METHODS OF CREATION OF DIGITAL TERRAIN MODEL OF THE CENTRAL PART OF THE LVIV

B. Chetverikov, R.Rega
Lviv Polytechnic National University

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Formulation of the problem

In recent years, we have witnessed the emergence of commercial implementations and the consolidation of the positions of fully automated methods for generating three-dimensional models. Obviously, these methods have a great future. The technology developed at Berkeley University was bought by Google. Microsoft also has a similar technology. The services of these two largest geographic information providers are gradually being filled up with three-dimensional urban models.

However, the development of such technologies and models on their basis does not necessarily belong to large corporations, which confirms a huge number of local projects.

The center of Lviv is a historical and cultural heritage that belongs to UNESCO and needs to be preserved. The means of preserving this property is the DEM.

Analysis of recent research and publications

The subject of the creation of historical digital terrain is a large number of both foreign and domestic scientists and researchers [1,2,3,4,5]. In particular, the department of photogrammetry and geoinformatics of the Lvivska Polytechnic National University created a digital model of the locality of the town of Shednitsy [6]. Among the all-Ukrainian projects of creating a historical digital terrain model, a large project on the reconstruction of the fortress Tustan [7] can be identified. In this paper, we want to propose one of the possible technologies for the creation of DEM and the means of its implementation.

Setting objectives

The purpose of the work is to create a digital model of the locality of the central part of the city of Lviv, whose objects are protected by UNESCO.

Presentation of the main research material

The main inputs for the implementation of the task were: a space shot, a central part of Lviv, obtained from the GeoEye-1 satellite in 2015, and the texture library used to create a digital terrain model.

This library contained promising photographs of the facades of buildings in the central part of Lviv. Each building should be photographed on four sides. For more detail, some complex building elements (bas-reliefs, etc.) were photographed for better interpretation. The optical axis of the camera when taken is perpendicular to the facade of the building.

An example of the city hall's city hall is shown in Fig. 1

Fig.1 Picture of the captured facade of the Town Hall of Lviv

One of the possible technological schemes for a similar type of work (Fig. 2), which consists of six main stages, is proposed for realization of the work.

Geometric correction of the space image was carried out with 9 reference points in the Erdas Inagine software package with a maximum error of 2.1 m. in the locality. After correction, the image was saved to GeoTIFF format.

At the stage of vectorization, the buildings of the central part of the city (Fig. 3) are digitized using satellite imagery and standard tools in the SketchUp software.

The next step is to create frame models of buildings, which uses the pull / push tool.
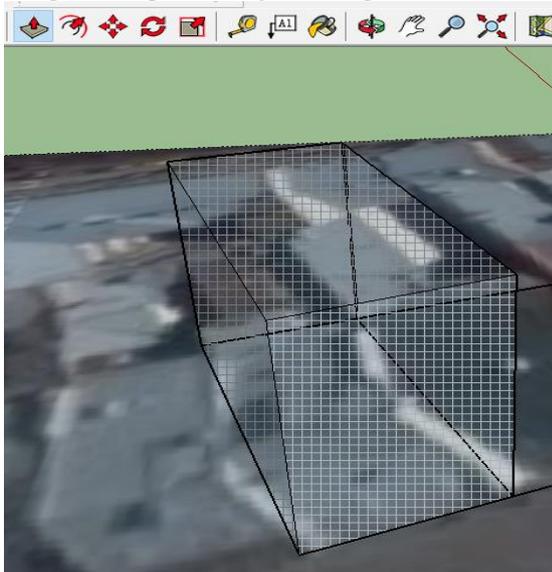
An example of such a model is shown in Fig. 4
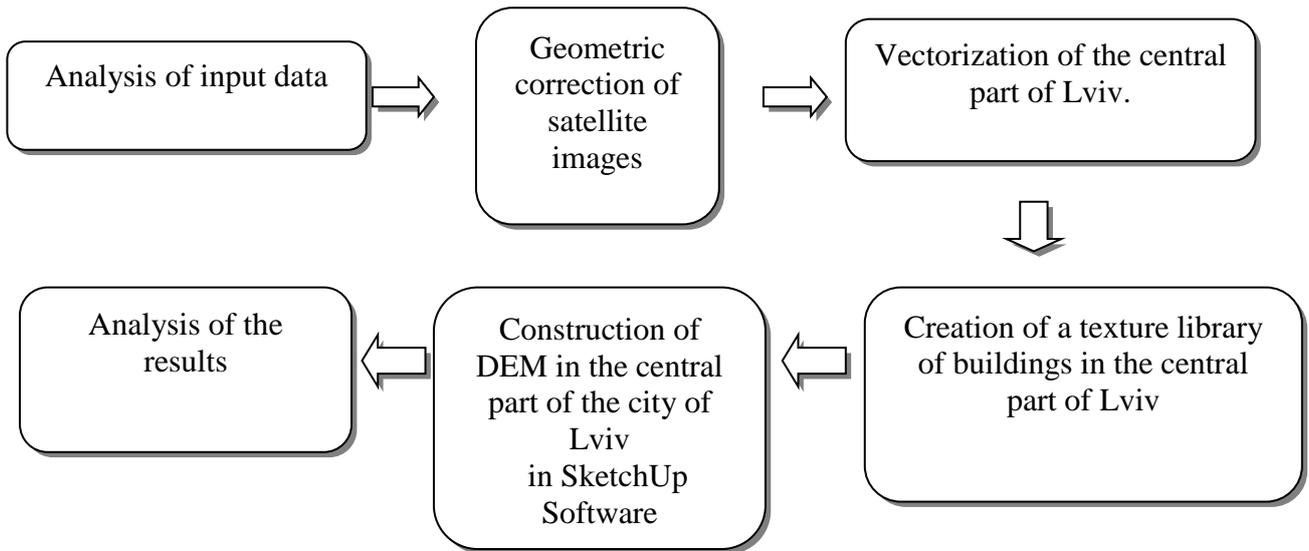
Fig.2 Technological scheme of construction of DEM central part of Lviv

