ILLINOIS ASPHALT PAVEMENT ASSOCIATION (IAPA) SCHOLARSHIP

THE AUTOMATED DISTRESS DETECTION IN PAVEMENTS - A LITERATURE REVIEW ON THE INNOVATION METHOD

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ABSTRACT

The purpose of this literature review is to explore the recent advancement in assessing pavement distresses on asphalt concrete pavements using automated devices. The manual method is time-consuming, labor-intensive, and has a safety hazard for the surveyor compare to the automated detection method. This literature review presents a few current studies on this automated innovation to detect and assess potholes on highways before rehabilitation and maintenance. If this innovation is worth implementing, it will replace the manual method and save time and money for transportation agencies.

INTRODUCTION

Road Rehabilitation and maintenance are routine tasks to be carried out to give the road an acceptable quality for users. Timely and well-maintained roads will reduce clashes, reduce wear and tears on vehicles, and decrease delays. To effectively carry out these maintenance tasks, the pavement surface needs to be assessed for distresses.

Pavement distresses are irregularities on the road pavement surface that decreases road users' comfort and safety and indicates the road pavement's failure. Different causes related to climate, traffic, and construction techniques will give different types of pavement distresses. The examples of distresses and their causes in this review are longitudinal and transverse cracks (Figure 1(b) resulted from shrinkage or contraction of the pavements and potholes (Figure 1(a), which are caused by watering seeping into the cracks and grow into a hole. Potholes develop from cracks, and the parameters to assess their severity are the diameter, depth, and the number on a stretch. Parameters to assess cracks are their severity indicates by are crack width. Another type of pavement distress is rut depth caused by deformation in pavements and measured by the rut depth.

(a)

(b)

Figure 1. (a) A typical pothole and (b) Longitudinal cracks.

If these potholes and cracks and not assessed and various maintenance strategies are not done on time, it will damage the vehicles, reduce the safety and comfort of road users, and reduce the area's economic activities. The pavement distress assessment can be done either manually or automatically.

Manually, the pavement surface video and profile data collected by digital inspection vehicles are reviewed by engineers to detect and assess distresses. This method is usually time-consuming and costly. Researchers are working tirelessly to develop an automated detector that will detect and assess potholes on asphalt pavements. This will be less time-consuming and less costly. This paper aims to do a limited literature review on current research to access pavement distress through automated methods.

