Automatic Extraction of Cracks in the Roadbed by Mobile Laser Scanning Data

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Key words: mobile laser scanning, image decoding, crack identification

SUMMARY

The results of analyzing automatic cracks extraction in the roadbed by mobile laser scanning data are presented. All roadbed defects are visually well-identified using mobile laser scanning data. This is achieved by analysis of laser points and digital images. In technique development for automatic crack identification was used the IDIMA software as that of including automatic image decoding algorithms and TerraSolid software used for laser scanning data upload and processing. Automatic image decoding algorithms in IDIMA software are studied for the purpose of crack extraction. The estimation of crack extraction accuracy from images taken by the mobile laser scanning system is described.

The technique for obtaining identified crack coordinates using IDIMA software in the world coordinate system is outlined. The matter of this technique is that initial images in TerraSolid project work directory are replaced by images with detected cracks, and then laser points are painted according with colors taken from images. The technique for obtaining identified crack coordinates using only TerraSolid software is also described. Conclusions on the feasibility development of completely automated technique for crack extraction are given.

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1. INTRODUCTION

Automatic identification of defects in the roadbed and its monitoring are the major tasks in road facilities. The most common defects are cracks and chuck-holes. If cracks are not repaired, it can be lead to the road havoc. Therefore, all places where the cracks appear should be revealed in time and repaired.

Today the method of road reconnaissance is used for roadbed crack identification. This method is highly labour-consuming and takes a lot of time. Mobile laser scanning allows reducing the volume of field works, labor effort and increasing the speed and the accuracy of crack identification [1].

Mobile laser scanning is widely used in architecture, town planning, electric power industry, road facilities, oil and gas industry. Mobile laser scanning data can be used for creation of 3D models, topographic maps, cross and longitudinal profiles, and road certification [4, 5].

2. THE METHODS

Using mobile laser scanning data all roadbed defects can be well and fast identified. This is achieved by two methods. The first one is simultaneous analysis of laser points in display mode by the reflected signal intensity and images taken by digital cameras equipped with a mobile laser scanning system. The second one is creation of digital surface models of the roadbed. Before creation of models it is necessary to carry out classification of laser points and to allocate only points of the roadbed surface. Having multitemporal data of the same area it is possible to detect roadbed changes.

The results of Novosibirsk area surveying carried out in August 2012 were used for the development of automated crack extraction technique. The surveying was carried out by Lynx Mobile Mapper M1 system. IDIMA and TerraSolid software was used for investigations [2].

The nonadaptive image classification algorithm is implemented in IDIMA software. Classification is carried out on the basis of object self-organization of any image into robust homogeneities which are correleted with each other in a consistent structure (CS-strucrure) [3].

To extract certain groups of objects in IDIMA software using images, it is necessary to create a training sample using area masking. Masking should be used for deletion from processing certain image areas. For creating a training sample several pixels of any determined object should be selected. In our case these pixels relate to cracks.

For analyzed image several various structures are created in IDIMA software. This software allows applying them for classification and to choose certain set of structures. One of analyzed images used for crack identification and an image with a superimposed mask is shown in Fig. 1. An example of several structures constructed by this image is shown in Fig. 2.

Fig. 2 shows that varying structures extract image detailes by differently ways. Using these structures a training sample was created and classification process had been implemented. The result of crack identification in software IDIMA is shown in Fig. 3a.

Figure 1 – The initial image

The reliability of image classification depends on characteristics of extracted objects, quantity of shadows, a quality of created training sample and masking results. Cracks can be not recognized if they are in a shadow area. The less area a crack occupies the more complicated to recognize it automatically, the more incorrectly classified pixels are on the resulting image, and the more a noise.

Practically all crack areas have been completely recognized on the classified image but also there is still some other pixel groups incorrect recognized as cracks.

The crack coordinates in the world coordinate system can be determined using TerraSolid software tool for painting laser points according to colors taken from images. The matter of this technique is that initial images in TerraSolid project work directory are replaced by images with recognized cracks. The laser points matching by cracks were painted in red color as in images (Fig.3b). Painted laser points can be separately saved.

