IJCSE International Journal of Computer Sciences and Engineering Open Access
Review Paper Vol.-7, Issue-2, Feb 2019 E-ISSN: 2347-2693

A Review Paper on Pothole Detection Methods

Jetashri R. Gandhi[1*], U. K. Jaliya[2], D. G. Thakore[3]

[1,2,3]Dept. of Computer Engineering, Birla Vishvakarma Mahavidyalaya, V.V. Nagar, Anand, Gujarat, India

[*]*Corresponding Author: jetashrigandhi3ce@gmail.com*

DOI: https://doi.org/10.26438/ijcse/v7i2.379383 | Available online at: www.ijcseonline.org

Accepted: 22/Feb/2019, Published: 28/Feb/2019

Abstract- The growth of a country depends on the transportation services for traveling safely. Many distresses of asphalt pavements are responsible for the unsafe pavement surface. Potholes are the main reason for the distress of pavement. For detecting and repairing asphalt pavement having potholes, many methods are proposed in the literature for detecting potholes. There are many reasons for the distress of pavement surfaces like heavyweights of vehicles, an unspecified amount of materials, and environmental changes. In this paper, different methods are surveyed like vibration-based method, 3D Reconstruction, and vision-based method for detecting potholes. The vibration-based methods use an accelerometer, 3D laser method uses laser sensor, and vision-based method uses different image processing techniques for detecting potholes. 3D Reconstruction includes 3D laser method, Stereo Vision method, and Kinect Sensor method. The Vision-based method includes a 2D image-based method and Video-based method. In this review paper, the advantages and disadvantages of various methods are also discussed.

Keywords- Potholes, Vibration-based method, Vision-based method, Stereo vision method, Image processing.

I. INTRODUCTION

Traffic is one of the common problems in India. It causes accidents and trouble driving. The reasons for these problems are climate change in a pavement, heavy rainfall, and fog on roads, potholes, and overloaded vehicles. Here, we discuss potholes on the roads that cause problems while driving. A pothole can be defined as a depression in the pavement having a bowl-shape [1]. Due to potholes lower part of the vehicle gets damaged.

Maximum accidents are reported due to a pothole. It also depends on the quality of roads which are different in rural areas and urban areas. On British roads, there are many vehicles gone through pothole-related damages. Billions of pounds are spent to maintain the road and millions of pounds are spent in compensation by local councils.

It is difficult to find the size of potholes and report it to the current system. However, much information about pothole is affecting the patching like its size and severity. There are many methods for automatic pothole detection such as machine vision [10]. It only requires a camera as an input. Some of the approaches are based on the composition of road which results in low accuracy [10].

The main reason behind misdetection is due to variation in lighting conditions [21]. We can put the system for vehicles patrolling like a police van for continuous detection and evaluate the pothole. Real-time pothole detection will reduce the requirements of data storage [21]. In this paper, we study different approaches to detect potholes. The following is a list of methods to be discussed in this paper.

Methods List:

1. Vibration-based method
2. 3D Reconstruction
3. Vision-based method

In this review paper, we studied different methods with different sub-techniques. By analyzing these techniques, we find that vision based method use image processing techniques for finding potholes without using any equipments. It will improve the accuracy and reduce the time needed for finding potholes.

The rest of the paper is designed as follows. Section II involves Pothole Detection methods, section III contain Other Approaches in the Literature and section IV shows a summary.

II. POTHOLE DETECTION METHODS

There are many methods used to detect the potholes, which are vibration based method, 3D reconstruction based method and vision based method.

2.1 Vibration based method

For detecting the potholes, an accelerometer is used in this method. A vibration-based method is used in real-time

© 2019, IJCSE All Rights Reserved

processing and requires less storage. To develop this system, preliminary evaluations of pavement condition [12] use recent data acquisition hardware. The desolation of the pavement enforces impacting forces on the vehicle.

With the help of recorded responses of a test vehicle, pavement surface conditions can be estimated [21]. There are many advantages of this system such as cost-effective, smaller storage requirement and real-time data processing [21].