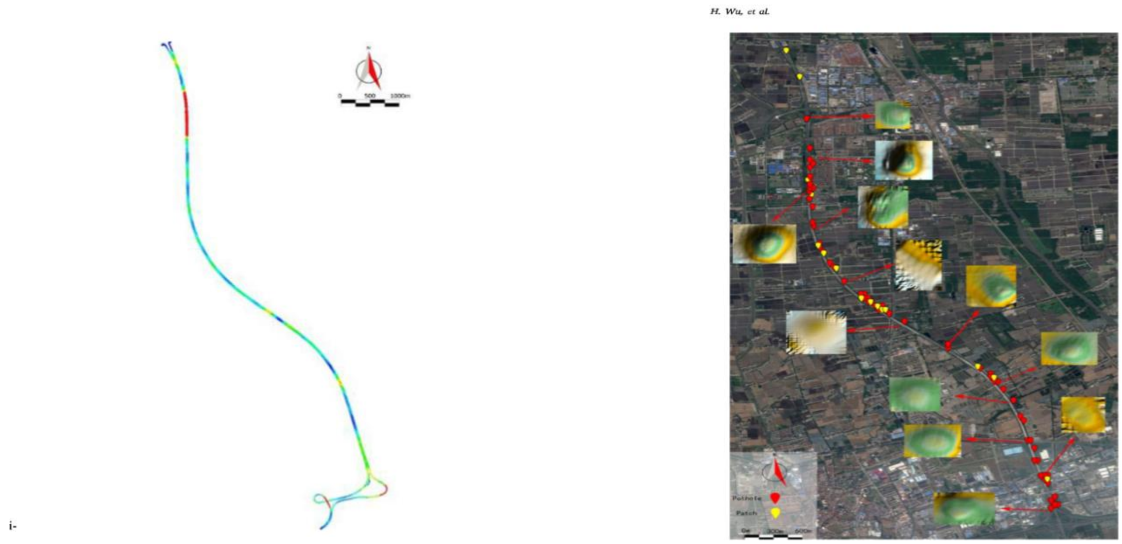
LITERATURE REVIEW

Wu et al. (2019) worked on point cloud and image methods to detect pavement distresses. Previously, visual surveys were traditionally used, and later several types of potholes extraction methods have been developed using mobile apps, images, and laser scanning clouds. The images show potholes' location but do not measure the length, width, and depth of the potholes. Laser scanning can extract the size and depth of potholes but is affected by the resolution or point cloud, thereby reducing the accuracy.

A new method based on combined laser scanning point clouds and image derived from mobile apps was used to address these issues. A pothole’s image is taken, and its width and length are estimated by software, then a scanner measured the depth of the potholes by a method called point clouds. The results were obtained from an experiment carried out in the Express G15 in Shanghai – China, to verify this method's validity using a Mobile Mapping System (MMS) that adopts laser scanners and a panoramic camera (Figure 1) were done. The data collected on the 26.4 km road section showed that, out of the total of 77 potholes, 49 were successfully identified by this method as potholes, about 63.6% success.

Figure 2. Set up of laser camera and panoramic camera used in the study (Wu, H. *et al.*, 2019).

A simulation experiment for the Geometric accuracy evaluation on the Campus of Tongji University using Manhole covers (Figure 2(a) and (b)) with known dimensions distributed on the campus, showed that the mean geometric accuracy of this same MMS method is approximately 1.5 to 2.7cm.

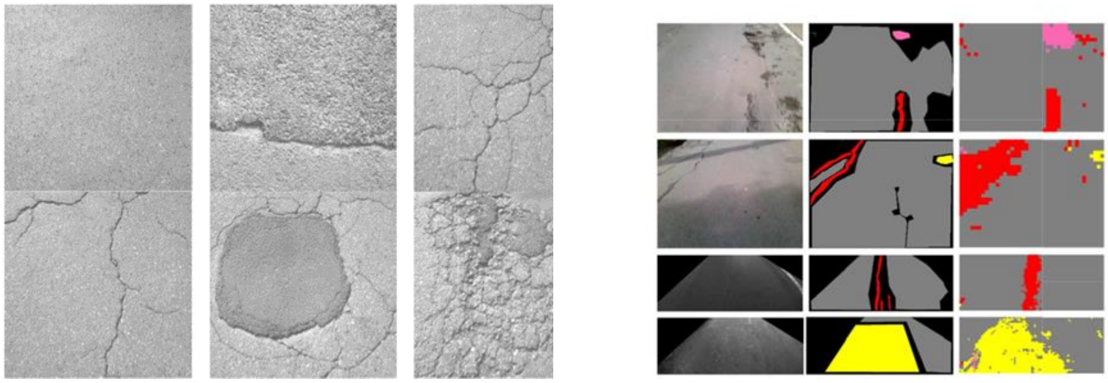


(a) (b)

Figure 3. (a) and (b) shows the road section and the simulation in the Tongji Campus (Wu, H. *et al.*, 2019).

Therefore, this method is only suitable for a higher investigation rate of potholes, which can be used for subsequent measurements. Further research should be carried out to improve on accurate and successful identification.

Radopoulou et al. (2016) used the Parking Camera, GPS, Car's accelerator, and driver's mobile phone for automated pavement distress assessment method. In this method, the parking camera's information is processed to detect pavement distresses, which are then processed to detect surface defects. The accelerator helps to detect the defects along the pavement's vertical axis while the GPS helps to give the Geolocation of the points. The defect type, location, and pixels are then classified according to the severity using the Road Condition Index (RCI). This information is stored in the Pavement Management System (PMS).