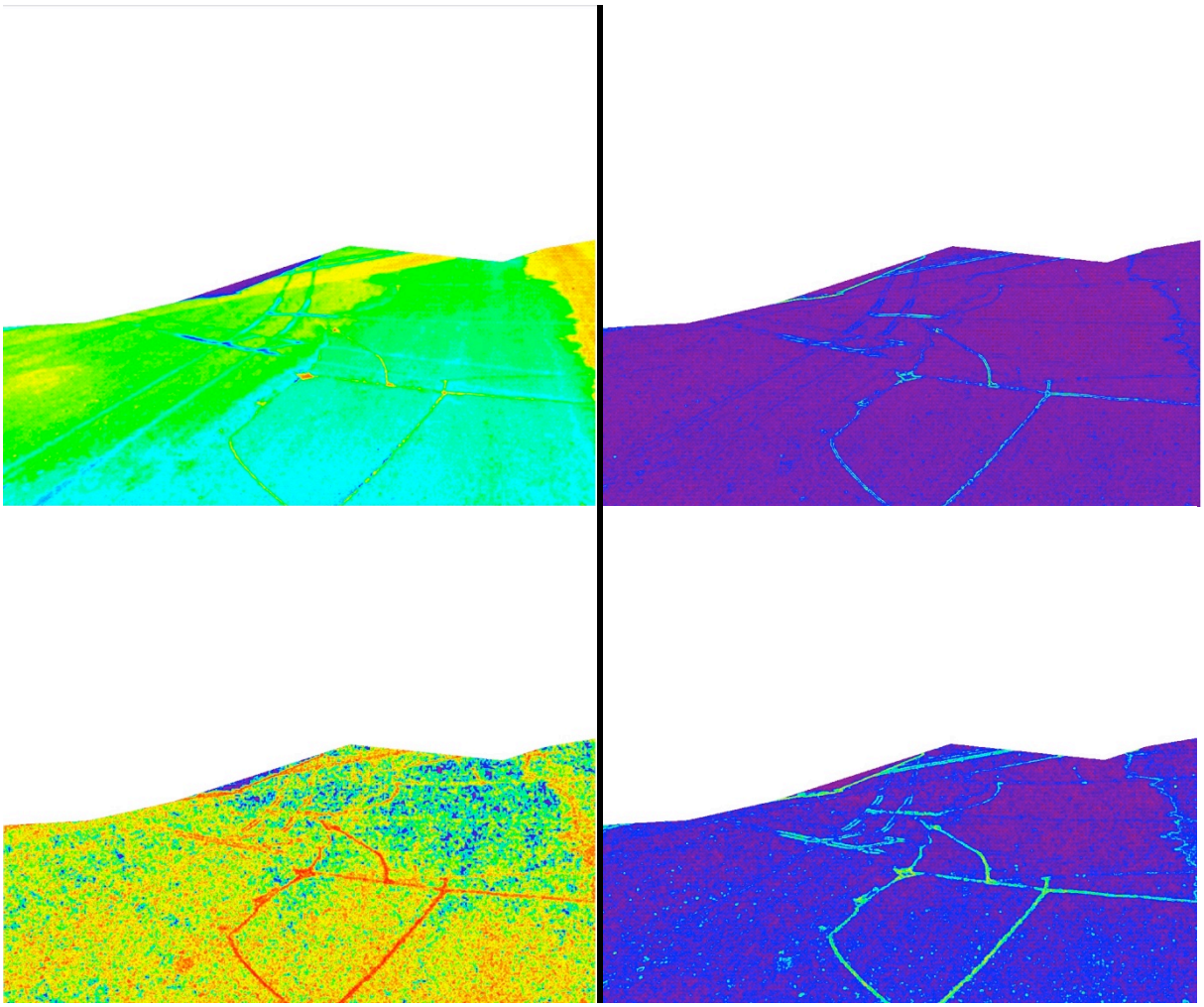
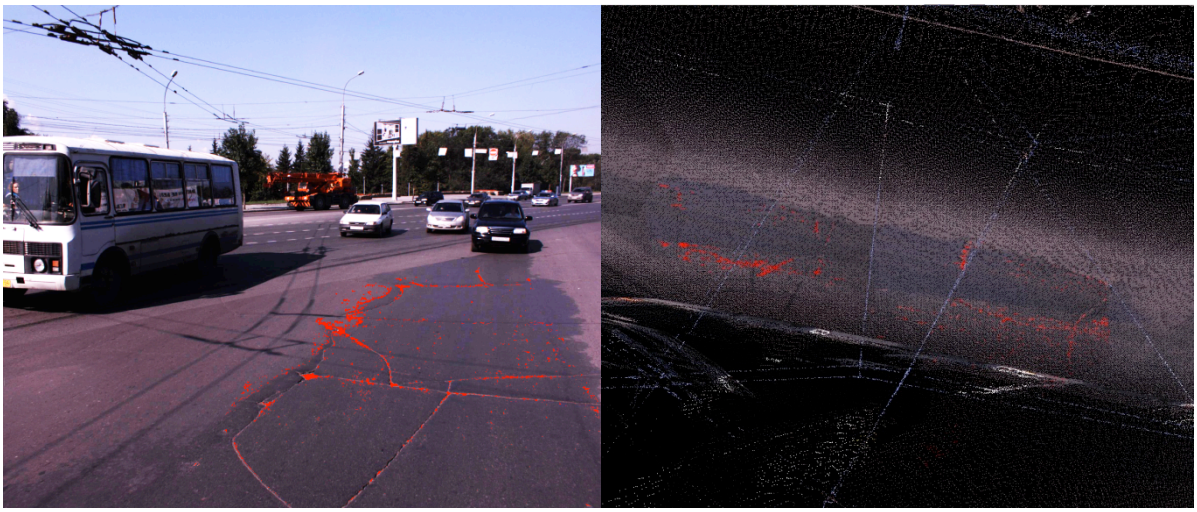


