Monitoring of road damage detection systems using image processing methods and Google Map

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Abstrak. In the traffic environment, accidents often occur due to road conditions with holes. This can be fatal for motorcycle riders and car drivers. Therefore, this paper aims to provide a road contour damage information system by detecting potholes on the highway and reporting damage on Google’s maps. So road users, especially vehicle drivers, can be careful when they want to pass that road. The method used in this paper, which uses Werner D. Streidt algorithm threshold values and edge detection in digital image processing to detect holes in the road, as well as mark the coordinates of hole locations and uploads them on Google’s maps, using the Raspberry Pi two embedded devices as a management center data, with a 6M NEO U-box Global Positioning System (GPS) sensor, as geotagging location and CSI camera interface. A raspberry pi 2 for taking pictures of road surface contours. System testing is carried out in several stages at different times. In daytime conditions, in sunny weather, the system’s success rate in detecting potholes is 83.2%. Whereas with tree barriers, the success rate is 67%, with detection failure 33%. In conclusion, this system succeeded in showing all points of the hole location by giving a mark on the Google Map display application.

1. Introduction
Damage to roads is not a strange thing for Indonesians. Most of the Indonesian people have often encountered damage to a road segment both on alternative roads and main roads. The types of damage are very diverse, generally in the form of cracks (cracking), in the form of waves (corrugation), in the form of grooves / depressions in the direction of extending the road around the track of the vehicle wheels (rutting), in the form of asphalt puddles on the road surface (bleeding), and some are in the form of holes (pothole) [1]. The type of damage that most motorists cause accidents is in the form of a hole (pothole).

Hole detection used by related parties is currently relatively simple, which still relies on information from the public and it is not uncommon for this information to be obtained after an accident occurs at the location of the hole. With these problems, it is necessary to create a road condition information system where this system can segment the location and real conditions in the form of images of holes on the highway. To perform the data segmentation process in the form of images, a special method such asage processing is needed.

From these problems, a research is proposed with the title, "Monitoring Of Road Damage detection systems using image processing methods and Google Map."
1.1 Literature Review
Road damage is caused by many things. Among other things such as cracked roads, bumpy, hollow road [1]. One of the road damages that caused an accident for motorists and drivers was a hole. One of them is by doing early detection of the presence of holes in the road. In 2015, a research was conducted on the application of image processing to the detection of holes on the highway by T. N. R. Kumar [2]. In this study, the detection of holes was carried out using the K-Mean clustering method where it was concluded that the method used had successfully detected holes but did not mention the effectiveness of its success. In 2015, S. Nienaber et al. [3] also carried out a research on the detection of holes on the highway. In this study, the convex hull algorithm method was used where it was concluded that the success of this system was 81.8%. Many studies that discuss information, among others, by SMS gateway aims to develop information systems that can determine the state of conditions or conditions, among others [4-6]. In a study on image processing applications for hole detection on the highway by Himanshu Punjabi, et al. [7]. In this study, the effectiveness of the application of image pixel counting methods, first-order moments, moments or seconds, and cross-correlation where of the four methods the most effective is the current method or the first and second moments with each method. has a strong effect. 100% but not an accurate tool testing method. The five studies above are used as reference and evaluation materials in designing a road damage information system application using image processing in this study. In this study, an information system was developed to detect potholes and location coordinates, and to classify road images. In addition, it can be identified damage to potholes in using the drawing process, as well as marking data, at the location of the existence of potholes, in a form that also marks the Google Maps application. The benefits that can be given are providing preliminary information to road users, so users can take precautions by reducing vehicle speed and increasing vigilance when driving through the road. An important part of this research is the Google Maps Application Programming Interface (API)[8] special Google's server map [9] which includes a database of satellite imagery, road views, altitude profiles, directions, maps with a touch of style, demographics, analysis, and large databases and can be equipped with various specific attributes according to the desire of the programmer, to build areal time application to estimate the camera pose[10]. In the information system to detect information on hole damage on the highway, among others. Figure 1 shows a map of the location that is integrated with the image display.