To monitor environmental pollution, BusNet sensor network [2] is used which are seated on public transport buses. Acceleration readings are taken and transmitted through BusNet which is collected by Main Station through central collection point [2],[21]. This method could give wrong results for the following cases: It detects hinges and joints [21] of the road as pothole even if it is not the case. Secondly, it cannot detect the potholes in the middle of the lane [21].

Mednis et al. proposed a mobile sensing system [5] for road, inconsistency detection with the help of Android OS based smartphones [4],[5]. They used 4.4 km long track for the testing with 10 consecutive laps. Using real-world data, this algorithm presented 90% true positive rate [21].

2.2 3D Reconstruction

For the detection of potholes in real time, a laser scanning system is used in the 3D reconstruction. As we know, the equipment used in laser scanning is much higher at the vehicle level.

3D Reconstruction can be classified into three different categories.

1) 3D Laser method
2) Stereo Vision method
3) Kinect Sensor method

2.2.1 3D Laser method

This method uses the reflected laser pulses [1],[7], which is used to create a digital model of the object. With the help of grid-based processing approach [21], the accurate 3D cloud points are captured during canning and focusing on distress features [21]. This method will accurately calculate the amount of materials needed to fill the potholes.

Chang et al. represent that scanning and extracted focusing on particular distress features were captured with accurate 3D cloud points with their elevation with the help of a grid-based approach [13]. Using this method, the required amount of materials can be calculated accurately and automatically with the help of severity and coverage of distress [13],[21].

Li et al. present inspection system [14], which is used to detect distress features like potholes, rutting and shoving with the help of 3D transverse scanning techniques [14], which is a high-speed technique. This technique uses laser line projector having infrared waves and a digital camera [14] for detecting potholes and other distress features. By using multi-view coplanar scheme [11], this system improves an accuracy employed by a calibration procedure which uses more feature points and shared across the field of the camera [21].

2.2.2 Stereo vision method

This method needs high computational effort in reconstruction of pavement surface [11], with the help of matching feature points. It is not useful in real time environment. It is necessary to accurately align both the cameras, if it is not aligned perfectly then it will directly affect the quality of the outcome in case of vibration of vehicle motion [11].

Stereo vision method [6] uses two digital cameras, which covers a pavement surface [11]. There are two steps in this method. They first analyze 2D images using both the cameras for detection and classification of cracks. The results of two source images are then combined so that missed cracks are counted in it which increases the accuracy [11]. Using a pair of images of the same pavement, they can establish a 3D surface model. They also found longitudinal and intersecting profiles [21] via geometric modeling.

There are sequences of steps performed to recover the 3D properties from 2D image pairs, they are camera calibration, distortion correct, matching stereo points, 3D reconstruct, and profile report should be performed [11],[21]. A total of 4 cameras in two pairs to collect the images of the pavement surface were used for an experimental platform, DHDV (Digital Highway Data Vehicle) [11],[21] survey vehicle was used. They present feasibility after applying stereovision as a preliminary result [11],[21].

2.2.3 Kinect sensor method

This method uses the Kinect sensors which will collect the depth images of pavement. It is used to find the volume of a pothole [1]. Images of Roads made from concrete and asphalt were collected using a low-cost Kinect sensor. For better visualization purpose meshes were generated. Depth is used to analyze the area of a pothole. Using trapezoidal rule, the volume of the pothole was calculated which uses area depth curves.

Joubert et al. [16] present a low-cost sensor system which uses a kinect sensor [16] and a high-speed USB camera [16] for detecting and analyzing potholes. Some experiments were done on using Kinect to examine potholes. This method is cost effective [11],[21]. It is necessary to research

© 2019, IJCSE All Rights Reserved

further in infrared technology based on the Kinect sensor to improve in error rate.

2.3 Vision-based method [10]

Vision-based pothole detection can be classified into two different categories

1) 2D Image-Based Approaches [1],[8]
2) Video-Based Approaches [1]

2.3.1 2D Image-based approaches

In 2D Image-based approach [1],[8], the image is segmented into a defect and non-defect regions [1],[21]. With the help of graphic characteristics of a faulted region, the shape of a pothole can be approximated. The composition of a region is obtained and relate with the composition of a defected region [1],[2] if the composition detected to be coarser and grainier than the region of interest is supposed to be a pothole.