Figure 2 – Structures created by the initial image



a b

Figure 3 – Crack identification result: a) in images, b) painted laser points

To identify cracks and chuck-holes of the roadbed, it is also possible with use of digital surface models. Creation of such models needs to be implemented on the basis of classified laser points related to the roadbed. Classification should be carried out along a travel path, setting out travel width.

In Fig. 4 the digital surface model of the roadbed and laser points with a chuck-hole received in August 2012 is shown. Chuck-holes are well seen and easy identified in digital model.

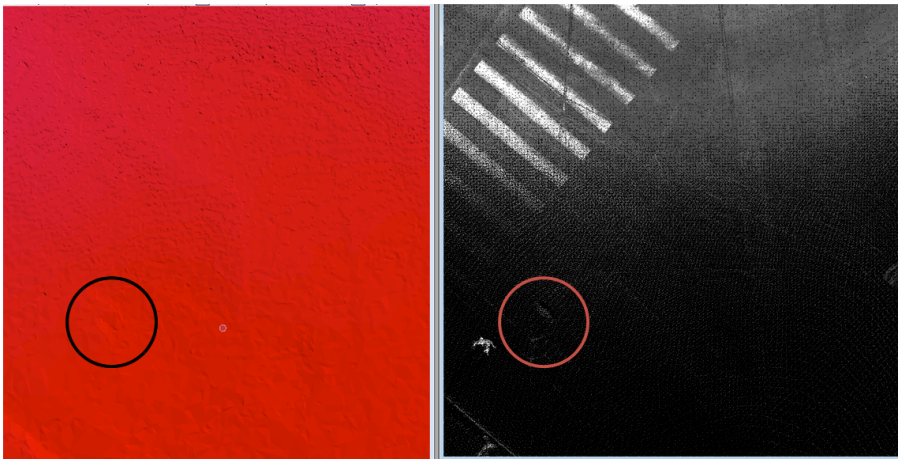


Figure 4 – Digital surface model and laser points with a chuck-hole in 2012

In Fig. 5 the same area is shown. Laser points of this area were received in 2013. This figure shows that the chuck-hole was increased in size for one year and the new one was appeared. This fact shows deterioration of roadbed quality and need of repair work to be done for the purpose of prevention of further deterioration of roadbed quality.

Thus, digital surface models of the roadbed can be used not only for extraction of cracks and chuck-holes, but also for roadbed change detection using multi-temporal data.

3. CONCLUSION

Major disadvantages of the technique are as follows: the necessity to process each image individually, online mask, a training sample creation and to analyze digital surface models. For the development of fully automatic technique for roadbed defects recognition additional investigations are necessary for CS-structures namely to determine the impact of various external factors on pixel brightness in CS-structures obtained from images with cracks. If there is a need to determine any dependence between defect brightness in CS-structure, time and image acquisition conditions, and size of defects, it is necessary to develop a new software or to improve the existing one used for defect recognition providing the opportunity to apply the pixel brightness average value relating to the certain object class, that is relating to the fixed training sample. For automatic extraction of cracks and chuck-holes from digital surface models of the roadbed it is necessary to develop the algorithm, allowing analyzing of the constructed models for the purpose of detection abrupt height differences in the models.

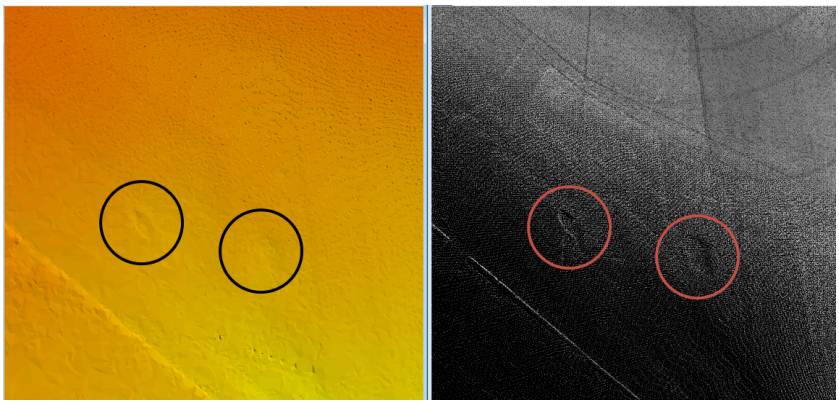


Figure 5 – Digital surface model and laser points with chuck-holes in 2013

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