![Example of using Google Maps API](image-url)
1.1.1 Global Positioning System (GPS)
The navigation system that provides position and time information using satellites. The GPS[8] receiver has data output related to the information above. This data was issued by the association of marine electronic device manufacturers in America, NMEA (National Marine Electronics Association) under the name NMEA-0183 with the header $GPGGA$ [10] decoding explanation in Table 1. In this study, using the GPS module NEO 6 GPS block, as shown in figure 2, with a high-performance position tracking machine, with programming application interface [11-13] using serial TTL (RX / TX), which can be accessed from a microcontroller with UART Function and the default baud speed is set at 9600 bps. Process up to 50 signal channels quickly with Cold TTFF (Cold Start Time-To-First-Fix)

**Table 1.** The GPS code report of NMEA-0183 with header $GPGGA$ [10]

| Position | Content                                      | Example         | Explanation                                                                 |
|----------|----------------------------------------------|-----------------|-----------------------------------------------------------------------------|
| 1        | Header                                       | SGPGGA          | GP is for GPS receiver, GGA – NMEA sentence type                           |
| 2        | UTC time in hours, minutes, and seconds      | 090507          | Time for fix is 5 min 7s after 9 am (GMT)                                   |
| 3        | Latitude                                     | 3540.468        | 35°40.4689° (decimal min not s)                                            |
| 4        | N or S                                       | N               | North                                                                       |
| 5        | Longitude                                    | 13931.896       | 1.39°31.8960°                                                               |
| 6        | E or W                                       | E               | East                                                                        |
| 7        | GPS quality indicator (0=invalid; 1=standalone; 2= Diff, fix) | 1               | Single positioning fix                                                      |
| 8        | Number of satellites in use                  | 8               | Not all satellite in view                                                  |
| 9        | HDOP                                         | 1.42            | Horizontal dilution of position                                            |
| 10       | Antenna altitude                             | 87.672          | Above or below geoid (mean sea level)                                      |
| 11       | Antenna heigh unit                           | M               | Meter                                                                       |
| 12       | Geoidal separation                           | 29.1            | Difference between WGS-84 ellipsoid and geoid                              |
| 13       | Units of geoidal separation                  | M               | Meter                                                                       |
| 14       | DGPS update age                              | 10              | Time in second since last update from reference station                    |
| 15       | Reference station ID number                  | 0515            |                                                                             |
| 16       | checksum                                     | *5B             | Always begin *                                                              |

**Figure 2.** Layout of GPS U-block NEO-6m board [11]

1.1.2. Determine the Image Model
Known as ‘image’ can be interpreted as a representation or similarity of an object. Images are divided into two types namely analog images and digital images. Digital images are divided into three types based on their intensity, including, color images, gray scale images and binary images. Image contrast and brightness settings are the operating point for each pixel of the image. To make images brighter or darker, is by changing the brightness of the image by adding (or reducing) constant b to each pixel, I
(x, y) in the image. Meanwhile, to increase the image contrast multiplying each pixel value, I(x, y) with a constant can be determined in equation 1.

\[ I'(x, y) = a \times I(x, y) + b \]  

To determine the contrast and brightness change algorithm used by Werner D. Streidt can do clipping on the image. Mathematically, the algorithm can be divided into two conditions namely if the contrast value is more than 0 and the contrast value is less than 1. The equation used can be seen in equations 2 and 3.

\[ \delta = \frac{127 \times \text{contrast}}{100} \]
\[ a = \frac{255}{(255 - \delta \times 2)} \]
\[ b = a \times (\text{brightness} - \delta) \]  

Whereas contrast values of less than 1 indicate the equation 3

\[ \delta = \frac{-128 \times \text{contrast}}{100} \]
\[ a = \frac{255}{(256 - \delta \times 2)} \]
\[ b = a \times \text{brightness} + \delta \]  

1.1.3 Comma Separated Value (CSV)
Separated Value is a file storage format in Excel programs where data or values contained in CSV files are separated by comma (,) characters. If you change the row, it is considered new data. One reason information is stored in CSV format compared to standard format (XLS) or XLSX is that files can be exchanged with many people who do not use Excel or for export / import data into database software.

2. Research methodology
In this section, we explain how a hole in a highway is detected using the image method, and the Google map can be seen in Figure 3.
From the flowchart system flow in Figure 2 can be explained as follows.

