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Pothole DB based on 2D Images and Video Data

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ABSTRACT

In Korea, damaged pavement like potholes 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. In order to solve this problem, a new research is being conducted for developing a technology which can detect and recognize potholes based on images, which may contribute to improvement of survey efficiency and pavement quality by prior investigation and immediate action. The purpose of this study is to develop pothole 2D DB based on 2D images and video data as a pre-study of developing a technology detecting and recognizing potholes based on images. In this study, we collect images of potholes through video recording on a moving vehicle, categorize potholes by type of shape and road class based on collected images, and develop a query system for the built pothole 2D DB. The obtained pothole video data and a query system for pothole 2D DB will be utilized for testing algorithms that will be developed to detect and recognize potholes based on images and video data.

Keywords: *Pothole, 2D images, Video data, DB, Query system*

1. INTRODUCTION

A pothole is defined as a bowl-shaped depression in the pavement surface and minimum plan dimension is 150 mm [1]. Potholes can generate damages as follows:

(1) Flat tire & wheel damage
(2) Impact & damage of lower vehicle
(3) Sudden braking & steering wheel operation
(4) Vehicle collision & major accidents

Recently, damaged pavement like potholes are increasing due to the climate change such as heavy rains and snow in Korea, and thus complaints and lawsuits of accidents related to potholes are growing. Tables 1 shows the number of potholes and repair costs for them.

Table 1: The number of potholes and repair costs for them (MLTM, 2013)

Year	National Highway		Freeway		Regional Highway		Total	
	Number of potholes	Repair costs ($)	Number Of potholes	Repair costs ($)	Number of potholes	Repair costs ($)	Number of potholes	Repair costs ($)
2008	20,020	3.3M	10,726	1.7M	67,829	2.2M	98,575	7.2M
2009	27,739	4.5M	12,622	1.8M	65,180	2.8M	105,541	9.1M
2010	49,735	69.8M	16,410	2M	137,073	3.4M	203,218	75.2M
2011	48,214	90.3M	20,797	2.8M	106,399	3.3M	175,410	96.4M
2012	44,537	85.3M	23,678	3.3M	101,534	5M	169,749	93.6M
2013 (July)	46,058	119.7M	12,181	1.9M	126,951	9.2M	185,190	130.8M
Total	236,303	372.9M	96,414	13.5M	604,956	25.9M	937,683	412.3M

In 2008, total number of potholes was 98,575 and in 2013, 185,190 of potholes were observed until July, which is 1.9 times of 2008. Also, repair costs for potholes were increased from 7.2 million dollars in 2008 to 130.8 million dollars in 2013.

Tables 2 shows the number of accidents related to potholes and compensation costs for them.

Table 2: The number of accident related to potholes and compensation costs for them (MLTM, 2013)

Year	National Highway		Freeway		Regional Highway		Total	
	Number of pothole accidents	Comp-ensation costs ($)	Number of pothole accidents	Comp-ensation costs ($)	Number of pothole accidents	Comp-ensation costs ($)	Number of pothole accidents	Comp-ensation costs ($)
2008	4	0.01M	36	0.03M	169	0.31M	209	0.35M
2009	15	0.004M	66	0.08M	299	0.67M	380	0.75M
2010	56	0.05M	249	0.2M	557	0.63M	862	0.88M
2011	92	0.04M	332	0.3M	628	0.42M	1,052	0.76M
2012	85	0.04M	162	0.12M	422	0.29M	669	0.45M
2013	22	0.01M	143	0.1M	886	0.32M	1,051	0.43M

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(July)								
Total	274	0.154M	988	0.83M	2,961	2.64M	4,223	3.62M

From 2008 to July 2013, 4,233 of accidents related to potholes happened. In 2008, total number of pothole accidents was 209 and in 2013, 1,051 of pothole accidents happened until July, which is 5 times of 2008. Among 4,223 pothole accidents, 2,961 accidents happened on regional highway, which is 70.1% of total pothole accidents.

Also, pavement distress detection such as cracks, potholes, etc. mostly performed manually is a labor-intensive and time-consuming. In Korea, in order to solve this problem, a new research is being conducted for developing a technology which can detect and recognize potholes based on images, which may contribute to improvement of survey efficiency and pavement quality by prior investigation and immediate action.

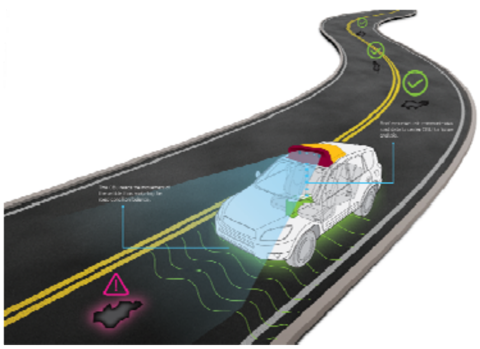

Fig 1: The concept of smart detecting system for pothole

The purpose of this study is to develop pothole 2D DB based on 2D images and video data as a pre-study of developing a technology detecting and recognizing potholes based on images. In this study, we collect images of potholes through video recording on a moving vehicle, categorize potholes by type of shape based on collected images, and develop a query system for the built pothole 2D DB.

By collecting the data of locations and shapes for potholes and processing DB, it is possible to collect various pothole data by shape, to maximize user-friendly convenience and the search efficiency, and to build quick inspection and implementation system. Also, the obtained pothole video data and a query system for pothole 2D DB will be utilized for testing algorithms that will be developed to detect and recognize potholes based on images and video data.

