ORTOPHOTO AS A BASIS FOR VECTORIZATION OF ROAD INFRASTRUCTURE

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Summary: *In the geodetic sphere of business, one of the parameters of success is time efficiency in performing work, in addition to sufficiently accurate and detailed collected spatial data. This has conditioned the current trend of application of laser scanning technology and unmanned aerial vehicles as the most modern technologies for collecting spatial data. Accordingly, the paper presents the technology of mobile laser scanning and its resulting products. In addition, a concrete example shows the possibility of vectorization of road infrastructure with the help of orthophotos, as a resulting product of point cloud processing. An analysis of the advantages and disadvantages of the orthophoto extraction procedure compared to the extraction of the same elements directly from the point cloud is given.*

Keywords: *Ortophoto, road, vectorization, laser scanning*

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1. INTRODUCTION

Spatial data are of great importance for many areas of business and research - construction, mechanical engineering, agriculture and the like. In order to perform work in these spheres with an adequate level of accuracy and safety, the basis is spatial data of high accuracy, precision and detail. In addition to these parameters, a significant access parameter today is the time and resources required to collect, process and forward data to downstream users. A significant contribution to this parameter has been made by modern spatial data collection technologies, including laser scanning. This technology is increasingly used not only in geodesy, but also in other areas precisely because of the many benefits in the application. According to [1], advantages of using laser scanning methodology are (1) high speed and being real time; (2) data-rich, motivated, high-precision, high-density, measurable; and (3) digital, information transmission, processing and expression easily. Laser scanner collects information on the surface of the Earth as scattered and unorganized thick point cloud. What makes it particularly attractive is the high spatial and temporal data resolution, as well as the ability to observe the atmosphere and cover the altitude from the ground to more than 100 km [2].

This paper will present theoretical basis on how mobile laser scanner works, what are final products of surveying and example will be shown on way of extracting spatial data from surveying products.

2. LITERATURE REVIEW

Many papers deal with usage of mobile laser scanner and extraction of road infrastructure elements.

Paper [3] shows algorithm for automatically extracting road features (including road surfaces, road markings, and pavement cracks). It assumes that curbs are road boundaries and extracts road surface points from large volumes of MLS (*Mobile Laser Scanning*) data through four steps: data profiling, pseudo scan line generation, curb detection, and road edge interpolation. The experimental results demonstrated that the accuracies of detected road surfaces meet the requirements of transportation-related road applications. Based on the detected road surface data, automated road marking and pavement crack extraction algorithms is shown. Some other papers deal with procedures of automatic extraction such as [4], [5], [6].

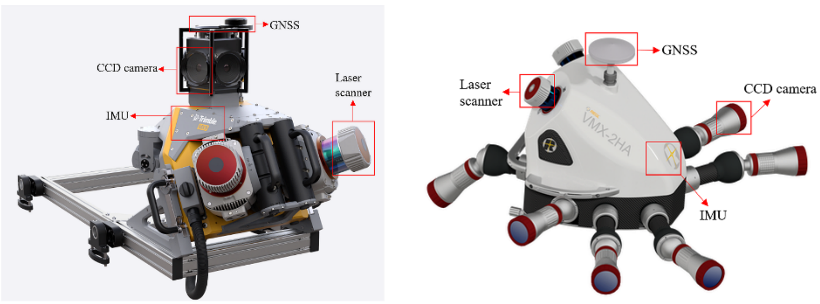
Algorithm for extracting street light poles from vehicle-borne mobile light detection and ranging point-clouds is shown in paper [7]. First, the algorithm rapidly detects curb-lines and segments a point-cloud into road and non-road surface points based on trajectory data. Second, the algorithm accurately extracts street light poles from the segmented non-road surface points using a pairwise 3-D shape context. The results show that street light poles are robustly extracted with a completeness exceeding 99%, a correctness exceeding 97%, and a quality exceeding 96%, thereby demonstrating the efficiency and feasibility of the proposed algorithm.

Paper [8] proposes a scan line based method to extract road markings from mobile LiDAR point clouds in three steps: (1) preprocessing; (2) road points extraction; (3) road markings extraction and refinement. A quantitative study shows that the proposed method achieves an average completeness, correctness, and F-measure of 0.96, 0.93, and 0.94, respectively. The time complexity analysis shows that the scan line based road markings extraction method proposed in this paper provides a promising alternative for offline road markings extraction from MLS data.

