used for edge detection, and this operator is like a Sobel operator. Convolution canny algorithm involving canny kernel and convolution is perform with pixel value of the image that to be processed, figure 2 below will be test for edge detection.
Figure 2. Crack damage in the road

For the process of detecting cracks in the road could be seen in the following pseudo code, the code is:

```java
public void setLowThreshold(float threshold) {
    if (threshold < 0) throw new IllegalArgumentException();
    lowThreshold = threshold;
}

public float getHighThreshold() { return highThreshold; }

public void setHighThreshold(float threshold) {
    if (threshold < 0) throw new IllegalArgumentException();
    highThreshold = threshold;
}

Arrays.fill(data, 0);
int offset = 0;
for (int y = 0; y < height; y++) {
    for (int x = 0; x < width; x++) {
        if (data[offset] == 0 && magnitude[offset] >= high) {
            follow(x, y, offset, low);
        }
        offset++;
    }
}

private void follow(int x1, int y1, int i1, int threshold) {
    int x0 = x1 == 0 ? x1 - 1 : x1;
    int x2 = x1 == width - 1 ? x1 + 1 : x1;
    int y0 = y1 == 0 ? y1 - 1 : y1;
    int y2 = y1 == height - 1 ? y1 + 1 : y1;

    data[i1] = magnitude[i1];
    for (int x = x0; x <= x2; x++) {
        for (int y = y0; y <= y2; y++) {
            int i2 = x + y * width;
            if ((y != y1 || x != x1) && data[i2] == 0
                && magnitude[i2] >= threshold) {
                follow(x, y, i2, threshold);
                return;
            }
        }
    }
}
```
The above pseudo code are some critical processes for detecting crack paths with canny algorithms and threshold functions. The result of edge detection process from the figure 2 by using the canny algorithm could be seen in figure 3 below:

![Figure 3. Edge Detection Result](image)

Based on the process of the canny algorithm that has been described and implement in mobile based edge detection application, the results can see in figure 4 below:

![Figure 4. Edge Detection Result in Mobile Application](image)

In Figure 4 there are some results of the edge detection process with the same object but have different results when the threshold value is replaced, so it can be concluded that the edge detection results in the image with the canny algorithm can affect when the threshold value on the picture is change, and this process also affects the time of edge detection process.

The Result of detection road damage by using canny algorithm and threshold function produce fast enough when using application because every object of image changed into grayscale image, and then by determining the minimum and maximum threshold values can reduce the detection error against objects that are not part of the road damage.

4. Conclusion

The Canny algorithm applied to a mobile application can be used to detect damage on the road very well with accurate results, but also by adding threshold function to the image can know the cracks in
the image more precisely because it will eliminate the smaller edge of pixel intensity of the edge pixel image that had crack.

5. References

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