Buza et al. represent an unsupervised vision-based method [16]. This method does not require expensive equipment, filtering, and training phase [16],[23]. They use image processing and clustering techniques for identifying potholes [21]. The method consists of three steps as follows:

1. Image segmentation
2. Shape extraction
3. Identification and Extraction

Using this method, they get 81% accuracy [21], which can be used as a rough estimation for repairs of a pothole.

2.3.2 Video-based approaches

Lokeshwor et al. presents a method for the detection of potholes, cracks, and patches from video clips [18]. The segmentation of video clips is done undoubtedly into two frames named, stressed and distressed category using the DFS algorithm [18],[21].

The distress frames database is processed using CDDMC algorithm [1]. CDDMC consist the steps like image enhancement, detection, segmentation, classification, visual properties extraction and quantification [1]. There are three visual properties which are used by decision logic for potholes, cracks, and patches. Those are standard deviation, circularity, and average width [1],[3],[21].

2D image-based method [1],[8] detects potholes from the single frame, but it cannot find the consequence of potholes. To overthrow this disadvantage of a 2D image-based method, video-based methods were introduced. These methods were used to find a pothole and count the total number of potholes in the sequence of frames [21].

Jog et al. proposed 2D recognition and 3D reconstruction [17] for the detection and measurement of potholes. With the help of a camera seated on the car [17], they can find the pothole and its measurements like width, number, and depth [21].

Another method was proposed by Koch and Brilakis [20] which is bounded to single frames so that it cannot find the magnitude of potholes from video-based pavement assessment frames [21]. Koch et al. give a pothole-recognition method [20] with an updated composition signature for perfect pavement regions and apply vision tracking to track detected potholes [20] from all the frames.

III. OTHER APPROACHES IN THE LITERATURE

3.1 Amila Akagic et.al in their paper discussed the vision-based method [1]. Analyzing RGB color space and performing image segmentation asphalt pavement are detected and the search continues in a detected region only. The results indicate that the method can be used as a pre-processing step [1].

3.2 Kanza Azhar et.al discusses pothole detection using computer vision[15] will detect pothole and non-pothole images [15]. Using Naive Bayes classification the system is trained and classify as a pothole or non-pothole [15] labels to the input image. It gives 90% accuracy for the detection of potholes [15].

3.3 Dong-Won Jang et.al says in their paper about the spatio-temporal saliency [3] method detects outliers. The object is slower than it is diagonal outliers [3]. The proposed method is effective for real video sequence containing potholes [3].

3.4 Yashon O. Ouma et.al states in their paper about a priori integration using wavelet transform[19] used for finding defects and non-defects[19] region using fuzzy c-means algorithm [19]. The mean CPU run-time was 95 seconds, the Dice coefficient of similarity[19] obtained was 87.5%, Jaccard Index[19] was 77.7% and sensitivity metric[4] is 97.6% [19].

3.5 Aravinda S. Rao et al. states that computer vision based pothole detection method is used to assist blind people [5]. In this system, laser projection is used to record the patterns and then analyze it to extract feature. Using this method, they get 90% accuracy in detecting potholes [5].

3.6 Akshata Bhat et al. shows detection of potholes using a camera attached to light poles [22]. Using image processing techniques the BMC officials are informed using the email system. This method was implemented using OpenCV library. They use canny edge and contour detection with the hough transform for effective pothole detection [22].

3.7 Ajit Danti et.al adopts a transformation method [7] for lane detection. They use color segmentation and shape

© 2019, IJCSE All Rights Reserved

modeling with the help of the nearest neighbor classifier [7]. They also use k-means clustering for pothole detection. Hence, the experiment was made to design driver guidance [7] to make the driving automated and safe. The results were tested on a real-time image databases which is collected from different roads.

