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Usability of wearable mobile laser systems in cadastral studies

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ABSTRACT

Lidar measurement systems have started to provide convenience in engineering and many multidisciplinary fields with their innovative approach. It allows to give positional information about difficult to access, narrow, small or closed areas. In addition, it enables map production in areas that cannot be measured with the GNSS device (where trees and housing are dense, etc.). The data obtained from the Wearable Mobile Laser System used in the study provides the ability to locally determine its own location and produce a map of the environment with the developed SLAM (Simultaneous Localization and Mapping) algorithm. At the same time, for the structures on the model, its usability in renovation works to improve existing cadastral work is discussed. In this study, the processing and accuracy criteria for cadastral studies were evaluated using the wearable lidar technology data in the Mersin University Çiftlikköy Campus region.

1. INTRODUCTION

The management of land and land has been of great importance since the first period when civilizations were established in the world. Accordingly, the work started to determine the borders, to establish and protect the property. By measuring the land plots and evaluating the measured data, it has been progressed on the axis of offering the right to use, use and disposition to its owner. Today; These studies are called cadastral activities or cadastre.

Social and environmental developments have gained a new dimension with the differentiation of human-soil relationship and land use. Cadastre 2014 study published by FIG; It is aimed to set standards in cadastre, to ensure public-private cooperation and to achieve digital transformation rather than classical measurements. Cadastre 2034 has started to be discussed with the vision of sustainable land management for the next 20 years. In this direction, sensitive, up-to-date, object-oriented, three-dimensional (3D) and four-dimensional (4D, 3D + time) cadastral concepts have been the primary goals. (Demir and Çoruhlu, 2009; Döner et al., 2007; Döner, 2015; Sultani and Şişman, 2014; Kaufmann et al., 2014; Yıldız et al., 2015)

99% of the cadastral works in Turkey are known to completion (Uzun and Çelik, 2011). However, the methods used and hardware that are expected from the cadastre (± 8 cm) accuracy insufficient to meet, incorrect or incomplete done some measurements, to find solutions to existing problems such as digitization of existing cadastral data and international standards adopted by Turkey (ISO 19 152, 19 112), Studies such as LADM, INSPIRE, Cadastre 2014 and beyond create the need for cadastral renewal. (Şahin et al., 2015; Çete and Yomralıoglu, 2013). These studies can be done with classical measurement methods, as well as with technological developments, providing the opportunity to be done with new methods and equipment (Döner et al., 2008; Karabin et al., 2017; Hao et al., 2011; Gura and Nedyakina, 2021).

In this study, the usability of laser scanning technology in renovation cadastre activities was examined. In this study, in addition to the points obtained by the total-station device with the data obtained by the wearable mobile (WMLS) laser scanning, the orthophoto obtained by the UAV photogrammetry was used in an integrated manner (Kaya et al., 2021; Ulvi et al., 2019;

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Yakar et al., 2016). Scans were carried out with WMLS and point cloud data belonging to the region were obtained. The vector drawings of the area were carried out in the light of the data obtained from two methods by using the orthophoto previously produced by the study team including the authors. Then, the accuracy of the study was examined by performing local measurements. The applicability of laser scanning method in cadastral studies has been tested by examining the results.

2. METHOD

In recent years, with the acceleration of the renewal cadastral under the sustainable land method, studies in this area have been started with new methods and equipment. Especially rapidly growing stock of construction and development of cities in Turkey are known to play an important role in making this work. With this urbanization pressure, the feasibility of cadastral studies with classical measurement methods is not possible due to the changing land conditions. Therefore, in this study, the feasibility of cadastral studies was tested with laser scanning technology (Otero et al., 2020; Williams et al., 2020), which offers a new and fast solution.

2.1. Study Area

Mersin University *Çiftlikköy* campus has been selected as the Faculty of Engineering test area. (Figure 1).

