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Automatic Extraction and Placement of Building Point Vector Data from Aerial Imagery for the 1: 25 000 Topographic Map Production

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Abstract:

Automatic extraction of building footprints, the outer surface of building rooftops, on high-resolution orthophoto is one of the most challenging and essential tasks [1]. Processing footprints is a follow-up of building topographical data extraction methodology. Production of digital topographic maps requires data extraction from different sources, guided by an established work methodology within the framework of strict cartographic rules. The classic restitution approach is time and labor-consuming. Therefore, the need to develop an advanced methodology for automatic building data extraction is justified.

The methodology is intended for the purpose of creating the fourth edition of the topographic map at a scale of 1:25 000 of the Military Geographical Institute in Belgrade, Serbia. The methodology was developed over the urban area of the city of Vranje. By applying the U-net convolutional neural network implemented in Python, on a 30 cm resolution satellite image (Figure 1, **view 1**), an object prediction mask (**view 2**) was obtained, as a result of binary segmentation based on the open INRIA dataset for model learning. Vector processing of the mask was performed, creating polygons with assigned rotation data (**view 3**), from which corresponding point vectors were generated (**view 4**). Algorithms were created for positioning the obtained point vector data so that the topographic data on the buildings meet the required cartographic rules. Algorithms were created using ArcGIS Model Builder, while Python was used for additional calculations. The externally developed algorithms had to satisfy the cartographic restrictions based on the minimal distance between buildings and the minimal distance from the graphic road marker. For a more adequate aesthetic presentation, the objects in the road environment are rotated in the same direction (**view 5**). In Figure 1 (**view 5**), the final topographic data are shown in transparent black, while the initial data are shown in red.

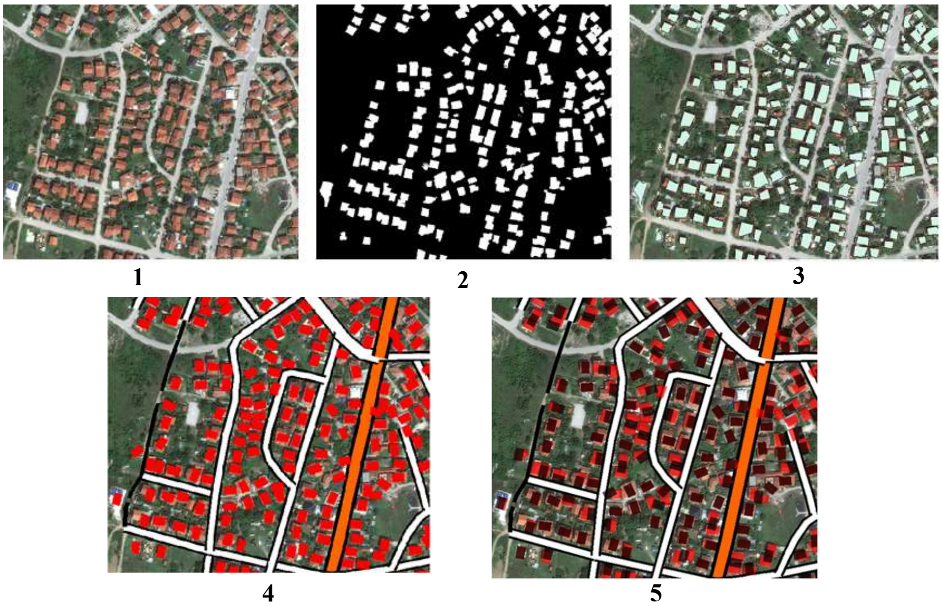

Figure 1. Building data extraction steps overview

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Obtaining point vector data corresponding to the building location on the prediction mask is the primary task, but a very important aspect of this work is the cartographic positioning of that vector data. Algorithms for positioning are placing the objects based on existing topographic road data. Building data points are positioned according to defined rules and regulations, and according to mutual proximity and the proximity and importance of roads. Algorithms also perform initial data generalization so that not all extracted data from the satellite imagery is displayed.

As the majority of buildings are represented by point vector symbols on the topographic maps of the Military Geographical Institute, it is necessary to explain how the accuracy of the deep learning model for extracting footprints of buildings affects the positional accuracy of the final topographic data. In Figure 2, a sample of satellite imagery (**view 1**) and the corresponding result of the deep learning model - the prediction mask (**view 2**) are presented. Also, an illustration of the ideal extraction result is shown (**view 3**). This methodology requires polygons vectorization of the prediction mask and generalization generated building footprints in order to obtain the orientation angle of the polygons. The orientation angle is matching the corresponding vector point in order to rotate the symbol. Finally, **view 4** of Figure 2 shows the rotated vectorized points on which the rotation values of the vectorized polygons are labeled. The vector point is defined by the center of gravity of the polygon and the rotation value, which in this case provides data that is not strictly dependent on the high accuracy of the results of the deep learning model.

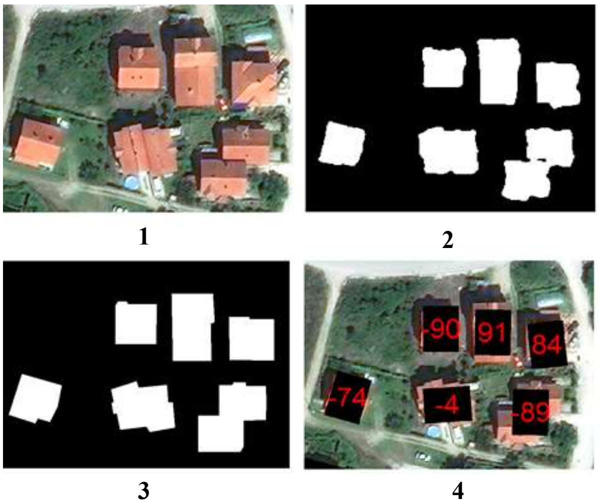

Figure 2. Argumentation of the accuracy of the model of deep learning

By applying the methodology[1], obtained data require minimal manipulation and correction, which results in saving time and other resources, as well as simplifies the creation of topographic maps in general. The tool was developed for the 1: 25 000 scale topographic map. The extent of the map sheet approximately covers an area of 120 km^2. With minor modifications, this tool can be used on the entire scale series of topographic maps.

References

Kokeza, Z., Vujasinović, M., Govedarica, M., Milojević, B. and Jakoviljević, G., 2020. Automatic building footprint extraction from UAV images using neural networks. In: *Geodetski vestnik* , Vol 64 (4), pp. 545.

Wu, G., Shao, X., Guo, Z., Chen, Q., Yuan, W., Shi, X., Xu, Y. and Shibasaki, R., 2018. Automatic Building Segmentation of Aerial Imagery Using Multi-Constraint Fully Convolutional Networks, In: *Remote Sens*, Vol 10(3), pp. 407.

[1] *Source code and the trained deep learning model are available for testing at:* https://github.com/milosbassa/ICC-2023

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