The Usage of Mobile Laser Scanning in Detail Visual Inspection

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SUMMARY

The Detailed inspection (DET) in general represents an intensive examination of a specific item, installation or assembly to detect damage, failure or irregularity. The Detailed Visual Inspection (DVI) detects measured areas or lengths for a wider range of more closely defined defects on the road. The maximum length that can be recorded depends on the cross-section position method that is being used. The linear defect is considered for length larger than 1m, while the area defect is considered for the area larger than 0.1m ^{2}. There is a wide range of types of defection. For example, major and minor fretting, cracking, chipping loss, local settlements, transverse joint cracking, joint faulting, loss of texture, patching, etc. For successful conduction of detail visual inspection, the highly precise and accurate spatial data are required. The most often used technology is one of the laser scanning - aero, mobile or terrestrial.

This paper gives a brief overview of the detection of different types of deformations on road. The data are collected using mobile mapping system. The product, obtained point cloud is then matched and prepared for post-processing. At first, the area of defect is marked with polygons, after which the required attributes are assigned. The paper showed how useful mobile mapping system technology is, not only for road infrastructure extraction but for different and minor detection as well.

Key words: DVI, mobile scanner technology, feature extraction, road defects

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1. INTRODUCTION

In numerous applications that involve different ways of environment management is necessary to collect and process spatial data. Based on these data, terrain models and maps are produced, and further analyzes are created - images of the endangered areas due to different disasters, various analyzes, calculations, etc. In order to perform all these and other analyzes, necessary precondition are high-quality spatial data (Kuzmić et al 2017).

Besides surveying technics, software plays an important role by which 2D and 3D observations of collected data became significantly better, with plenty of information and possibilities (Kuzmić et al 2017). Geoinformation technologies are improving the acquisition, processing, usage, and display of the terrain data. Those technologies , as a new group of methods, instruments, and systems have been widely applied in all scientific fields and practical activities (Kuzmić et al 2018)

In this paper, GIS tools are used to visualize certain data and manipulate with them. There are examples of detail visual inspection of different minor and major defections on roads. Pictures with exact locations referring to these defects are collected as well. Those data are obtained by using modern surveying technology - Mobile Laser Scanning (MLS), which is described below.

2. MOBILE MAPPING SYSTEMS

Light Detection and Ranging (LIDAR) is an accepted method for generating precise and directly georeferenced spatial data about characteristics of the Earth's surface. This method enables data that is more accurate, precise and dense. What makes LIDAR particularly attractive is high spatial and temporal data resolution, as well as an ability to observe the atmosphere and cover the altitude from the ground to more than 100 km. LIDAR instruments collect land surface data at a frequency of about 150 kHz. The resulting product is a dense network of georeferenced points, called point cloud (Carter et al 2012).

MLS surveying is performed by moving the vehicle on the ground, while laser scanner collects data about the environment, and navigation system based on GPS and IMU tracks the vehicle trajectory. This enables 3D scanning of roads, buildings and trees (Ninkov et al 2014).

It has to be pointed out significantly lower costs of the MLS system when compared to the air laser scanning (ALS). With appropriate software solutions, MLS can automate key processes such as: creating or extracting surface models, road signs, urban trackers, curbstones, track geometry and increase the cost-effectiveness of the mapping process.

This paper shows how useful MLS technology is, not only for road infrastructure extraction but for various defects detection as well.

3. APPLICATION OF MLS IN DETAIL VISUAL INSPECTION

As mentioned above, MLS technology is nowadays progressively being used for different spatial data collection. It has proven to be very useful and practical for detail visual inspection (hereinafter, DVI) of the road, as well. This chapter presents the ways of collection, detection and division of road defects.

DVI can generally be divided into two groups: inventry and defects.