Fig. 3 The process of building vectorization

Fig.4 Three-dimensional frame model of the building

The created library of textures included 161 images of objects belonging to the UNESCO register of monuments. Next, each of them was scaled up as long as the width of the building on the picture did not correspond to the width of the building, which was vectorized on the space shot.

But there is also another way to create a skeleton structure, in the SketchUp software product (Fig. 5).
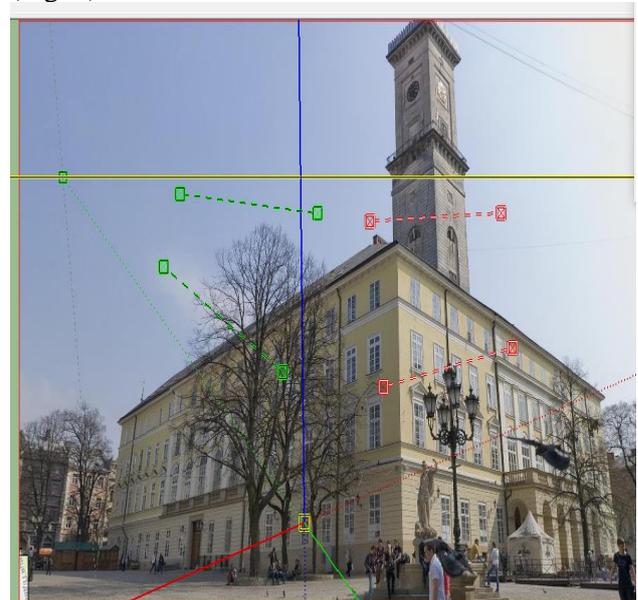

Fig. 5 A picture of the Town Hall with a split on the coordinate axes x, y, z.

Next, you need to place the axis so that the green axis is parallel to one side of the facade, and the red axis is parallel to the other. The result is shown in Fig. 6.
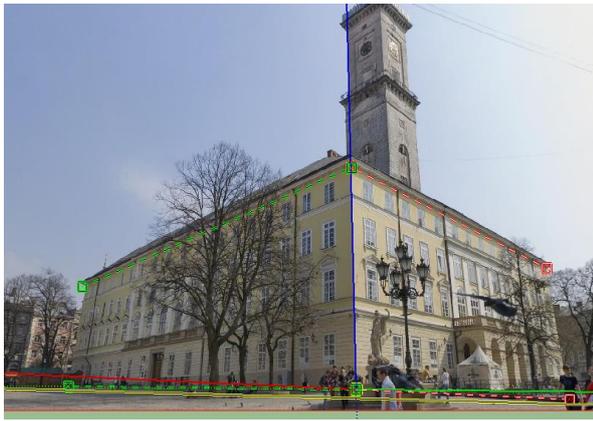
Fig. 6 Correctly located axis relative to the building.

