Record and Library Journal
https://e-journal.unair.ac.id/index.php/RLJ

Volume 5, No. 1, 2019
e-ISSN: 2442-5168

Potholes Asphalt Road Classification by Shape and Area Feature

Paper Type:
Research Paper

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Submitted 28 Macrh 2019
Accepted 30 Macrh 2019
Online 30 September 2019

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Abstract

Background of the study: Generally, during the rainy season, many potholes asphalt road are found. The high rainfall results in the fragile contour of the asphalt road and triggers a traffic accident. In the last decade, the development of potholes asphalt road detection has various method approaches.

Purpose: The research used precision to get a performance of the system.

Method: In this study, the development system can classify potholes asphalt road by a simple algorithm. It also considers the time and space complexity.

Findings: The algorithms as possible and only uses the handy-camera device to capture data which the level of performance as good as the results of previous research. Capturing data is also various distances with 450 point angles. For classification steps, the system applied two main features, area and shape feature of the object. The used parameters for these features are the length of major and minor axis object. It used to calculate area and eccentricity values.

Conclusion: In conclusion, the experiment result reaches 81.696% of the 1125 frames used.

Keywords: *area, classification, pothole, shape*

To cite this document:
Rosita, Y.D., Sugianto. (2019). Potholes asphalt road classification by shape and area feature. *Record and Library Journal*, 5 (1), 72 – 79.

Introduction

This study evaluates the previous research about potholes detection that can bring about a traffic accident. The potholes are caused by the higher rainfall that can fragile and destroy the asphalt road. However, in the last decade, many studies have analyzed pavement crack detection including the potholes. Nevertheless, a trigger of an accident is main caused by the potholes (Budi Sam Law, 2017). In one day a single accident occurred with an average number of 8 incidents due to perforated asphalt roads. According to (Madli, Hebbar, Pattar, & Prasad, 2015), the potholes asphalt road is not only triggers an accidents but also damages vehicle. In order to avoid these problems, the riders are expected to be able to find out the pothole asphalt road that can trigger an accident. Usually, it has an almost round shape and a relatively large size (Koch & Brilakis, 2011; Koch, Georgieva, Kasireddy, Akinci, & Fieguth, 2015; Koch, Jog, & Brilakis, 2012).

The previous discussion determined that the potholes have known by two features that are texture and shape features. The authors also used many methods to identify it such as Support Vector Machine (Li, Hou, Yang, & Dong, 2009), Artificial Neural Network (Bray, Verma, Li, & He, 2006; Xu, Ma, Liu, & Niu, 2008), and Fuzzy method (Ouma, Opudo, & Nyambenya, 2015). There are many precisions for the experiments. Commonly, the average of the experiment precision reached 80% approximately.
In another discussion, the experiment executed more than 10,000 frames, which contained potholes, cracks, patches, and various lightings in objects shadow (Tedeschi & Benedetto, 2017). To collect the data, the authors used a remote-controlled sensing robot vehicle which comprehended with a camera. The authors fit up the disadvantages of their previous study. Besides the image segmentation, the shape extraction, and the texture extraction, they added the texture signature (non-distressed and health area of the pavements) and the pothole tracking in subsequent frames. The result, the experiment get 75% of precision and 84% of recall (Koch et al., 2012).

Another author used mobile devices to detect the pavement cracks commonly that are the potholes, the longitudinal-transversal cracks, and the fatigue cracks. They used Local Binay Patter (LBP) cascade classifier. The algorithm requires the positives and negatives data for the training process. The positives data are the images of pavement cracks and vice versa. However, the amount of data is numerous to get a great classifier. Besides that, it needs more time for the training process. Furthermore, they built up the different classifiers on each of the crack detections to achieve good performance that more than 70% (Tedeschi & Benedetto, 2017).

Our system development allows real-time detection of the potholes road by video-based and uses a simple algorithm to consider time and space complexity. Moreover, the system shows the potholes asphalt road by highlight square line. The paper also shows the architecture system that is divided into 4 sections for classification of potholes road. The first section shows the pre-processing step before the image feature extraction. The second section presents a feature extraction of image by 2 features, shape and area features. The third section determines the values of features. In the last section, it uses the if-then-else concept to decide that the potholes road can cause an accident or not.