3.1. Inventry

Inventry involves the basic division of road assets, ie. the division in these groups: carriageway, footway, central island, cycle track, layby, longitudinal joint, traverse joint, kerb, traverse kerb and verge. some of these types are represented by polygons- carriageway, footway, verge, central island, cycle track and layby, kerbs and traverse kerbs are represented by lines, while points show longitudinal and traverse joint. after this major division, each inventory is assigned specific attributes: image, surface, material, construction, width, length, etc. the detailed procedure is explained above.

Data of specific area are captured with MLS technology and point cloud as an input product is obtained. Then initial processes, such as registration and matching of the point cloud are done. These are very important steps, and all further post-processing is depending on them.

After that, polygons are extracted in the Micro Station software package, where each polygon represents one type of inventory. For example, Figure 1 shows the division into polygons: yellow refers to the central island, red to the carriageway, while the footway is shown in green.

Figure 1: Extracted polygons according to inventry they belong to

By using Orbit software 3DM Publisher, images for each spatial entity have been captured and assigned as attributes with unique identifications. This software proved to be convenient for visual inspection, so attributes such as surface and material are added manually (whether it is concrete, natural stone, asphalt, grass ..).

In addition to these attributes, locating the items across the carriageway, using so -called Cross Section Positions is carried out. The Cross Section Position is a code representing a physical band across the highway, e.g. traffic lane, a footway or a verge.

The Main Carriageway Lanes are numbered from CL1 to CL9 or from CR1 to CR9 from the edge toward the centre of the carriageway for the left and right respectively Additional Lanes (for example, hard shoulders, dedicated bus lanes, acceleration lanes, parking bays, lay-bys) are prefixed "-" if they are inside the Main Lanes or "+" if they are outside the Main Lanes and they are numbered from L1 to L9 or from R1 to L9. The off carriageway features are numbered sequentially from L1 or R1 for the left or right respectively. Kerbs and Kerb defects are referenced to LE ("Left Edge") or RE ("Right Edge") (Wallis, 2009).

Attributes such as length, width and area are calculated using FME software package and its transformers for geometric calculations. FME is also used for finalization of DVI of inventry. The workflow is presented in Figure 2:

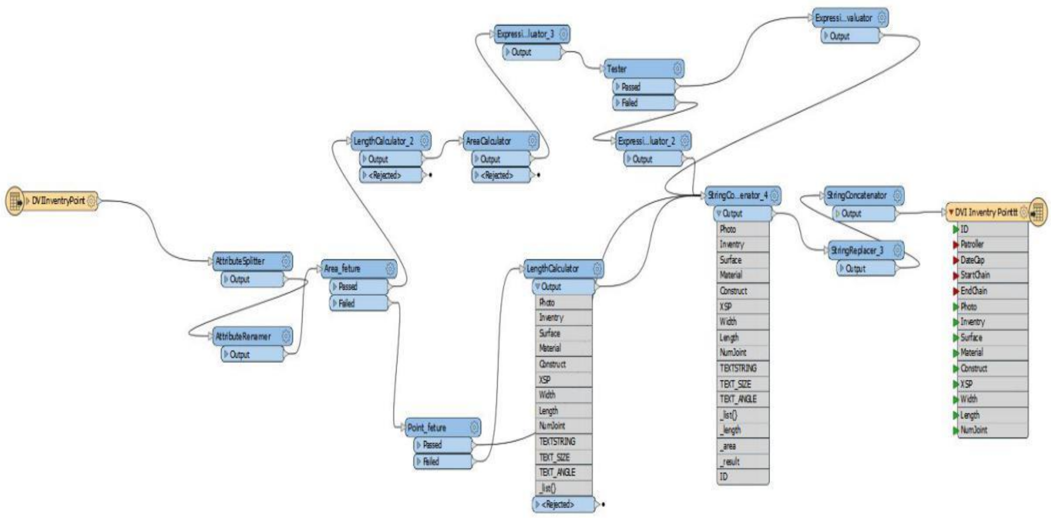

Figure 2: Workflow in FME

The final product is shp file, consisting of three vector types: polygons, lines and points with all attributes that are explained above. In the Figure 3 is showed one project part –round about, with selected inventry and its attributes are presented.