3. MOBILE LASER SCANNING

MLS system is an effective complement to the airborne laser scanner and terrestrial laser scanner systems. MLS can continuously scan the road surface and objects on both sides of roads, thus providing detailed elements of urban model such as building facades, road surfaces and road inventory [9].

Mobile laser scanning implies a laser scanner mounted on a mobile platform in the form of a vehicle. The vehicle equipped with the scanner moves along a defined path, i.e. surveying line. During that time, the laser scanner emits beams into the space around it, which are reflected from obstacles that they encounter in the form of trees, objects, road surfaces, sidewalks and the like. The reflected laser beam is returned to the receiver in the laser scanner. Based on the measured signal travel time, the distance of each point from which the laser beam was reflected to the laser scanner can be reached. By combining this data with data recorded by other sensors mounted on a mobile platform, it is possible to obtain three-dimensional coordinates of each point in the space from which the laser beam was reflected. The mobile platform is equipped with a GNSS (*Global Navigation Satellite System*) and INS (*Inertial Navigation System*) sensor that provide information on the position and orientation of the vehicle at any time [10]. In addition, the use of multiple camera arrays to provide 360º panoramic images in the horizontal plane is very common [11]. This significantly helps to interpret the data captured by the laser scanner because certain objects can be more easily identified from the image or video. Main parts of mobile laser scanners (*a - Trimble MX-9 MLS and b - RIEGL VMX-2HA*) are shown on Figure 1.



(a) (b)

Figure 1. Parts of MLS system (a - Trimble MX-9 MLS and b - RIEGL VMX-2HA) [12]

Depending on angular measurement, range measurement, position and orientation information, highly accurate 3D coordinates of points scanned with MLS system are stored in the form of point cloud as resulting product of surveying using MLS system [12].

4. DATA EXTRACTION FROM ORTOPHOTO

Within this chapter, an example of surveying results using a mobile laser scanner *Trimble MX9* is given. The specification of this scanner is given in Table 1.

Table 1. Specification of Trimble MX9 [13]

Scan speed	500 scans/sec
Accuracy / precision	5 mm / 3 mm
Field of view	360° "full circle"
Accuracy - X, Y Position (m)	0.02
Accuracy – Z Position (m)	0.05

The object of the surveying presented in the paper is the road network in United Kindgom. After planning the mission and collecting data, a point cloud was obtained, i.e. a three-dimensional view of the narrow belt along the road. This laser scanner has also mounted cameras on the vehicle, so the back, down and panorama images are obtained as well. By matching images with point cloud, even the smallest details can be detected. After inital processing, obtained point cloud and panorama images are matched together by using software *3DM Publisher* (Figure 2). This software is suitable for the extraction of some spatial entities, but also for detail visual inspection of road infrastructure.

Figure 2. 3DM Orbit Publisher – matched point cloud and images

Based on the obtained point cloud, an orthophoto image was created in the software *Agisoft PhotoScan*. The obtained orthophoto of part of the section is given in Figure 3.

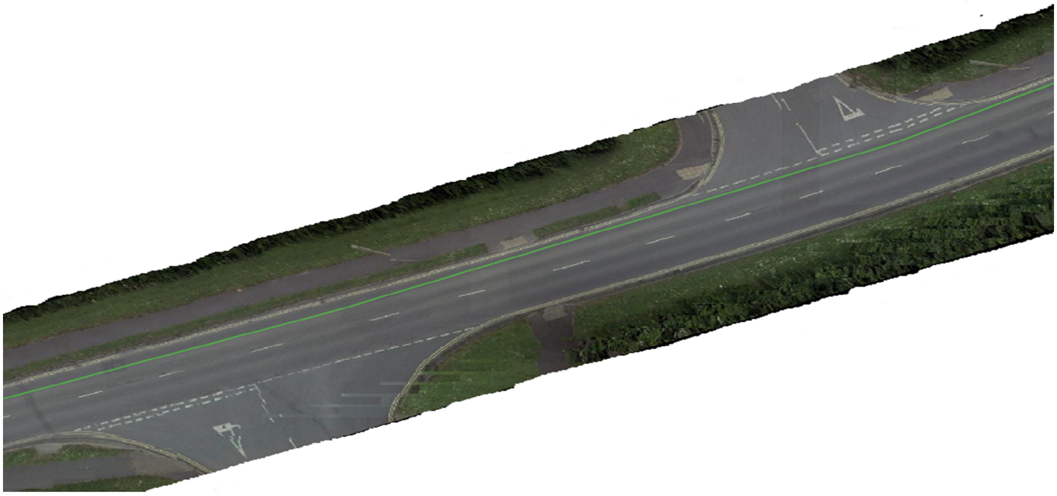


Figure 3. Obtained orthophoto of one section part

Based on the orthophoto, the elements of the road infrastructure were extracted in 2D view - the edges of the road, sidewalks, road markings, green areas, islands etc. The extraction result of particular project part is given in Figure 4.

