Cadastral map update with modern technologies in Hungary

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Key words: Cadastre; Digital cadastre; Laser scanning; Photogrammetry

SUMMARY

In 2020, a pilot development was carried out with the participation of the Hungarian Chamber of Engineers, the Budapest University of Technology and Economics, Óbuda University, and several market players (Pannon Geodézia Ltd, Geodézia Ltd). The aim was to investigate the applicability of point cloud-based survey techniques (UAV, TLS, MLS) for cadastral surveys, with a focus on map update. In this article, we briefly describe the results of the pilot project. We present the developments in our Institute that have been made as a result of this project, which we hope can effectively support point cloud-based evaluations for cadastral purposes. We will also discuss the possibilities and limitations of automation.

SUMMARY (HUNGARIAN)

2020-ban a Magyar Mérnöki Kamara, a Budapesti Műszaki és Gazdaságtudományi Egyetem, az Óbudai Egyetem és több piaci szereplő (Pannon Geodézia Kft., Geodézia Kft.) részvételével kísérleti fejlesztés valósult meg. A cél a pontfelhő alapú felmérési technikák (UAV, TLS, MLS) alkalmazhatóságának vizsgálata volt a kataszteri felmérésekben, különös tekintettel a térképfrissítésre. Ebben a cikkben röviden ismertetjük a magyarországi kísérleti projekt eredményeit az Intézetünkben, a projekt eredményeként megvalósult fejlesztéseket, amelyek reményeink szerint hatékonyan támogathatják a kataszteri célú pontfelhő alapú kiértékeléseket.

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1. INTRODUCTION

In 2020, the Geodesy Section of the Hungarian Chamber of Engineers has been commissioned to investigate the practical applications of modern point cloud-based technologies for the renovation of cadastral maps. Unfortunately, cadastral maps are outdated in most countries, including many parts of Hungary too, so revising them and carrying out new surveys is a challenging task ahead. The way to a professional, innovative and cost-effective survey is through new technologies. Several specialists from several universities (BUTE, ÓBUDAI), companies (Pannon Geodesy, Geodesy Ltd.) and several experts participated in the project. In this article, instead of giving a general description of the research, we will only discuss in detail the accuracy studies carried out by our Institute. The full study is available [1].

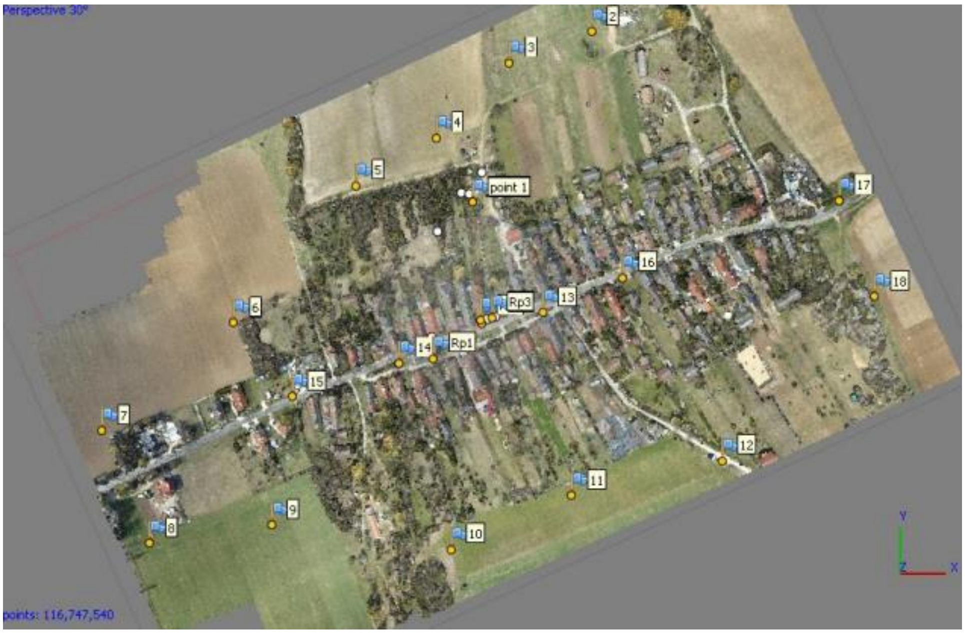

Fig 1. Point cloud cut in the study area [1]

