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VERIFICATION OF BUILDING RECOGNITION WITH EXPERT DATA

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Abstract. *Automatized building recognition is one of the principal aspects of Earth remote sensing data processing. This article describes an information processing technology of building recognition in high spatial resolution photogrammetric images. Specifically, we describe a stage of building recognition verification with expert data. Developed methods allow us to eliminate small non-building segments and aid this verification stage with a neural network trained on expert data. This article also describes an analysis of probable errors due to inadequate processing inherent to complex image properties (presence of shadows, overexposure, compact planning, compound building roofs).*

Keywords: *photogrammetric images, high resolution capability, segmentation, building recognition.*

Introduction.

The share of satellite images in the entirety of Earth's remote sensing data increases annually. Satellite image quality and accuracy increase along with reduction in cost of images as a reflection of increased productivity of satellites. Automatized buildings recognition helps save time and resources for geoinformation system database updates, maintenance of contemporary municipal geodetic data, site development control, securing cartographical, navigation tasks, etc. However, automatized recognition of high-resolution satellite images does not immediately become efficient probably because of high heterogeneity of spectral, three-dimensional, and textural characteristics.

Besides "welcomed" objects (buildings and roads), high-resolution images include objects that block or interfere with three-dimensional recognition (e.g., trees, cars, and most of all – the shadows). Therefore, a task of building recognition of the high-resolution photogrammetric images is complex.

Main text.

Multispectral high-resolution three-dimensional satellite images create the following requirements for the segmentation algorithms [1]:

- high operation speed of big data processing;
- ability of joint utilization of spectral and textural criteria;
- ability to select clusters of different sizes, forms and density under conditions of minimal a priori information;
- ability to select unknown beforehand number of clusters;
- resistance to the presence of "noise" in input data;
- simplicity in setting parameters.

Several authors propose different approaches for artificial object and building recognition using neural networks, uncontrolled clusterization, object-oriented approaches, and multi-stage methods [2-4].

A review of modern building recognition technologies suggests that there are still a small number of the automatized building recognition information technologies and each is with certain weaknesses and limitation in methods and algorithms. This necessitates continuation of efforts in improving such technologies and development of a well encompassing solution.

The proposed technology consists of the following stages:

- image splitting into sections to eliminate empty sections and to define the section type;
- histogram analysis;
- criterion segmentation (border definition) in the image space;
- addition of expert data attributes;
- usage of shadows for verification and elimination of non-building segments;
- elimination of segments with low probability to be a building, based upon geometrical estimations;
- finding a building contour and generalization.

Histogram analysis [5] allows for robust generation of histogram peaks for the building roofs in a case where buildings are dominant among the special features of a section.

Based on a Suzuki-Abe's algorithm [6], a search for a building contour is run within a section after the histogram analysis. Figure 1 shows preliminary recognition results where sections with spectral characteristics similar to the buildings become part of the building contour.