Research Method

The research applies the collaborative reasearch methodologies. The data was collected by handy-camera with simple specifications. The aim is to compare with the tools used in previous studies with higher specifications. The data used is in the form of images and videos. Image data is used for training datasets and video data is used for testing datasets. Generally, capturing data uses camera. In another study, in order to get wider coverage, information extraction is needed by High-Resolution Satellite Image (Singh & Garg, 2013, 2014). Automatically, it needs to cost a lot.

Table 1. The Device Specification

Characteristic	Description
Resolution	8 MP

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Optical Zoom	X24
Screen Size	3 inch
Min-max Focal Ler	38mm-190mm
Maximum Shutte	1/1000 s
Video Resolutioı	1920x1080 Pixe
Frame Rate	50 fps
File Format (image and	.jpg, .avi

The data collection location is along the highway in the Mojokerto, Sidoarjo, and Jombang. It needs approximately 2 until 4 weeks with various sun light level. Capturing data of potholes asphalt road is obtained by the height of 140 m and the slope angle of 45^0. The needed duration is 4-5 seconds in each capturing.

To support this research, Matlab is the right tool in digital image processing. We designed the system as simple as possible. Nevertheless, it can detect potholes asphalt road with the equal precision of the previous research and only used the handy-camera. For general architecture system, we divided into three major processes that are pre-processing, feature extraction, and classification. We used a simple algorithm for this study. The system flow is given the below:

1) Read the image
2) Segmentation
3) Binarization
4) Removing noise
5) Morphology
6) Feature extraction
7) Classification of the objects by shape and area feature

Discussion

To obtain the good image, the system has to pre-processes an digital image as an input. The first point until fifth point of the algorithm is steps for pre-processing. Read image process is coversion of continous image to digital image that contains RGB (Red, Green, Blue) color. The digital image is going to convert into grayscale color. For grayscale conversion, we use luminance approach (Cadik, 2008; Kanan & Cottrell, 2012; Macedo, Melo, & Judith, 2015). Each pixel of RGB color is multiplied by the constants the added together.

$$grayscale = (R \times 0.2989) + (G \times 0.5870) + (R \times 0.1140)$$

For the next step, the grayscale image is filtered which calculates the local intensity range of neighborhood around each pixel of an image (Mathworks, 2018). The process well be known as segmentation image process. The intensity range of the pixels of a neighbourhood is computed as equation 2.

$$R = \max(x) - \min(x)$$

Where x is the value of the pixels in the neighbourhood. The neighbourhood is defined by the domain binary mask. Elements of the mask with a non-zero value are considered part of the neighbourhood. By default a 3 by 3 matrix containing only non-zero values is used. At the border of the image, extrapolation is used (Mathworks, 2018).

The next step is defining the foreground and backgound of the image. It is called by binarization image process. It converts grayscale color of the filtering image result to black-white color. It replaces all pixels of grayscale color into 0 or 1 with the specified threshold (Talab, Huang, Xi, & Haiming, 2016). In another research, binarization image by threshold can use local threshold (Chambon & Moliard, 2011). When the value of pixel is greater than threshold value, it replaces into 1 value (white color), and vice versa. Commonly, the binarization image uses Otsu's method. It requires iteration by means of all the possible threshold values and calculates a gauge of spread of pixels at each side of threshold (Makkar & Pundir, 2014).

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After the process, the removing noise is required. Although the filtering image and the binarization were passed, the unexpected small objects still appear. So, we added the processing which can remove the unexpected of small objects. The system eliminates all relevant part (objects) that have fewer than the number of pixels from the binary image.

Furthermore, applying the morphology process is needed to cultivate images by shapes. Morphological operations adjust an arranging element to an input image, making the same size of an output image. The value of each pixel by a comparison of the suitable pixel of the input image with its neighbours. The morphological operation is constructed by the selecting the shape and size of the neighbourhood. Dilation and erosion are the most popular morphological operation. For dilation, pixels are added to the boundaries of objects in an image and removed on object boundaries. These turn on the size and shape of the arranging element used to process the image. Assigning any given pixel in the output applies a rule to the corresponding pixel and its neighbour.

