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A Guideline for Pothole Classification

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ABSTRACT

Recently, damaged pavement like potholes in Korea are increasing due to the climate change such as heavy rains and snow, and thus complaints and lawsuits of accidents related to potholes are growing. Many researchers have studied methods to detect potholes and improve survey efficiency and pavement quality through prior investigation and immediate action. With these detecting methods, there is need for developing a classification guideline for supporting decision-making system of porthole repair. The purpose of this study is to develop a guideline of pothole classification for supporting a decision-making system of pothole repair. In this study, first we review the existing criteria. Next, we collect images of potholes through video recording on a moving vehicle, present a guideline for pothole classification, and apply the guideline to the collected images and pothole 2D DB.

Keywords: *Pothole, Classification, Guideline, DB*

1. INTRODUCTION

A pothole is defined as a bowl-shaped depression in the pavement surface and minimum plan dimension is 150 mm [1], as shown in Fig 1.

Fig 1: Examples of a pothole

Recently, damaged pavement like potholes are increasing in Korea due to the climate change such as heavy rains and snow, as shown in Fig 2 and thus complaints and lawsuits of accidents related to potholes are growing.

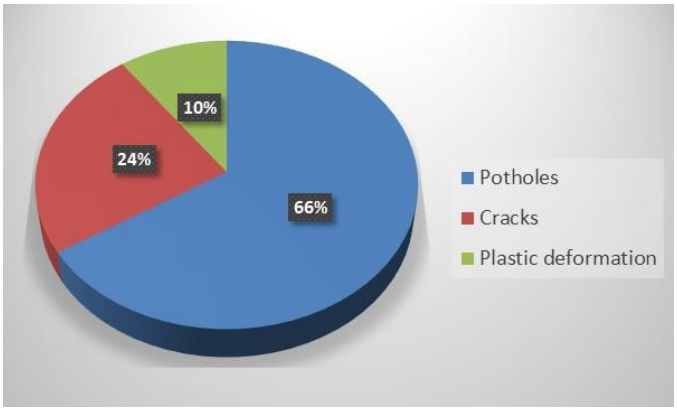

Fig 2: Main types of damages on asphalt roads [2]

Pavement distress detection such as cracks, potholes, etc. mostly performed manually is a labor-intensive and time-consuming. Thus, many researchers have studied methods to detect potholes and improve survey efficiency and pavement quality through prior investigation and immediate action. Existing methods for pothole detection can be divided into vibration-based methods [3–6], 3D reconstruction-based methods [7–13], and vision-based methods [14–19].

With these detecting methods, there is need for developing a classification guideline for supporting decision-making system of porthole repair. Thus, the purpose of this study is to develop a guideline of pothole classification for supporting a decision-making system of pothole repair. In this study, first we review the existing criteria. Next, we collect images of potholes through video recording on a moving vehicle, present a guideline for pothole classification, and apply the guideline to the collected images and pothole 2D DB.

2. RELATED WORKS

There are not many works that have been done until now, related to the pothole classification.
Potholes in Unites States are classified into 3 levels; low (< 25mm deep), moderate (25mm to 50mm deep), and high (> 50mm deep) [1]. Pothole depth is the maximum depth below pavement surface.

Also, Northamptonshire County Council in UK has defined a pothole according to the pothole location and network hierarchy of the asset, as shown in Table 1 [20].

Table 1: The exposure condition of video data and still images in this study [20]

Location	Network hierarchy	Length	Depth
Carriageway	Strategic road, main distributors, and secondary distributors	Greater than 250mm	Greater than 40mm
	Local access roads and link roads	Greater than 250mm	Greater than 50mm
Footway	-	Greater than 75mm	Greater than 20mm

Further, they has defined the maximum permissible time between a pothole being identified and the defect being repaired according to the magnitude of the pothole and the network hierarchy of the asset containing the pothole as follows [20].
1) Emergency: Two hours (a road collapse)
2) Category 1: 5 working days
3) Category 2: 4 months (carriageway) or 2months (footway)