The first step is to determine the location with the detection of the highway hole. Furthermore, the second step is detected by using an algorithm on unique hole characteristics in the form of changes in the color contrast between the area around the hole with bright colors and the edge area of the hole with intensities that tend to be dark. The third step is to take live video, then determine the ROI with a size of 640 x 480 pixels, convert it to a gray scale using the Werner D Striedt algorithm, then detect the edge of the hole using the Canny method. The fourth step determines the average pixel value of the image with an average value (threshold) ranging from 0.65 to 130. The next step is to save the image requesting location data from the GPS U-block NEO-6m, and save the location data in a Comma Separated Value (CSV) file. Extracting latitude and longitude data that links access to the Google map API script in GMLib, then creates pinpoint geotagging locations. The ublox NEO-6m GPS module serves as a means to determine the location of the hole’s existence with data output in the form of degrees of longitude and latitude. The GPS module is connected to Arduino via the transmitter pin (Tx) of the GPS which is connected to the Arduino 2 pins. The Receiver (Rx) pin is connected to the Arduino 3 pins. To change the function of pin 2 and pin 3 so that it functions as Tx and Rx, serial library software used. Next, the final step is a microSD card breakout board that functions as a data storage location for holes in the form of CSV files. The process of identifying location data requests is run when the system detects a hole in the image. The request is in the form of sending 'get' character data from raspberries to Arduino using the command. Terminal access on UNIX uses the command "struct termios serial; specified characters to be sent, char * str = (char *) "get". The interconnection process between Raspi Cam, Raspberry Pi 2 and Arduino, and the NEO-6m U-block GPS module can be shown in Figure 4.
3. Result and discussion
The results of system testing, from experiments conducted on two road objects with criteria, namely the first test road without lines and signs with lots of tree shadows, and the second test road without lines and signs with few tree shadows. Where each test has five subject periods is due. The testing time starts from 09.00 until 14.00 WIB (Western Indonesia Time). It is around 08.00 hours from GMT. The vehicle's average speed is 20 km/h to 40 km/h when testing the system can be shown in the Table 2. The two type of the road we where test, is to determine the accuracy of potholes detection based on type of the road, and difference vehicle speed, when the system capture the image for image processing, detection and geo tagging can be displayed in the Table 3.

Table 2. Testing on road 1, vehicle speed on average 20k m/h, road without lines and signs with lots of tree shadows

| Number of testing | Number of potholes | Potholes detected | Potholes not detected | Miss detect |
|-------------------|--------------------|-------------------|-----------------------|-------------|
| I (09.00-10.00)   | 12                 | 6                 | 5                     | 1           |
| II (10.00-11.00)  | 12                 | 10                | 2                     | 0           |
| III (11.00-12.00) | 12                 | 11                | 1                     | 0           |
| IV (12.00-13.00)  | 12                 | 11                | 1                     | 1           |
| V (13.00-14.00)   | 12                 | 10                | 2                     | 0           |
| Percentage        | 80 %               | 20 %              | 3.2 %                 |             |

Table 3. Testing on the 2nd road, the average vehicle speed of 40 km/h, the road without lines and signs with little shadow.

| Number of testing | Number of potholes | Potholes detected | Potholes not detected | Miss detect |
|-------------------|--------------------|-------------------|-----------------------|-------------|
| I (09.00-10.00)   | 9                  | 9                 | 0                     | 0           |
| II (10.00-11.00)  | 9                  | 9                 | 0                     | 0           |
| III (11.00-12.00) | 9                  | 9                 | 0                     | 0           |
| IV (12.00-13.00)  | 9                  | 9                 | 0                     | 0           |
| V (13.00-14.00)   | 9                  | 9                 | 0                     | 0           |
| Percentage        | 100 %              | 0%                | 0%                    |             |
As the result of twice system testing on Table 2 and Figure 5, Table 3 and Figure 6 the system performs better with little error on the road without lines and signs with little shadow. From the Werner D. Streidt algorithm (as on equation 2 and 3 the values of a and b are used in several experiments on a number of different hole image samples. From these experiments, it is known that the contrast and brightness values that generally can show the characteristics of a maximum aperture are 200 and 100, as shown in the following Table 4.

**Figure 5.** Image data of test results on a road without markers with lots of shadows

**Figure 6** Image of test results on an unmarked road with a little shadow

**Table 4.** Testing parameter of Werner D. Streidt algorithm for contrast and brightness road characteristics

| Brightness, contrast | Image sampling 1 | Image sampling 2 | Image sampling 3 |
|----------------------|------------------|------------------|------------------|
| 0,0                  | ![Image](image1) | ![Image](image2) | ![Image](image3) |
| 50,100               | ![Image](image4) | ![Image](image5) | ![Image](image6) |
| 100,150              | ![Image](image7) | ![Image](image8) | ![Image](image9) |
In testing the system, the data will be shown the suitability of the detection of pothole by requesting location from GPS u-boxNEO-6m, through the Google Maps GUI application. The results of the test, the data is displayed in a GUI application such as in Figure 7 that has its parameters stored, in CSV format, complete with satellite view of the road.

![Figure 7 Data storage and geotagging on CSV point data](image)

4. Conclusions
System testing is carried out in several stages at different times and type of roads. In daytime conditions, in sunny weather, the system's success rate in detecting potholes is 83.2%. Whereas with tree barriers, the success rate is 67%, with detection failure 33%. In conclusion, this system succeeded in showing all points of the pothole location by giving a mark on the Google Map display application.

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