3.8 Seung-Ki Ryu et.al shows a pothole detection method based on 2D images [23] for improving the existing method. For testing purpose, they used 2D road images in Korea collected by survey vehicle and compared with the existing method. They used different conditions such as road, recording, and a brightness[23] and the results were good. They collected the information using this method and use it for the maintenance of the road.

3.9 Nilam kumbhar et.al designs a system in their paper which will detect the potholes on the road. They used ultrasonic sensor [9] to measure the depth of the pothole. With the help of image processing, they captured the image of that pothole which will provide the size of pothole such as large, medium, small [9]. GSM will send the SMS having information about the pothole [9].

3.10 Zhen zhang et.al discuss a stereo vision[10] based pothole detection system. Potholes can be detected by using the discrepancy map used from an efficient discrepancy calculation algorithm[10]. They produce a size, volume, and the position which unable the pothole repair according to its harshness. The quadratic road surface model was used for camera orientation variation, road drainage and up/down hill gradients [10]. Experimental results were satisfactory in various scenarios for finding potholes.

IV. SUMMARY

This paper consists of a review of the current pothole detection methods and the main use of each method with their principle ideas. All the methods have their own pros and cons. Among them, the vision-based method is more accurate and needs less equipment, which will reduce the cost of detecting potholes.

REFERENCE

[1] A. Akagic, E. Buza, S. Omanovic "Pothole Detection: An Efficient Vision Based Method Using RGB Color Space Image Segmentation", In the proceeding of the 2017 IEEE conference on MIPRO, pp. 1104-1109, 2017.

[2] K. D. Zoysa, C. Keppitiyagama, G. P. Seneviratne, and W.W.A.T. Shihan, "A public transport system based sensor network for road surface condition monitoring", In the proceedings of workshop on Networked Systems for Developing Regions, pp. 1-6,2007.

[3] D. Jang, R. Park, "Pothole detection using spatio-temporal saliency", IET Intelligent Transport Systems, pp. 605-612,2016.

[4] A. Mednis, G. Strazdins, R. Zviedris, G. Kanonirs, and L. Selavo, "Real time pothole detection using Android smartphones with accelerometers", In the proceedings of the International Conference on Distributed Computing in Sensor Systems and Workshops, pp. 1-6,2001.

[5] A. S. Rao, J. Gubbi, M. Palaniswami and E. Wong, "A Vision-Based System to Detect Potholes and Uneven Surfaces for Assisting Blind People", IEEE ICC 2016 SAC E-Health, 2016.

[6] K. C. P. Wang, "Challenges and feasibility for comprehensive automated survey of pavement conditions", In the proceeding of 8th International Conference on Applications of Advanced Technologies in Transportation Engineering, pp. 531-536, 2004.

[7] A. Danti, J. Y. Kulkarni, and P. S. Hiremath, "An Image Processing Approach to Detect Lanes, Pot Holes and Recognize Road Signs in Indian Roads", International Journal of Modeling and Optimization, Vol. 2, No. 6, pp. 658-662, December 2012.

[8] C. Koch, and I. Brilakis, "Pothole detection in asphalt pavement images", Advanced Engineering Informatics, Vol. 25, pp. 507-515, 2011.

[9] N. Kumbhar, D. Mhetre, A. Mujawar, S.T.Khot, "POTHOLE DETECTION USING IMAGE PROCESSING", International Journal For Technological Research In Engineering, Vol. 3, Issue. 9, pp. 1887-1889, May-2016.

[10] Z. Zhang, X. Ai, C. K. Chan and N. Dahnoun, "AN EFFICIENT ALGORITHM FOR POTHOLE DETECTION USING STEREO VISION", IEEE International Conference on Acoustic, Speech and Signal Processing (ICASSP), pp. 564-568, 2014.

[11] E. Salari, E. Chou, and J. J. Lynch, "Pavement distress evaluation using 3d depth information from stereo vision", Tech. Rep., 2012.

[12] B. X. Yu, and X. Yu, "Vibration-based system for pavement condition evaluation", In proceeding of the 9th International conference on Applications of Advanced Technology in Transportation, pp. 183-189, 2006.