(a) (b) (c) (d)

Figure 4 (a) to (d) shows an example of Pavement images, example ground truth along with the original video, and the results, respectively (Radopoulou *et al.*, 2016)

For this framework, data was collected from the local streets of Cambridge- Uk. The results gave an accuracy of 84%, and the best results were obtained from color video frames, not monochrome videos. This approach is used to know the general state of paved road degradation and cannot be used for road degradation assessment. More research is, therefore, still needed to give better accuracy.

Koch et al. (2013) worked on the Asphalt pavement video data method to assess pavement distress. The Automated Pothole Distress Assessment using Asphalt Pavement video data where an increased pothole recognition method that uses vision tracking to track detected potholes over a sequence of frames (Figure 5). This enables the potholes to count in pavement videos, avoid inefficient redetection, and match every frame, resulting in a significant processing time reduction.

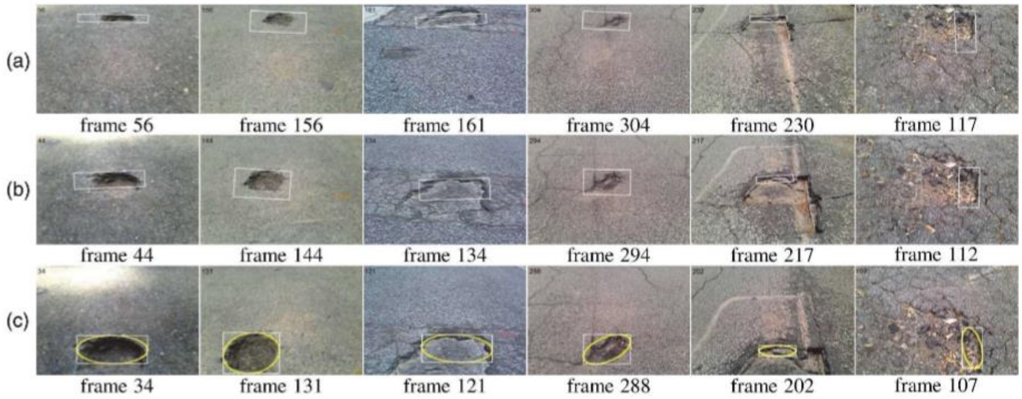


Figure 5 . shows selected potholes-recognition results in pavement videos (Column by Column) (a) tracking results; (b) tracking results; (c) detection results (Koch *et al.*, 2013).

Using a remotely controlled sensing robot vehicle (Figure 6) equipped with a webcam, tested on 39 pavement videos containing more than 10000 frames, provided a wide variety of potholes (shapes, sizes, and texture), other distresses like cracks and patches, and diverse lighting conditions in terms of shadows.

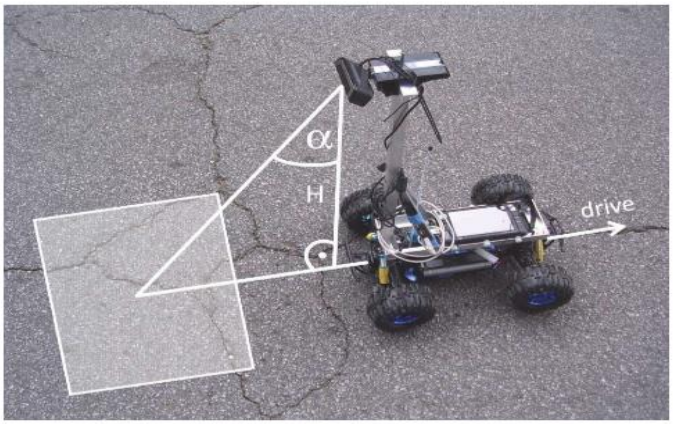


Figure 6. shows a remotely controlled sensing Robot vehicle for the experiment (Koch et al., 2013)

The results show that this method can successfully recognize and count potholes with a precision of 75% and a recall of 84%. Compared with the previous method where images and videos were collected by digital inspection vehicles, reviewed by technicians on the computers, and manually detected and assessed potholes distress, the performance was increased by 53%, and the computation time was reduced by 57%.