Table 2: Pothole responses for carriage way and footway [20]
(a) Pothole responses for carriage way

Depth \ Hierarchy	Local access road	Link road	Secondary distributor	Strategic route
40mm to 50mm	No action		Category 2	
50mm to 75mm, <30mph	Category 2		Category 1 or 2	Category 1
50mm to 75mm, >30mph	Category 1 or 2		Category 1	
≥75mm	Category 1			

(b) Pothole responses for footway

Depth \ Hierarchy	Little used rural	Busy rural	Busy urban	Main shopping
<20mm	No action			
20mm to 30mm	Category 2		Category 1 or 2	
30mm to 40mm	Category 2	Category 1 or 2	Category 1	
≥40mm	Category 1 or 2	Category 1		

Table 3 shows the classification criteria of potholes in Malaysia [21].

Table 3: Pothole severity classification in Malaysia [21]

	Surface area of a pothole (m^2)		
	<0.1	0.1 to 0.3	>0.3
Depth(mm)	Pothole severity classification		
<25	Low	Low	Moderate
25 to 30	Moderate	Moderate	High
>30	Moderate	High	High

3. VIDEO COLLECTION OF POTHOLES

We collected video data of potholes using a high resolution DSLR camera (1980*1080, 60 f/s) and a Blackbox (1980*1080, 30 f/s) that mounted at the height of a rea-view mirror during movement [22]. Also, stereo cameras (1980*1080, 60 f/s) were installed in front of a survey vehicle using brackets for obtaining 3D point cloud from 2D images,
Fig 3 shows examples of collected images for potholes by DSLR, Blackbox, and Stereo cameras, respectively.

(a) By DSLR

(b) By Blackbox

(c) By left Stereo camera

(d) By right Stereo camera

Fig 3: Examples of collected images for potholes [22]

Total 100 of video clips for potholes were collected through video recording on national highways 6, 37 and 47 from May to June 2014. Also, after building 2D image DB, we implemented a query system for pothole 2D DB, as shown in Fig 4.

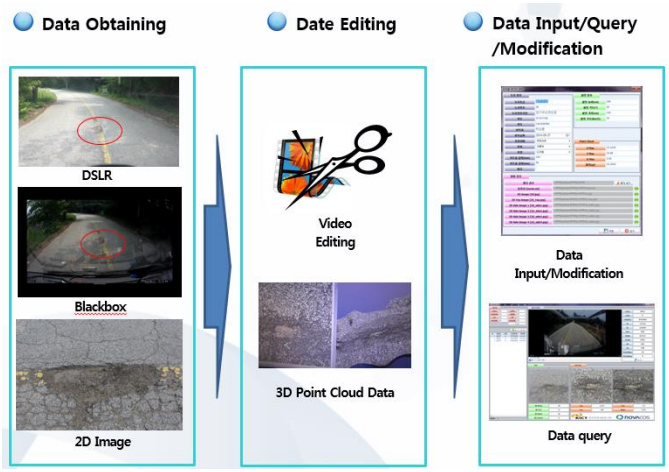

Fig 4: The process of Pothole data collection and DB

4. POTHOLE CLASSIFICATION

We developed a guideline of pothole classification according to location, shape, length, and depth. Also, the developed guideline was applied to the collected images and pothole 2D DB.

4.1 Guideline for classification criteria

First, we can classify potholes by the location, as shown in Tables 4 and 5.

Table 4: Pothole classification by the location of pothole

Classification	Definition	Location
Wheel path	The part touched by the vehicle wheel loads	±0.6m to 1.3m from the center of lane
Non-wheel path_ Center	The center of lane, which is not touched by the vehicle wheel	Within ±0.6m from the center of lane
Non-wheel path_ Edge	The edge of lane, which is not touched by the vehicle wheel	Greater than ± 1.3m from the center of lane

Table 5: The example of pothole classification by the location of pothole

Location	Left of lane	-	Center of lane			-	Right of lane
Criteria	-1.3m more	-1.3m	-0.6m	0m	+0.6m	+1.3m	+1.3m more
Classifi-cation	Non-wheel path_ Edge	Wheel path	Non-wheel path_Center			Wheel path	Non-wheel path_ Edge

Also, potholes can be classified by the shape of pothole, as shown in Table 6.