[13] K.T. Chang, J. R. Chang, and J. K. Liu, "Detection of pavement distress using 3D laser scanning technology, Conference on Computing in Civil Engineering, pp. 1-11, 2005.

[14] Q. Li, M. Yao, X. Yao, and B. Xu, "A real-time 3D scanning system for pavement distortion inspection", Measurement Science and Technology, Vol. 21, No. 1, pp. 15702-15709, 2009.

[15] K. Azhar, F. Murtaza, M. H. Yousaf, H. A. Habib, "Computer Vision Based Detection and Localization of Potholes in Asphalt Pavement Images", In proceeding of the IEEE Canadian Conference on Electrical and Computer Engineering (CCECE), 2016.

[16] Buza, E. S. Omanovic, and A. Huseinnovic, "Stereo vision techniques in the road pavement evaluation", on Information Technology and Computer Networks,, pp. 48-53, 2013.

[17] G. M. Jog, C. Koch, M. Golparvar-Fard, and I. Brilakis, "Pothole properties measurement through visual 2D recognition and 3D reconstruction", In Proceedings of the ASCE International Conference on Computing in Civil Engineering, pp. 553-560, 2012.

[18] H. Lokeshwor, L. K. Das, and S. K. Sud, "Method for automated assessment of potholes, cracks and patches from road surface video clips", Procedia – Social and Behavioral Sciences, Vol. 104, pp.312-321, 2013.

[19] Y. O. Ouma, M. Hahn, "Pothole detection on asphalt pavements from 2D-colour pothole images using fuzzy c-means clustering and morphological reconstruction", ELSEVIER, pp. 196-211,2017.

[20] C. Koch, G. M. Jog, and I. Brilakis, "Pothole detection with image processing and spectral clustering, Journal of Computing in Civil Engineering, Vol. 27, No. 4, pp. 370-378, 2013.

[21] T. Kim, S. Ryu, "Review and Analysis of Pothole Detection Methods", Journal of Emerging Trends in Computing and Information Sciences, Vol. 5, No. 8, pp. 603-608, August 2014.

[22] A. Bhat, P. Narkar, D. Shetty, D. Vyas, "Detection of Potholes using Image Processing Techniques", IOSRJEN, Vol. 2, pp. 52-56, March 2018.

© 2019, IJCSE All Rights Reserved

[23] S. Ryu, T. Kim, and Y. Kim, "Image-Based Pothole Detection System for ITS Service and Road Management System", Hindawi Publishing Corporation, Vol. 2015, pp. 1-10, April 2015.

AUTHORS PROFILE

Miss. Jetashri R Gandhi pursed Bachelor of computer science and engineering from Gujarat Technological University in 2012 and currently pursuing masters in computer engineering from Birla Vishvakarma Mahavidyalaya, VVnagar, Anand, Gujarat, India.

Dr. Udesang K Jaliya pursued Bachelor of Engineering in Computer Engineering and Master of Engineering in computer engineering. He also pursued Ph.D. and currently working as Assistant Professor in Department of Computer Engineering, in Birla Vishvakarma Mahavidhyalaya, VVnagar, Anand, Gujarat, India. He has published more than 35 research papers in reputed international journals and national journals conferences including IEEE and it's also available online. He received Best Paper Award in IEEE Sponsored International Conference on Data Mining and Advanced Computing. He has 15 years of teaching experience. He also Guided more than 20 Project of master level. He also published 2 Books related their field area. He is also registered as a PhD supervisor at GTU.

Dr. Darshak G. Thakore pursued his Bachelors of Engineering from Sardar Patel University (SPU) and Master of Technology from IIT-Delhi. He pursued his PhD from M.S University, Vadodara, Gujarat, India and currently working as Professor and Head of Computer Department in Birla Vishvakarma Mahavidyalaya. He has professional membership of ISTE, India. He successfully presented and published multiple papers in national journals and international journal. His main research work focuses on Digital Image Processing. He has 25 years of teaching experience along with research experience and 4 months of industry experience.

© 2019, IJCSE All Rights Reserved