2. RELATED WORKS

Koch and Brilakis presented a method for automated pothole detection in asphalt pavement images using histogram shape-based thresholding, morphological thinning, and elliptic regression [2]. Under the proposed method, the image is first segmented into defect and non-defect regions. The potential pothole shape is then approximated according to the geometric characteristics of a defect region. Next, the texture of a potential region is extracted and compared with the texture of the surrounding non-defect region. If the texture of the defect region is coarser and grainier than the one of the surrounding surface, the region of interest is assumed to be pothole. In order to test the proposed method, it was implemented in MATLAB utilizing the Image Processing Toolbox, and images were cropped from video files captured using a remote-controlled robot vehicle prototype equipped with a HP Elite Autofocus Webcam which was installed at an altitude of about 2 feet as shown in Fig 1. Total 120 images were collected, and 50 images of them were used for training and others for testing. The resulting accuracy was 86% with 82% precision and 86% recall.

However, the method by Koch and Brilakis was limited to single frames and therefore cannot determine the magnitude of potholes in the frame of video-based pavement assessment. In order to complement and improve the previous method, Koch et al. presented an enhanced pothole-recognition method which updates the texture signature for intact pavement regions and utilize vision tracking to track detected potholes over a sequence of frames [3]. The proposed method was implemented in MATLAB and tested on 39 pavement video containing 10,180 frames. The resulting total recognition precision and recall were 75% and 84%, respectively. Consequently, compared with the previous method, the texture-comparison performance was increased by 53%, and the computation time was reduced by 57%. They assumed that only one pothole enters the viewport at a time, and therefore additional work is needed for considering multiple potholes in the viewport.

Recently, Buza et al. proposed a new unsupervised vision-based method which does not require expensive equipment, additional filtering and training phase [4]. Their method deploys image processing and spectral clustering for identification and rough estimation of potholes. The proposed method is divided into three steps such as image segmentation, shape extraction using spectral clustering, and identification and extraction. The proposed method was implemented in MATLAB and tested on 50 pothole images which were selected from Google image collection. The accuracy for estimation of a pothole surface area was about 81%. So, this method can be used for rough estimation for repairs and rehabilitation of pavements.

3. VIDEO COLLECTION OF POTHOLES

To collect video data of potholes, a high resolution DSLR camera (1980*1080, 60 f/s) and a Black Box (1980*1080, 30 f/s) were mounted at the height of a rea-view mirror, and they recorded the road surface ahead during movement as shown in Fig 2. Also, stereo cameras (1980*1080, 60 f/s) were installed in front of a survey

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vehicle using brackets for obtaining 3D point cloud from 2D images. The coordinates of potholes and route information can be obtained using the GPS.

(a) Side view

(b) Front view (Inavi FXD 900 & Sony A77)

(c) Stereo cameras & Brackets

(d) Stereo camera (Model: GOPROHDERO3)

Fig 2: Vehicle and equipment for collection

Total 100 of video clips for potholes were collected through video recording on national highways 6, 37 and 47 from May to June 2014. The exposure condition of video data and still images is shown in Table 3.

Table 3: The exposure condition of video data and still images in this study

Exposure condition	Video data	Still Images
Height	180Cm	160Cm
Angle	40°	40°
Distance	50m	2m
Speed	40Km/h	0Km/h

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

4. A QUERY SYSTEM FOR POTHOLE DB

We categorized potholes by type of shape and road class through the collected pothole video clips and built 2D image DB of potholes using data management program as shown in Fig 4.

Fig 4: Pothole data management program

Also, after building 2D image DB, we implemented a query system for pothole 2D DB as shown in Fig 5.

Fig 5: Query system for Pothole 2D DB

A query system for pothole 2D DB consists of DB, PC, and operating S/W (viewer). As shown in Fig 5, this system has a query function by condition and can display 2D image, point cloud data, and additional information of a corresponding pothole for a selected video. The PC consists of core i5-3230M (Dual 2.6GHz), RAM 8G, HDD 1TB, etc.

Fig 6 shows the display of the location information of a pothole on Google Map.

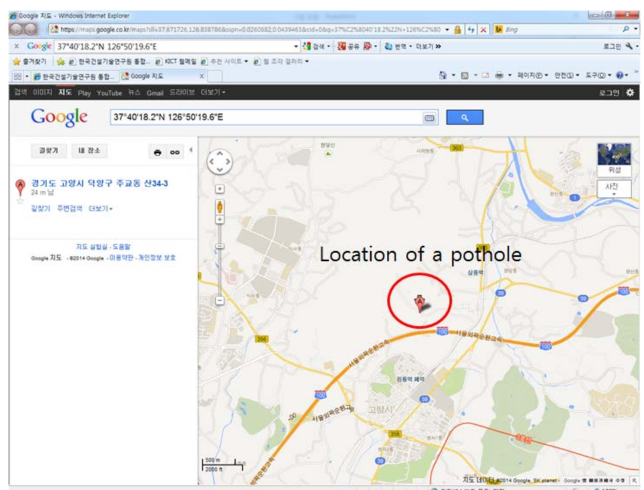

Fig 6: The example of location information display of a pothole on Google Map

5. CONCLUSIONS

In this study, before developing a technology detecting and recognize potholes based on images, we collected pothole images through video collection on a moving vehicle, categorized potholes by type of shape based on collected images, and developed a query system for built pothole 2D DB.

Still there is the need for detailed categorization according to the pothole position within the lane, the shape, length, depth, severity, etc. The obtained pothole video data and developed query system for pothole 2D DB will be utilized for testing algorithms that will be developed to detect and recognize potholes based on images and video data.

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