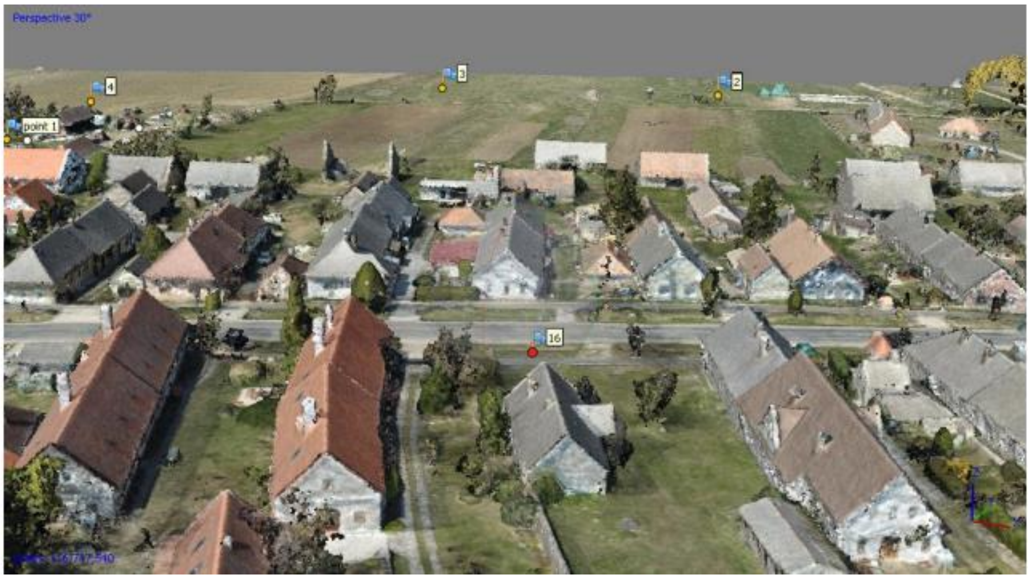

Fig 2. Point cloud cut in the study area [1]

2. EXAMINING THE GEOMETRIC POSITION OF MEASURED POINTS

Several field data collection technologies (classical geodesy, UAV-based photogrammetry, terrestrial static, and mobile scanner) were used and evaluated from a technical and economic point of view. The multiple data collection technologies also allowed for large-scale comparisons where a single area was evaluated by multiple surveys. Over the past decade we have become well acquainted with the capabilities and limitations of digital photogrammetry and lidar technology, its accuracy and reliability figures. The main objective of the comparison was not to determine the achievable accuracy, as it is generally known that we have carried out such studies ourselves [2,], [3], [4] but to compare the possibilities of cadastral delineation using a given technique (photogrammetric, static, mobile scanner) with classical methods. The block contour of the Main Street and its surroundings was surveyed with a mobile laser scanner and a static laser scanner in addition to the traditional survey (total station, GNSS) technology. An self-developed application for a commercial program (AutoCAD MAP) was developed to compare the two types of scanner surveys.

The algorithm searches for the points evaluated from the two types of scanning within a given environment (0.5m) of the points of the conventional ground survey. If it finds identical points from at least one type of scan survey, it treats them as identical. If more than one point falls within the selection set, it marks them, as well as any points from the ground survey for which it did not find a point pair. These were checked and analyzed manually afterwards. Automated analysis of the photogrammetric workpieces would prove considerably more difficult, given the sparser point cloud population. A precise analysis of these, using multiple camera systems, is expected in the coming year.

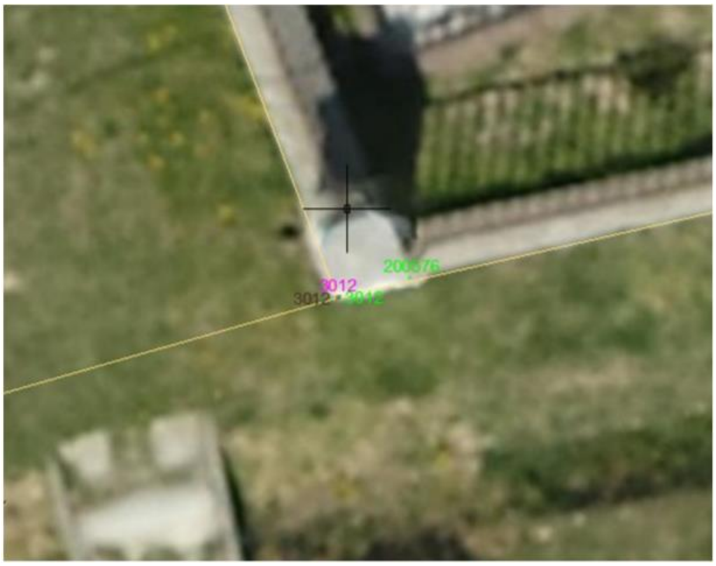

Fig 3. Points from different sources on an orthophoto extract (brown: traditional survey TS, GNSS, purple: mobile, green: static survey) [1]

Some 652 points from the ground survey, 205 from the mobile survey and 234 from the static survey were used in this way. Due to the nature of the surveys, these points are typically the corner points of land parcel boundaries and buildings that are in contact with public space. Based on the same points, statistics were determined for the distance differences between points from different sources.