Ji *et al.* (2020) used the integrated approach method to assess distresses on pavements. This proposes an integrated approach to automatically detect and quantify cracks in asphalt pavement at the pixel level for operation and maintenance. This approach is based on:

1. A Convolutional Neural Network Deeplabv3+ that can achieve automatic crack detection in asphalt pavement at the pixel level.
2. A crack quantification algorithm can quantify five aspects of detection cracks in pixel level (length, mean width, mass width, area, and ratio).

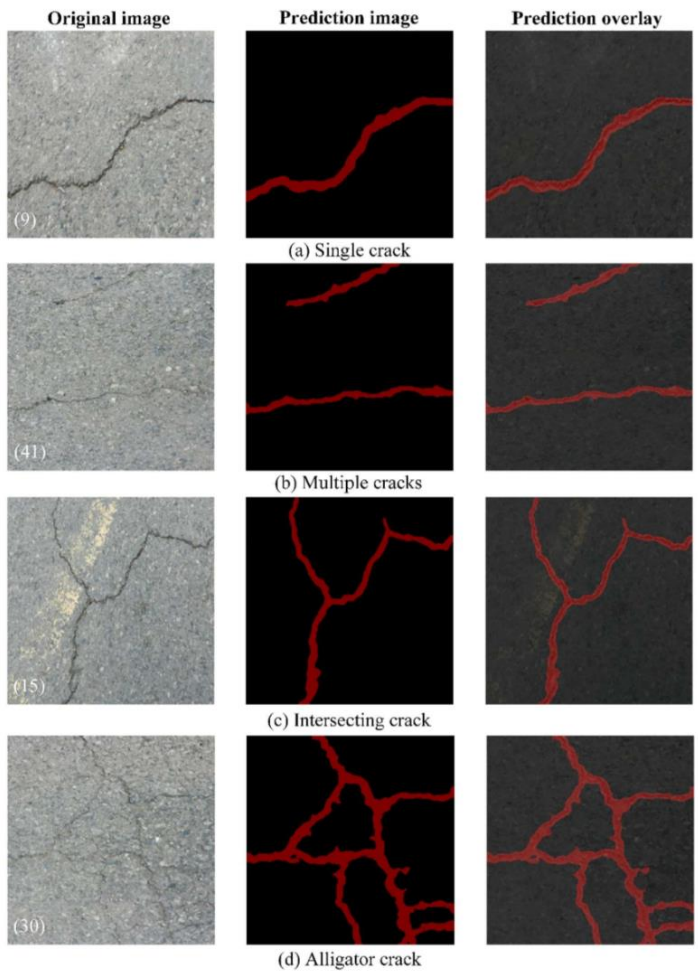


Figure 7. shows test results of four types of cracks in asphalt pavement (Ji *et al.*, 2020).

Compared with Fully Convolutional Network (FCN), Deep crack, an encoder-decoder network, and median-axis algorithm showed that the Integrated approach outperformed all these algorithms in terms of effectiveness accuracy, both for crack detections and quantification. However, the approach has some limitations, like working with many near-ground, high-quality wages that show more pavement damage types.

CONCLUSION

The four research examined by this review have proven that it is possible to come up with automated devices to detect and assess potholes on asphalt pavements to cut down computation time and save money. However, none of the studies has proven to be 100% accurate, successful, and useful.

The integration of point cloud and images derived from mobile mapping sensors has 63.6% success in detecting potholes, while the automated pavement condition monitoring with the use of a packing camera, GPS, Car's accelerator, and the driver's mobile phone has 84% accuracy. Also, the automated assessment using asphalt pavement video data with an increased pothole recognition method using vision tracking to track defected potholes on a sequence of frames has 75% precision in recognizing and counting potholes the traditional methods. Lastly, the integrated approach to automatic pixel-level crack detection and quantification of asphalt pavement by the Convolutional Neural Network Deeplabv3+ and the crack quantification algorithm that can quantify five (length, mean width, mass width, area, and ratio) aspects of detection cracks in pixel level, is useful and accurate compare to other algorithms for both cracks and quantification but some limitations like working with a large number of near-ground. These high-quality wages show more types of pavement damage.

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