Figure 3: Line inventry- Kerb with its attributes, picture and position in 3DM Publisher

3.2. Defects

Defects for DVI are processed separately from inventry. The procedure was as follows: The whole surveyed area is visually inspected by using 3DM Publisher, then all road defects are extracted as polygons, lines or points, during which images are captured. The needed attributes are assigned for each defect, particularly for each extracted element. Some of the attributes are defect type, image ID, depth, length, direction, percent..

There are different division of defects: by material, by size and by defect type.

Considering the material, there are: bituminous, concrete, blocked, flagged..

Defects by size are divided into minor and major.

Defect types are: cracking, chip loss, fretting, fatting, left or right recorded edge deterioration severity, surface deterioration, missing filler, bituminous patching, spot defects, local settlement/subsidence, cracked and depressed blocks, not assessed area, not defective area...

The final product is shp file consisting of polygons, lines and points that refer to defects (Figure 4).

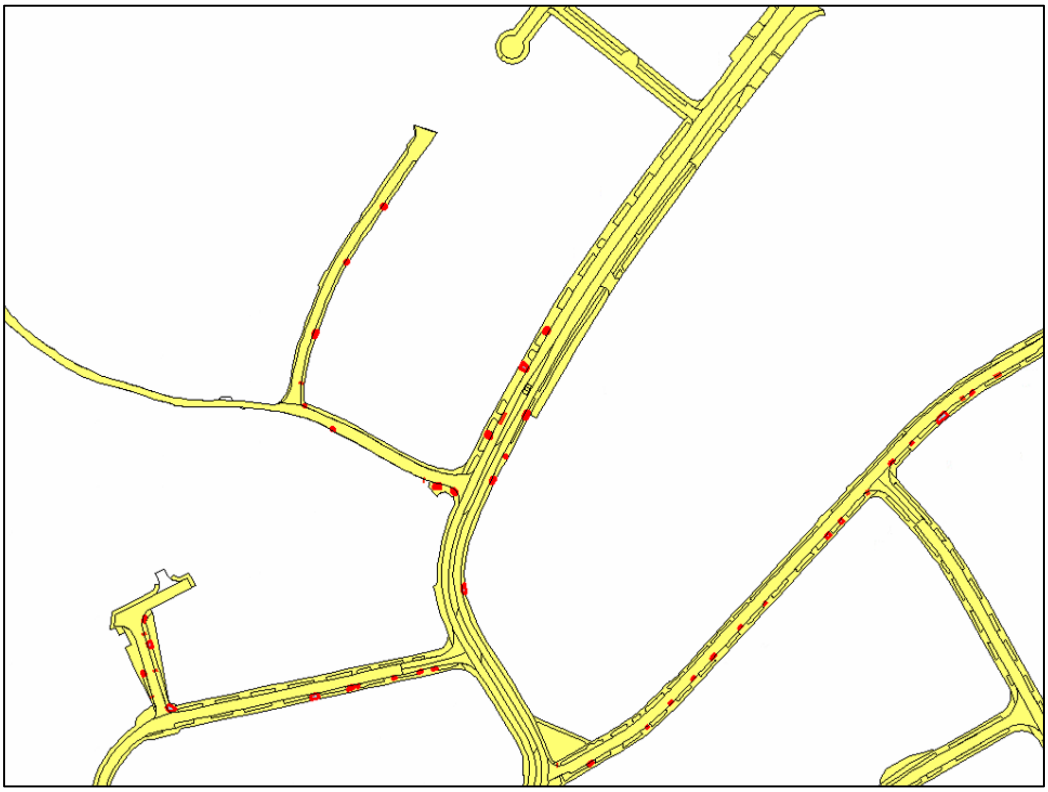

Figure 4: An overview of defects for one project part

All those vectors have attributes explained above. For example, in Figure 5 are presented some polygonal and line defects minor cracking.