TABLE I. TYPICAL DIFFERENCES IN SCANNER PROCEDURES COMPARED TO GROUND SURVEYS[1]

	mobile difference (m)	static difference (m)
average deviation	0.072	0.058
standard deviation	0.048	0.042
maximum deviation	0.218	0.276

When analyzing the larger differences, it was clear that these were differences in delimitation due to the specificities of the different survey techniques (these were removed from the statistics). Examples of these are shown in the following figures.

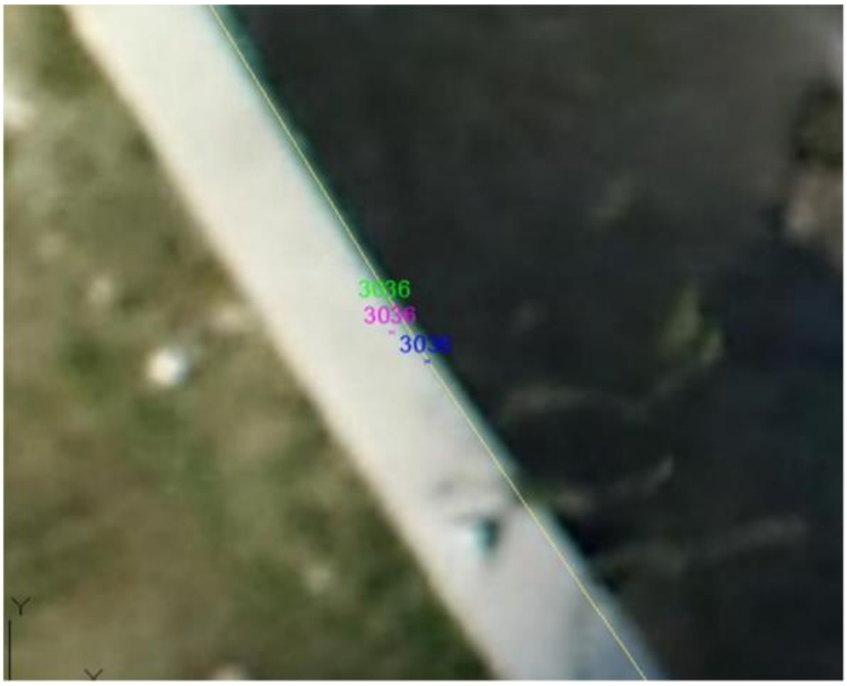

Fig 4. Delimitation differences between different survey techniques (blue: total station or GNSS, purple: mobile, green: static laser scanner survey) [1]

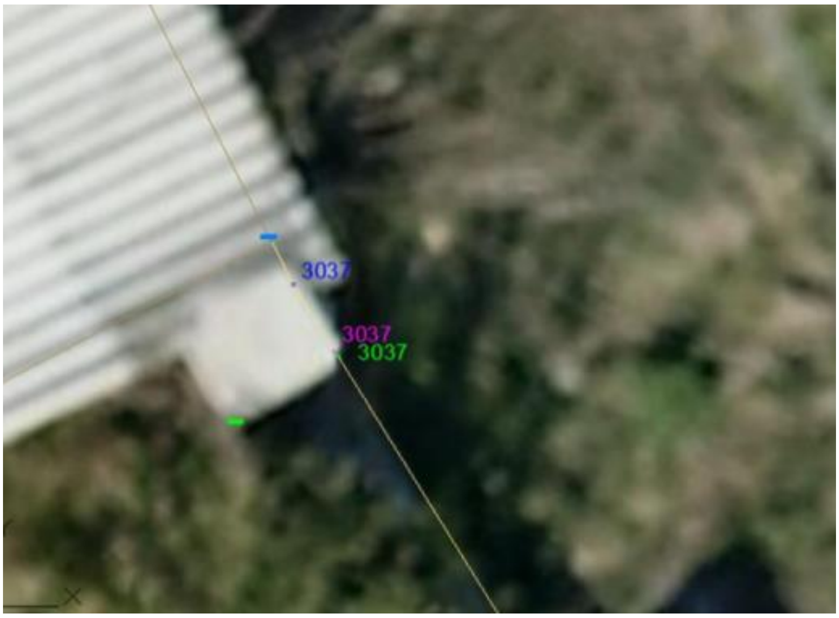

Fig 5. Delimitation differences between different survey techniques (blue: total station or GNSS, purple: mobile, green: static laser scanner survey) [1]