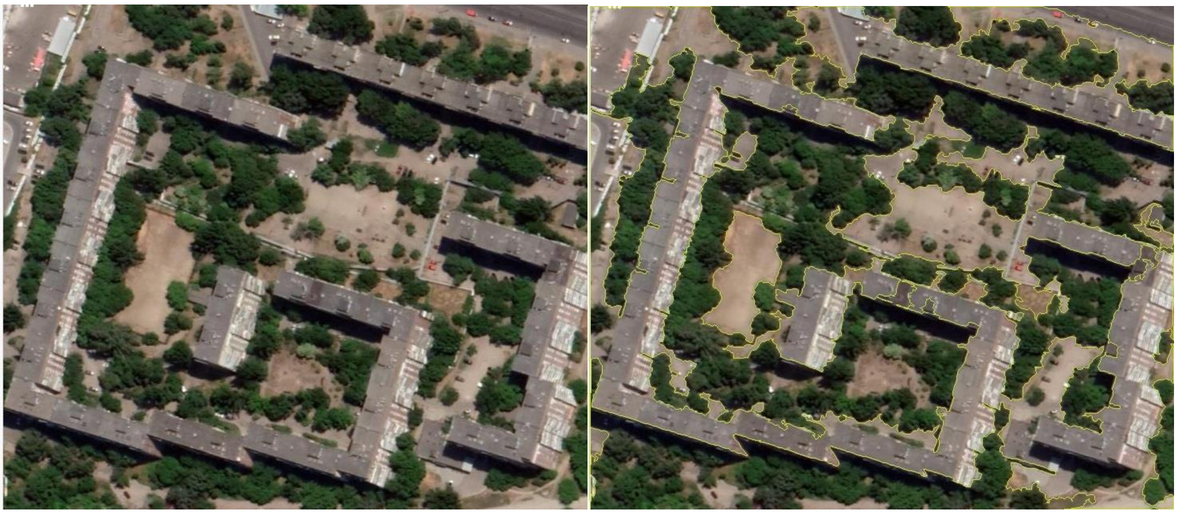

Figure 1 – Preliminary recognition results: a) output image; b) land surface is segmented jointly with buildings

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The results verification is necessary for the elimination of defects and errors of recognition. Expert data are valuable information for the building recognition process. Expert data must be up to date and closest to the time of image capturing.

For the verification of recognition results on the basis of expert data, let's assume that buildings must have certain minimal size. As a result, all segments smaller than expected from expert data are eliminated. Further, a neural network trained on expert data makes a decision based on a probability of the eliminated segment to be a building. Results of the verification based on the expert data are shown on Figure 2.

Figure 2 – Results of the verification based on expert data

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Divergence between the surface area from expert database and the estimated surface area of a segment could be observed at this stage due to the following (Figure 3):

1. Database errors – a database may be outdated or not relevant or there is a significant time gap between database update and the date and time of image capture.
2. Recognition defects –eliminated segments may be due to errors of omission or commission based on specifics of the automatized process,.

Figure 3 presents a typical case of omission error. In the part (a), the building has air ducts on the roof, and this causes the lacunas in the image segment. As a result, the size of segment is lower than the size in the expert database. Part (b) of the same figure shows the omission errors due to shadows from adjacent trees. The size of a selected segment is lower than the size of an expert one. In the part (c), a sector attached to the building has spectral characteristics similar to spectral characteristics of a building and thus resulting in the area of a selected segment to become larger than the area of an expert one. Images on the part (d) illustrate another common defect of a separation process. Due to sloping roof and different color shades, effective roof area is divided into separate segments.

Large size of a segment does not mean that a recognized segment is a building. Figure 2 shows adjacent area to the building and which is recognized as a part of the building. Shadow and geometrical analyses help correct such and other defects [7-9]. Figure 4 presents an outcome of the full-length verification.

Conclusions.

The current work illustrates that verification based on expert data improves recognition results. A decrease in number of omission errors may be achieved through the engagement of subsequent verification stages. However, the development of future recognition technologies should continue.