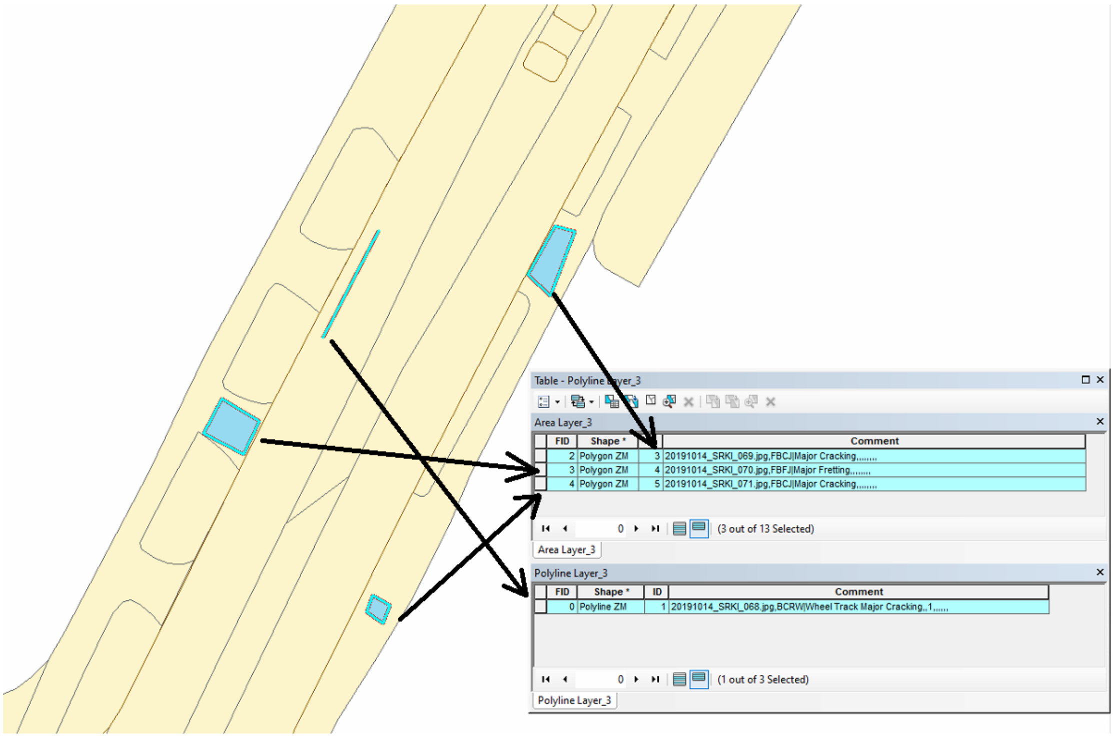

Figure 5: Selected defects with its attributes and picture below

4. CONCLUSION

The objective of this paper was to give a brief overview of different deformations types on the road and its detection. The obtained point cloud is matched and prepared for post-processing. At first, the appropriate area of defect is extracted, after which required attributes are assigned.

In general, extraction of spatial entities based on point cloud recorded by the MLS system is increasingly gaining in importance due to obvious advantages over traditional surveying methods . By using this method, in less time is possible to obtain a significantly larger amount of data, represent the larger part of the terrain with a higher level of detail. The laser scanning method is applicable to an expanding number of areas, and consequently, increasing attention is paid to the further development of this method and improving its accuracy (Vasić et al 2019).

Besides these advantages of surveying technologies, it should be mentioned the advantage of developing software packages, that provide fast, accurate and very precise post-processing of data.

Note: Project presented in paper is published with kind permission of the contributor. The original data were provided by DataDEV company, Novi Sad, Republic of Serbia.

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BIOGRAPHICAL NOTES

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