The analysis was extended to points evaluated from the point cloud from the photogrammetric survey. These are typically building corner points in the cadastral inventory. Here, the comparison is based on the ground survey control points (24) and the building detail points determined by the mobile 68 (44) and static scanner (80). The results are summarized in the following table. This inspection volume also meets the quality assurance requirements of the Passive Aerial Remote Sensing Services Design Guide. [5]

TABLE II. TYPICAL DIFFERENCES WHEN EVALUATING A POINT CLOUD BASED ON IMAGE MATCHING COMPARED TO OTHER SURVEYS[1]

	checkpoint difference (m)	static difference (m)	mobile difference (m)
average deviation	0.178	0.095	0.101
standard deviation	0.101	0.045	0.055
maximum deviation	0.521	0.192	0.236

Compared to the ground control survey (total station or GNSS), a high value (of about 52 cm) was recorded for a wall plane that was difficult to define. Since the number of common points was relatively low, we extended the survey to include detail points from static and mobile scanning that were not breakpoints. These are typically the line points of a building that can still be evaluated from the public domain within a given parcel of land. For the points selected in this way, we determined their measured distance from the nearest building and then derived statistics for these distance deviations. 284 additional control dimensions were obtained, and the results are summarized in the following table:

TABLE III. TYPICAL DISTANCE DIFFERENCES FOR BUILDINGS WHEN EVALUATING THE POINT CLOUD BASED ON IMAGE MATCHING COMPARED TO OTHER SURVEYS[1]

	distance measurement (m)
average deviation	0.104
standard deviation	0.102

This method also proved to be suitable for verifying evaluations. The larger differences were naturally caused by the differently demarcated building accessories, which were excluded from the statistical calculation.

It is worth noting here that a high level of routine of point cloud evaluation is required to properly test accuracy. In carrying out this study, we have involved a number of evaluators, both experienced and less experienced. The differences were clearly visible up to several cm variation in the vectorization process according to the level of experience. This procedure was chosen for the study in order to clearly demonstrate the viability and usability of the technology. In a real situation, from a worker's point of view, only more accurate results can be achieved in the future.

3. CONCLUSIONS

Overall, the study shows that all the measurement technologies used have the potential to replace classical survey technologies in whole or in part. For the implementation of nationwide projects, the development of automated recognition and identification procedures supported by deep learning, as well as the organization of high-level training and courses to maximize the reliability of manual evaluation and analysis tasks, could be important. The capabilities of technology have proved to be fully convincing and satisfactory. By applying them, it is hoped that the renovation of cadastral maps, which have become obsolete over the decades, can be carried out economically in the foreseeable future. In the future, our university plans to build a new professional test field for validation and to further develop our point cloud testing algorithms to achieve even higher reliability numbers.

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BIOGRAPHICAL NOTES

Máté LEHOCZKY, was born in 1991 in Várpalota, Hungary. He graduated as a surveyor and land surveyor from the Óbuda University, and then obtained a degree in digital spatial development from the National University of Public Service. In 2021-22 he was one of the first to obtain the qualification of drone control and data analysis engineer in Széchenyi István University. From 2009 to 2022 he worked at Pannon Geodesy Ltd, where he developed and managed aerial mapping tasks. Currently, in addition to his own companies, (LehoGeo Engineering Ltd and Intellinvest Plc) with a wide range of geomatics tasks, he is researching the practical applications of unmanned aerial vehicle work and its engineering applications. He is a research fellow at Óbuda University, president of Aerial Cartographic and Remote Sensing Association and a member of the board of the Geodesy and Geoinformatics Section of the Hungarian Chamber of Engineers.

Zoltán TÓTH was born in 1979 in Székesfehérvár. He graduated from the Faculty of Civil Engineering at the Budapest University of Technology and Economics and obtained his PhD degree in 2009.

He is engaged in engineering surveying, mining development and image processing applications.

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