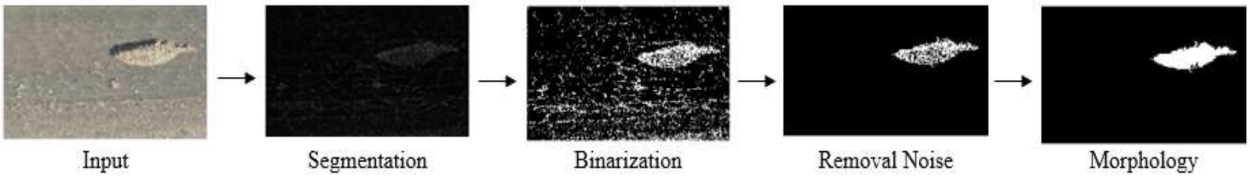

Figure 1. The Pre-processing Result

Feature Extraction

According to eyes perceptions, the potholes road that can cause the accident has 2 features, shape and area feature. For the shape feature, the potholes road almost has round shape that can be calculated by eccentricity (Mente, Dhandra, & Mukarambi, 2014). It can be known the major-minos axis length of it. The more same the lengths of both, the more round the shape. the length is the number of pixels contained in these shapes horizontally and vertically of an object digital image.

$$e = \sqrt{1 - \frac{b}{a}}$$

Notations,
a : the half of major axis length
b : the half of minor axis length
e : the eccentricity

The eccentricity value of round shape is zero (Wikimedia, 2019). The more eccentricity value approaches zero, the more round the shape. We set the maximum of the eccentricity of circle is equal less than 0.85.

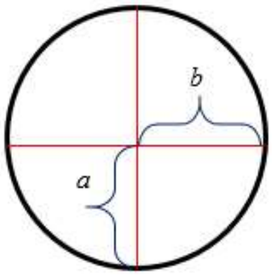

Figure 2. The Half of Major-Minor Axis Length

For the area feature, it only calculates the area (L) of a target digital image. The major-minor axis length can be defined by height-width of an object digital image. For computing the area, we define the semi-major axis and semi-minor axis then use multiplication all of them by phi that it is given by 3.14. The area value of a target digital image which can cause an accident is more than 10000.

$$L = \frac{1}{2} \times (height \times width) \times \pi$$

Classification

In this step, the system can detect the target object by shape and area with “and” operator. We

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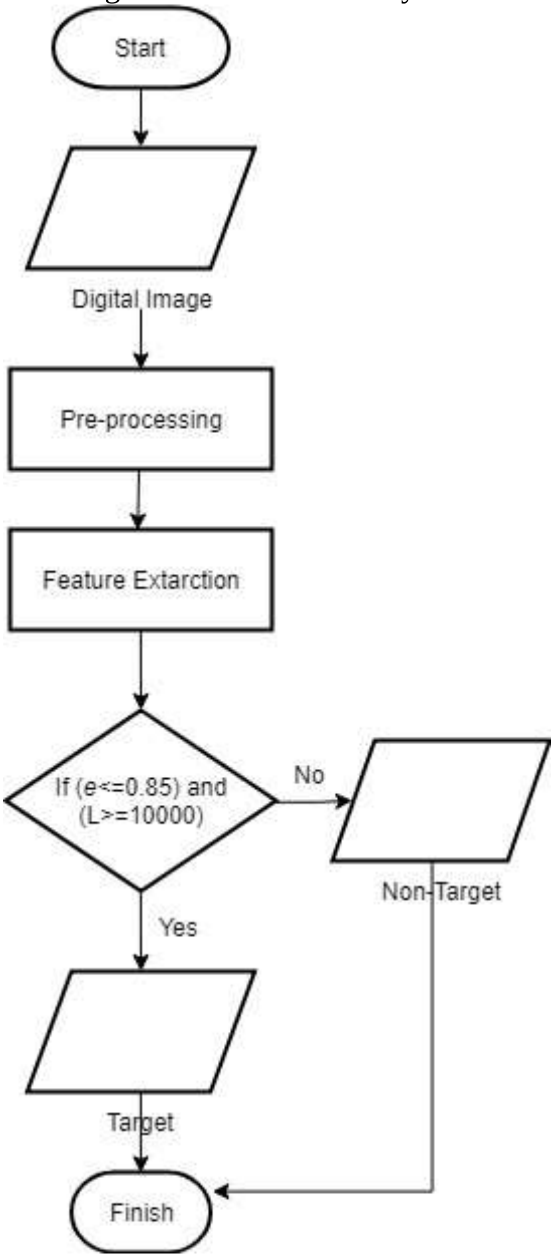
didn't use an exclusive classifier which spent more time and space to get a classifier model because it needs sample data enormously like Gray Level Co-occurrence Matrix (GLCM), linear classifier, neural networks, Support Vector Machine (SVM) (Siddharth, Ramakrishnan, Krishnamurthy, & Santhi, 2012). So, the system only used the if-then concept. The whole system in short is also developed by Prachi More (More, Surendran, Mahajan, & Dubey, 2014). We try to compare with the previous complicated method and this method.
After feature extraction, the system get the object digital image. It will classify the object digital image as the target trigger of an accident or not. If the objectt digital image has met the limits of the eccentricity and area value, the object digital image is a true target.