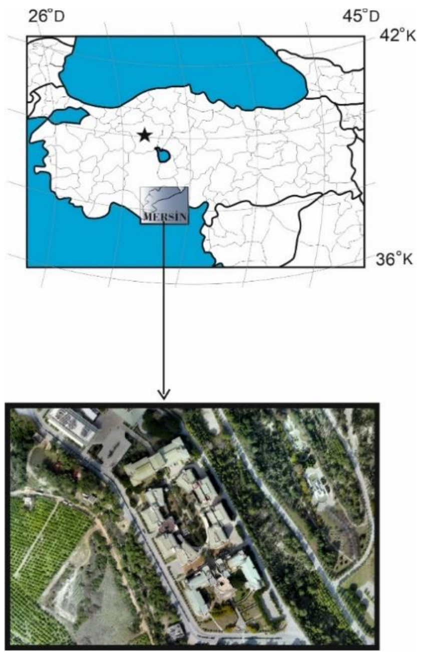

Figure 1. Study area

The WMLS device was used for reasons such as the presence of trees in an area of 18660 m2, the narrow distance between buildings, and the fact that conventional measurement methods can cause user-induced errors and take time. The fieldwork was completed in two sessions of 40 minutes in total.

2.2. Equipment

In this study, Gexcel Heron Lite Color wearable lidar scanner was used to test. Technical features of the device are given in Table 1. In addition, electronic length meter (total-station) and GNSS receiver were used.

Gexcel Heron Lite Color wearable lidar scanner is a measuring device with IMU integrated positioning system without the need for time of flight satellite navigation systems (Balenović et al., 2020; Döner and Bıyık, 2007). This device extracts the 3D point cloud of the area by detecting the different geometric properties of the objects around it. The map of the working area can be created in the local coordinate system. These products are produced with the SLAM algorithm, which is actively used to determine the map and location of the surrounding area. (Di Filippo et al., 2018; Zeybek, 2019; Güney and Sayın 2016).

Table 1. Technical features of Wearable Mobile Laser Systems

Features	Value
Panoramic camera	+
post processing software	Heron Desktop
lidar sensor	Velodyne VLP 16
IMU	+

2.3. Data Proccesing

In order to process the data obtained from field scans, the process was performed in the WMLS device's own software, Heron Desktop software.

In the process phase, the necessary odometer settings were made first. Odometer work flow is given in Figure 2.

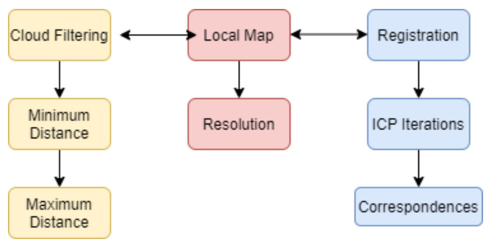

Figure 2. Odometer work flow

In the "cloud filtering" part of the first section, "minimum distance" and "maximum distance" settings; It is the section where it is adjusted to eliminate distortions that will occur according to the structure of the land, the location of the objects and environmental factors.

In the second part, the "local-map" settings determine the geometric criteria of the 3D point cloud map to be created.

The third part is the "Registration" part. In the laser scanning process, scans are carried out overlapped. In the data obtained, one of the measurements for the same object is taken as a reference (fixed) and all other scans are converted to the coordinate system of the reference point cloud. In the Registration section, the transformation parameters between two point clouds are calculated with points in the common scanning area. Therefore, "Correspondences" and "ICP iteration" are important to reduce the minimum error and obtain a precise result.

The "create map" process is the process of creating an index map by splitting it into trajector map sets.

After the create map process, it was passed to the global optimization part. The ICP iteration number is chosen as default in the parameter adjustment with the alignment of the fragmented maps. The main purpose of this section is to increase the precision of accuracy. After parameter setting, links to fragmented maps are tied and connected to each other. All fragmented maps were connected in accordance with this condition and balancing was made by selecting the “optimize cluster”.

Balanced point cloud data is transferred to the reconstructor software for the last step of geo-referencing. During the field survey, TAG points were purchased in areas where GCP was measured by GNSS and Total-station device. By using these target TAG points, the transformation from local coordinate to country coordinate system has been performed in Reconstructor software. The average error after conversion is ± 3cm.

3. RESULTS

In the study, a region within the Mersin University campus was scanned in a short time with the "Gexcel Heron Lite Color" scanner and 3D point cloud data was obtained (Figure 3).

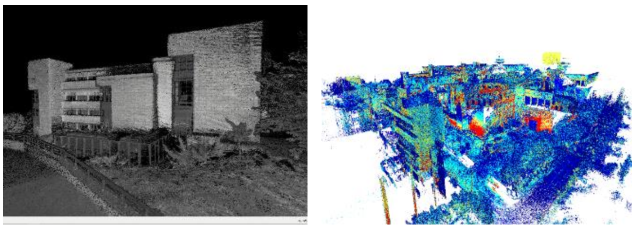

Figure 3. Point cloud data from WMLS

In the Recontructor program, 2D orthophoto image was obtained by using the point cloud data created (Figure 4). These orthophoto and orthophoto images produced with UAV were drawn in Netcad program and comparisons were made.