Table 6: Pothole classification by the shape of pothole

Classification	Definition
Circle	The edges are curved and the ratios of the major axis and minor axis are equal.
Oval	The edges are curved and the ratios of the major axis and minor axis are not equal.
Polygon	Polygon includes squares and diamond shapes.
Mixed	Mixed type
Uncategorized	Classification not possible

Considering the criteria of length and depth in United States, we propose the criteria of length and depth as shown in Tables 7 and 8.

Table 7: Pothole classification by the length of pothole

Classification	Note
≤150mm	X-axis: perpendicular to the running direction of the vehicle. Y-axis: parallel to the running direction of the vehicle. Length of pothole is based on the maximum length of Y-axis.
>150mm	

Table 8: Pothole classification by the depth of pothole

Classification	Magnitude	Repair treatment period
≤25mm	Low	Caution
25mm to 50mm	Moderate	Repair
>50mm	High	Emergency repair

4.2 Application of classification criteria

We applied the developed criteria of pothole classification to the collected images and pothole 2D DB.
First, we categorized the potholes into three groups such as wheel path, non-wheel path_center, and non-wheel path_edge, as shown in Table 9. Among a total of 100 potholes, most of them (86 potholes) were located on wheel path or non-wheel path_edge.

Table 9: The example of classification by criteria of locations

Criteria	The number of potholes	Sample image 1	Sample image 2	Sample image 3
Wheel path	37			
Non-wheel path_ Center	14			
Non-wheel path_ Edge	49			

Next, we categorized the potholes into five groups such as circle, oval, polygon, mixed, and uncategorized, as shown in Table 10. Among a total of 100 potholes, most of them (78 potholes) had the shape of circle, oval, or polygon. The ratio of oval type was biggest as 35% and next one was circle type as 23%.

Table 10: The example of classification by criteria of shapes

Criteria	The number of potholes	Sample image 1	Sample image 2	Sample image 3
Circle	23			
Oval	35			
Polygon	20			
Mixed	12			
Uncate-gorized	10			

Also, we categorized the potholes by the location and shape of pothole, as shown in Table 11. As shown in Table, most of them (29 of 37) in wheel path had circle, oval, or polygon shape and the ratio of oval is biggest as 46%. For non-wheel path_center and non-wheel path_edge, the ratios of circle, oval, and polygon are almost equal.

Table 11: The example of classification by location and shape

Criteria		The number of potholes	%
Location	Shape		
Wheel path	Circle	8	8
	Oval	17	17
	Polygon	4	4
	Mixed	6	6
	Uncategorized	2	2
Non-wheel path_Center	Circle	4	4
	Oval	4	4
	Polygon	4	4
	Mixed	1	1
	Uncategorized	1	1
Non-wheel path_Edge	Circle	11	11
	Oval	14	14
	Polygon	12	12
	Mixed	5	5
	Uncategorized	7	7
Total		100	100

From this result, we can see that the pothole shape on wheel path is likely to be the oval. Also, with this relation between location and shape, we need further study about the mechanism of pothole generating.

5. CONCLUSIONS

The purpose of this study is to develop a guideline of pothole classification for supporting a decision-making system of pothole repair. In this study, first we reviewed the existing criteria. Next, we collected images of potholes through video recording on a moving vehicle, presented a guideline for pothole classification, and applied the guideline to the collected images and pothole 2D DB.

Still we are on the process for converting 2D images to 3D point cloud data. After this work, we can get the detailed information about the length and depth of potholes collected and show the classification of potholes by the combined criteria such as shape-length-depth or location-length-depth. The proposed guideline of pothole classification can well support a decision-making system of porthole repair.

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