Figure 3. The Flowhart System



Result

This experiment used 10 videos with duration 3-5 seconds per video. On average, each video has 110 frames. The system processes frame by frame. Each frame will be extracted to get features. The system inserts rectangles on the potholes object. It only detects the object which has a large area and

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eccentricity with strictly 1 value.

Figure 4. The Display Result

In this study, we used precision as a measurement of system performance level. Required parameters include identified objects as True Positive (TP) and unidentified object as False Positive (FP). This measurement is given by the equation (5).

$$precision = \frac{TP}{TP + FP} \times 100\%$$

The research has 10 videos that contain 1125 frames for experiment. Each video has a various precision result. We summarize the result in table 2. The system will display the result by giving a yellow square line for the target like a figure 4. The system detect it by real-time video based.

Table 2. The Device Specification

Description	Frames	True Positive	False Negative	Precision (%)
Video-1	130	87	43	66.93
Video-2	105	77	28	73.07
Video-3	120	119	1	99.18
Video-4	125	101	24	80.80
Video-5	120	100	20	83.54
Video-6	85	70	15	82.17
Video-7	50	42	8	83.83
Video-8	170	151	19	88.6
Video-9	95	66	29	69.02
Video-10	125	112	13	89.73

Based on the experiment result, the system also found objects as non-potholes asphalt road. These are caused by the objects foreground and in classification criterions (area and shape) such as wheel of vehicle or other passing object. In the other hand, the potholes object are unidentified correctly. These are caused by the distance of the object with handy-camera device is relatively far so it looks small and is considered as noise. Nevertheless, the system is capable of achieving a precision rate of 81.696% with simple algorithm and video-based. Finally, precision results are not much different from precision in previous research.

Table 3. The Result of Previous Research

	Feature Extractior	Classifi	Numb	R

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Density and hitogram (B	Neura	25 images (d (non	100% (defect),
Density, proximity and fra et al., 2009	Support V	450 images images	78.4%
Shape (Koch & Bril	If-Th	120	81.6%
Texture (Koch et a	If-Th	1018	75% (
Texture or shape (Tedesc 2017)	Support Vec Artificial N	1000	75.35%

Table 3 shows another method and different number of sample data. Their precision is not more than 85%. The research uses density and histogram features. It also has the prefect precision for defect detection (Bray et al., 2006) although the number of the images is only 25 items.

Conclusion

The distance of the potholes asphalt road affects the classification process. When the object is so far, the object seems small size. The system assumes the small objects as noise. Then, other objects which passing are also still considered as targets. Therefore, it requires the process to recognize the objects as the target or others, such as vehicles, animals, etc. However, it requires a huge number of negative and positive images. Actually, it also needs a more time to training process. According to the experiment, potholes road detection by shape and area feature is usefull although it is only use s simple algorithm and device specification.

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