Figure 4. 2D orthophoto image obtained from WMLS

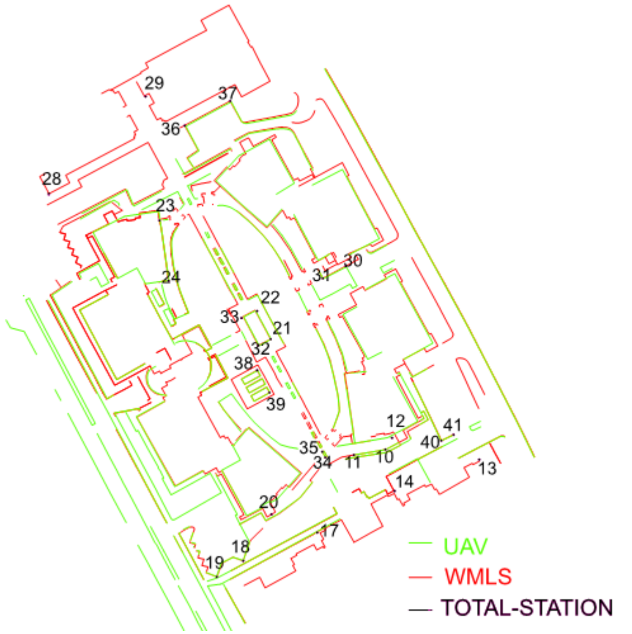

Figure 5. Vectorial drawing obtained from WMLS, UAV and Total-Station data

As a result of the vector drawings made on both orthophotos; These data were compared in terms of accuracy. First, drawings were made from the image produced from lidar, and then drawings were made on the image obtained from the UAV. For the accuracy of these drawings, measurements were carried out at the locations determined by ground measurement techniques during the field study phase. The same lengths were taken from both orthophotos and compared with the positional measurement data (Figure 5).

Table 2. Accuracy analysis of the lengths taken from the orthophoto

Point Numbers	Total Station V	WMLS [V_1]	UAV [V_2]	[V- V_1]	[V- V_2]
11-10	11.763	11.788	11.812	0.025	0.049
24-23	22.489	22.510	22.541	0.021	0.052
21-22	12.132	12.102	12.090	-0.030	-0.042
19-18	11.383	11.331	11.420	-0.052	0.037
30-31	9.556	9.552	9.561	-0.004	0.005
32-33	12.152	12.112	12.100	-0.040	-0.052
34-35	2.333	2.344	2.300	0.011	-0.033
36-37	19.044	19.05	19.088	0.006	0.044
38-39	9.378	9.444	9.434	0.066	0.056
40-41	5.022	5.07	4.990	0.048	-0.032

4. DISCUSSION and CONCLUSION

In this article, WMLS has been tested in the university campus area through mapping. It has been observed that moving objects (people, cars) in the environment have a negative effect on scans due to outdoor measurements. For this reason, it was determined that there should not be any moving objects close to the device during the measurement.

With the study, it has been observed that the mapping performance with WMLS is comparable with other systems, and it is possible to reposition it by synchronizing with any point cloud.

As a result of the comparisons (Table 2), it is predicted that the orthophoto obtained from WMLS can be used for cadastral studies. In addition, in addition to the lidar method, it is seen that the orthophotos obtained from the UAV can be used in an integrated manner in order to obtain successful and more precise results.

It is more difficult to make correct drawings on orthophoto (UAV) in areas where construction is intense. Precise and complete information is not obtained about the features such as the floor area of the building, entrances, porches etc. In addition, it was not possible to draw the wooded and shaded areas on the orthophoto produced with the UAV.

WMLS; There are advantages and disadvantages of having all the details struck by the laser of the scanned area on the 2D orthophoto. The disadvantage of the data obtained by WMLS in the process is that the parameter values vary according to the field and scanning, and it depends on the experience of the operator.

While drawing with the WMLS orthophoto, going parallel with the point cloud provides a healthier drawing opportunity. In the 2D image, it is possible to see all the indentations and exits of the building such as balconies and porches. In addition, it was determined that the border lines (sidewalk, refuge, etc.) in the area where the trees are located are seen more clearly in 2D. Therefore, it is suggested that the WMLS device can be used in cadastral renewal works.

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