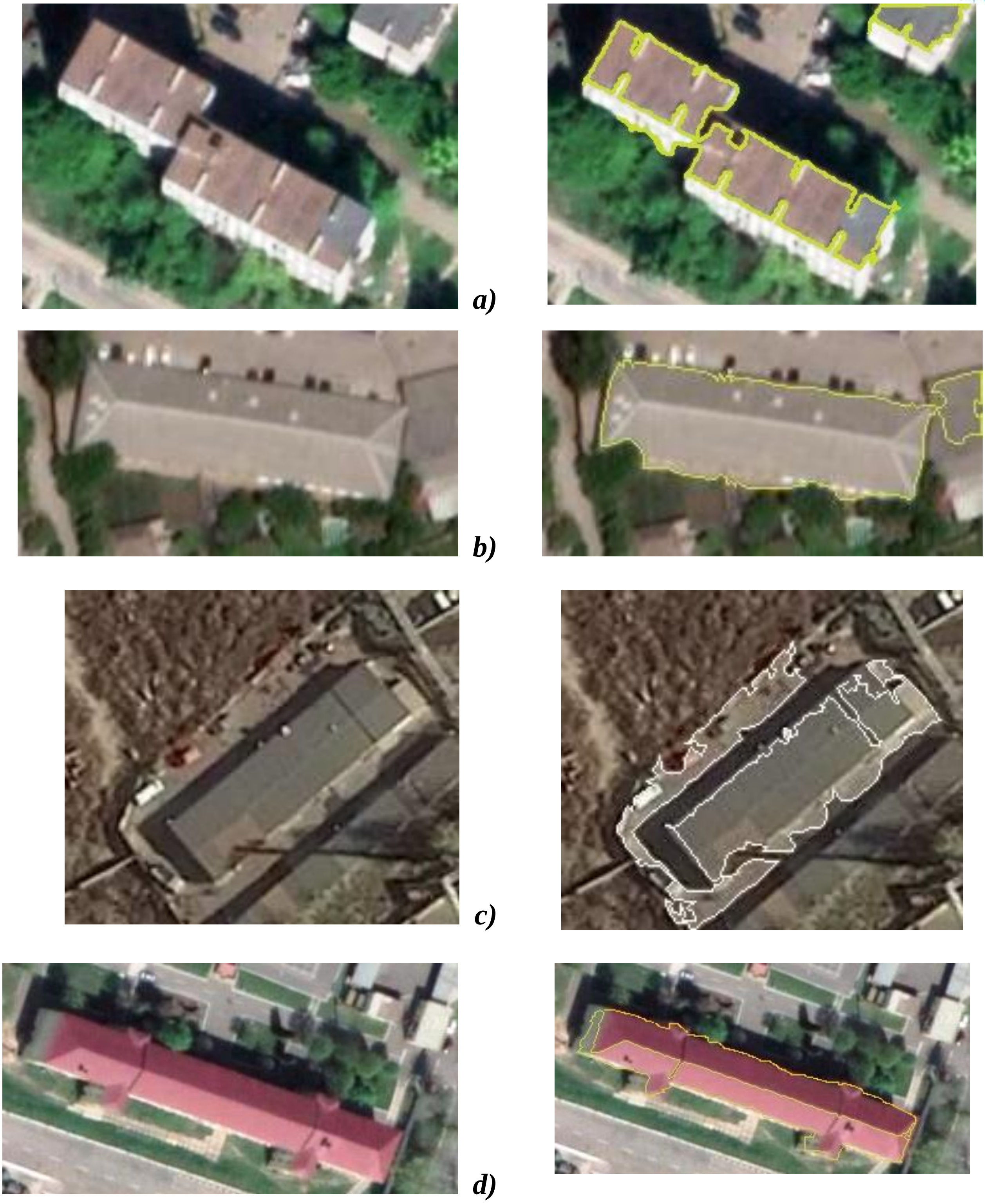

Figure 3 – Recognition defects on example of omission errors (input image on the left and elongated segment on the right)

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Figure 4 – Recognition results after a three-stage verification

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Анотація. *Автоматизоване розпізнавання будівель є важливим завданням обробки даних дистанційного зондування Землі. Робота присвячена опису інформаційної технології розпізнавання будівель на фотограмметричних зображеннях високого просторового розрізнення, зокрема етапу верифікації результатів розпізнавання з використанням експертних даних. Розроблені методики дозволяють усунути сегменти маленького розміру, які не можуть бути будівлями, та виконати перевірку даного етапу за допомогою нейронної мережі, яка пройшла навчання на експертних даних. Проведений аналіз можливих помилок недоробки, які виникають на даному етапі розпізнавання за рахунок складного характеру зображення (наявність тіні, щільна забудова, сонячне світло, складність геометрії дахів).*

Ключові слова: *фотограмметричні зображення, висока роздільна здатність, сегментація, розпізнавання будівель.*

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