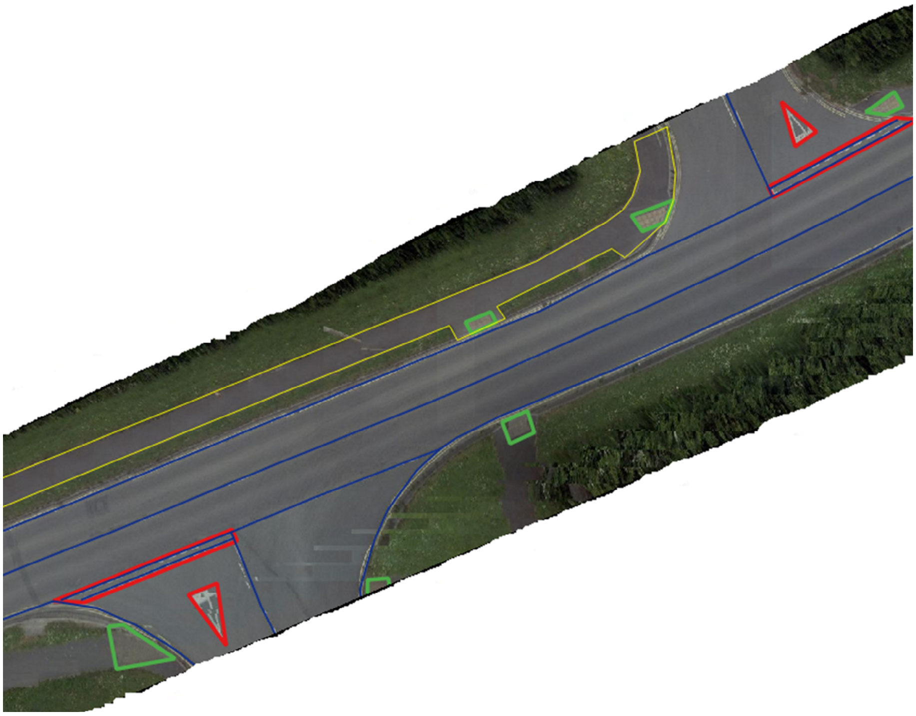
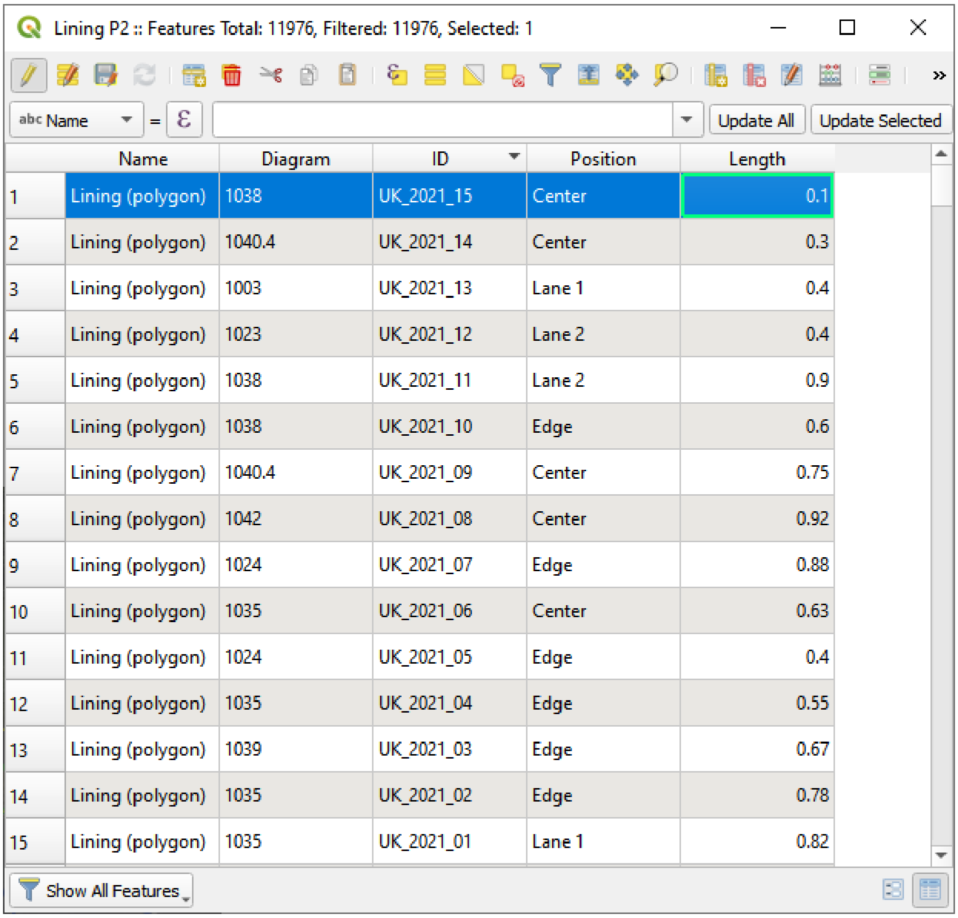


