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Evaluation of UAV Photogrammetric capability in Road Pavement Cracks Detection

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ABSTRACT: To establish a system for managing road pavement, it is mandatory to prepare information components based on various perspectives of pavement management. One of the most significant information components in these systems is quality assessment regarding road pavement status. Accordingly, in this regard, data containing details of surface pavement failures and defects are of great significance. Apart from causing vehicle depreciation & damage, maintenance costs, and reducing the useful lifespan of the pavement structure, road pavement failures also lead to accidents and reduce road safety. Bearing in mind that the most important surface damages in road pavement are related to cracks with longitudinal, transverse, oblique, alligator, and block types, and as such cracks and defects can be visually and non-destructively assessed and evaluated, imaging-based approaches and techniques can provide details such as the type of defect, its severity, extent, and location and prove to be highly useful. In this paper, the Unmanned Aerial Vehicle (UAV)/drone photogrammetry has been proposed as a complementary approach aimed at providing information on defects caused by cracks in the country's road pavement management system. According to the author, the output of UAV photogrammetric products will significantly improve if the system parameters are adjusted. Consequently, through presenting a procedure to investigate the optimal parameters in the design of a UAV photogrammetric network, further, attempts were made for the implementation of an automated algorithm based on image processing operations & classifier decision tree which is independent of scale and image dimensions. Hence, after removing the road edges and determining the asphalt area, a pixel detection operation was carried out to reveal the cracks. Furthermore, after preparing the ground reality through selected orthophoto mosaic, the evaluation of crack pixel detection was determined using the proposed algorithm with three methods. An accuracy of 96% was determined for the main orthophoto mosaic. For the test orthophotos, which were the result of images taken by Phantom 4 Pro and Mavic Pro at different altitudes, an accuracy of approximately 82% to 91% was determined.

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1- Introduction

Extraction of road cracks automatically and using images taken by a photogrammetric drone are very useful and cost-effective in various ways. Field visits by experts can be very time-consuming and costly. On the other hand, in most cases, experts evaluate only a part of the road and generalize its condition to other parts of the road, which causes serious errors and mistakes in examining the condition of road pavement [1-3]. Laser scanners can be used to automatically check the condition of paved roads and asphalt cracks. These tools are very expensive and costly to purchase, maintain and maintain. Therefore, the use of UAV images to detect and extract road cracks seems to be an essential need in managing and monitoring the condition of roads. In this way, it can be done automatically at a relatively low cost.

2- Methodology

In general, the proposed method in this paper consists of 4 operational and processing phases, which are:

Network design and data collection: In this phase, after identifying the area and performing ground mapping operations, network design operations and adjusting camera parameters are performed.

Photogrammetric processing and calculations: In this phase, first, the obtained images are pre-processed, then, using specialized software in the field of UAV image processing, photogrammetric products such as orthophoto mosaic are produced with the highest separation from the asphalt surface of the roads.

Detection of crack pixels due to cracking: In this phase, steps such as roadside removal, image preprocessing, feature extraction, training data generation, and crack detection

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A: The first part of the road B: The second part of the road

C: The third part of the road D: The fourth part of the road

Fig. 1. Final results related to crack detection in different sections of the road

are presented based on a method based on supervised classification using the decision tree [4-6].

Output accuracy assessment: The results of the mentioned method are compared with the ground reality and after the formation of the ambiguity matrix, the accuracy of the proposed method is determined [7-8].

3- Results and Discussion

At this stage, after the feature vector of the eight components related to the segmented tiles from each orthophoto mosaic section produced is introduced as the input to the decision tree, the output is labeled crack or non-crack. Figure 1 shows an example of an orthophoto-mosaic at the height of 20 meters and the final output of four sections of road with dimensions of 100 pixels by 100 pixels.

Figure 2 also shows an example of cracks detected based on the proposed method relative to ground reality in the orthophoto generated from a height of 20 meters to evaluate the results of the output of the proposed algorithm. The first type is marked in yellow and the second type is marked in red.

To evaluate the accuracy of the above method, the ambiguity matrix values were calculated. According to Table 1, an example of the accuracy of the output with three methods is shown on the orthophoto at the height of 20 meters.

4- Conclusion

In this research, a method for extracting road cracks automatically using a decision tree algorithm based on orthophoto mosaic from UAV images is presented. Evaluation of crack pixel detection operation was determined by three methods, which was determined to be about 96% accuracy for the main orthophoto mosaic at the height of 20 meters. Also, according to the tests performed, it was determined that the Phantom 4 Pro UAV at the height of 20 meters and a speed of 2 meters per second has a good performance in detecting crack pixels.

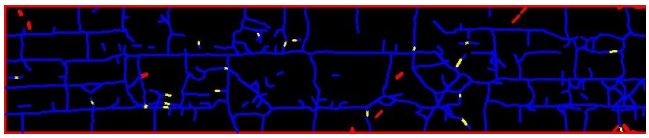

Fig. 2. Comparison of a sample of detected cracks with ground reality

Table 1. The Confusion Matrix

Total number of pixels (449649792)		Predicted number of pixels	
		Crack	**No crack**
Number of known pixels	**Crack**	TP = 66931991	FN = 3522736
	No crack	FP = 15167803	TN = 364027264
Accuracy		96%	
Kappa		96%	
F1 Score		88%	

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