Figure 4. Extraction of road infrastructure

Apart from extracting road infrastructure, attributes about it were automatically stored. Some of those attributes are automatically calculated geometrical values, such as polygon centroid, length, diameter, area etc. Besides this, attributes referring to position of extracted element (for example, in which lane is element), name of the extracted element (grass area, island, white road marking line), unique ID and others are assigned. This attributes are stored in a database that is easily accessible and the data can be analyzed according to certain criteria without much effort. Example of stored attributes and database is shown in Figure 5.



	Name	Diagram	ID	Position	Length
1	Lining (polygon)	1038	UK_2021_15	Center	0.1
2	Lining (polygon)	1040.4	UK_2021_14	Center	0.3
3	Lining (polygon)	1003	UK_2021_13	Lane 1	0.4
4	Lining (polygon)	1023	UK_2021_12	Lane 2	0.4
5	Lining (polygon)	1038	UK_2021_11	Lane 2	0.9
6	Lining (polygon)	1038	UK_2021_10	Edge	0.6
7	Lining (polygon)	1040.4	UK_2021_09	Center	0.75
8	Lining (polygon)	1042	UK_2021_08	Center	0.92
9	Lining (polygon)	1024	UK_2021_07	Edge	0.88
10	Lining (polygon)	1035	UK_2021_06	Center	0.63
11	Lining (polygon)	1024	UK_2021_05	Edge	0.4
12	Lining (polygon)	1035	UK_2021_04	Edge	0.55
13	Lining (polygon)	1039	UK_2021_03	Edge	0.67
14	Lining (polygon)	1035	UK_2021_02	Edge	0.78
15	Lining (polygon)	1035	UK_2021_01	Lane 1	0.82

Figure 5. Stored attributes about road infrastructure elements - road marking lines

5. CONCLUSION

This paper gives theoretical approach to mobile laser scanning and example on what are resulting products of surveying with mobile laser scanner and what can be obtained from them. However, in this paper is presented slightly different approach – data about road infrastructure are not extracted from point cloud, but from obtained ortophoto. It can be concluded that this way of extracting data is much faster and easier than extraction from point cloud. For a start, the view of the orthophoto is in 2D, so the procedure of extracting certain edges of the road, sidewalks and green surfaces is much more intuitive. In addition, during the extraction, attribute data can be stored directly and a database of spatial entities can be formed during the extraction. Of course, it should be noted that in this way a 2D representation is obtained, the extracted entities are not displayed in three-dimensional space and the data are to some extent of lower accuracy. However, when extraction of road infrastructure elements is required in a shorter period of time, when the accuracy parameter is not a key factor, but storing additional attribute data about extracted entities is - extraction of elements from orthophoto is recommended.

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ОРТОФОТО КАО ОСНОВА ЗА ВЕКТОРИЗАЦИЈУ ПУТНЕ ИНФРАСТРУКТУРЕ

Резиме: *У геодетској сфери пословања, један од параметара успешности јесте временска ефикасност у обављању посла, поред довољно тачних и детаљних прикупљених просторних података. То је условило данашњи тренд примене технологије ласерског скенирања и беспилотних летелица као најсавременијих технологија прикупљања просторних података. У складу са тим, у раду је представљена технологија мобилног ласерског скенирања и њени резултујући продукти. Поред тога, на конкретном примеру приказана је могућност векторизације путне инфраструктуре уз помоћ ортофотоа, као резултујућег производа обраде облака тачака. Дата је анализа предности и мана поступка екстракције са ортофотоа у поређењу са екстракцијом истих елемената директно из облака тачака.*

Кључне речи: *Ортофото, пут, векторизација, ласерско скенирање*