The next step is to digitize one side of the structure along the green coordinate axes. Standard tools are also used for this, and then the "drag and drop" function is applied to the red axes. As a result, the finished skeleton of the building was received (Fig. 7).
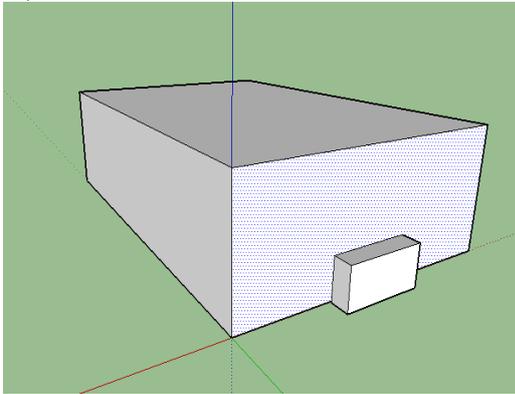
Fig.7 Ready skeleton of the building is created using the function "match_photo"

To overlay the textures, you need to select the desired side of the facade and from the texture library to import the corresponding image, then place it on the frame model of a three-dimensional building. Standard tools are used for this. The result obtained is depicted on (Fig. 8)
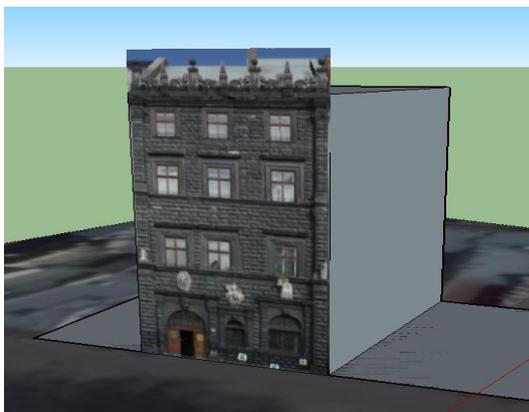
Fig.8 The texture on the facade of the building on the Rynok Square is applied

Create additional building elements. At this stage, it was necessary to create such elements of buildings as: windows, doors, window sills, etc.

It is necessary to remember that separate decor elements, preferably in different layers, to improve the performance of the program. On Fig. 9 one can notice the difference between the facade barrel in the 2D view (Fig. 9a) and the 3D representation (Fig. 9b), which greatly improves the visual perception of the building.

a)   *b)*
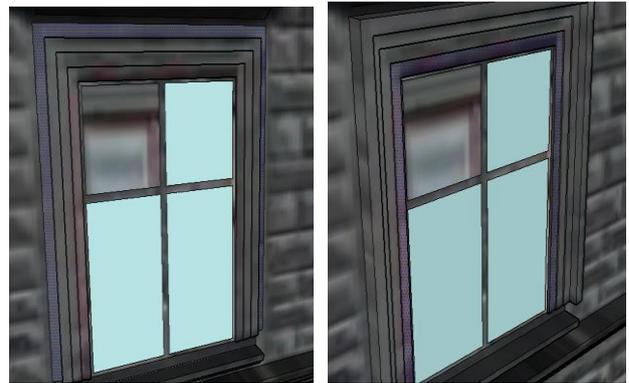
Fig.9. The basil facade of the building a) in the 2D view; b) in 3D view

After digitizing one window with a bas-relief, you can copy it and apply it to other non-digitized windows in order to ease the work, because the windows in this building are one standard. To do this you can use "smart" copying and insertion. Its essence is that we measure the distance between the windows, and then point it to the program, as well as the number of windows. The software then inserts the copied files at a certain interval.

In this way, it is necessary to apply other elements of the facade and decor. These include the following elements:

• Window sills
• Simple stucco molding
• Stairs
• Doors of buildings
• Arches

However, there are buildings in which to apply technology "match photo" is required more than once, and two or more, as in the case of Lviv City Hall. For her, it is desirable to apply this technology four times, because all its facades are different. To do this, you need to import a new photo and specify "Import how New match photo" in the dialog box. A new image with new axes and a model linked to them will open (Fig. 10).
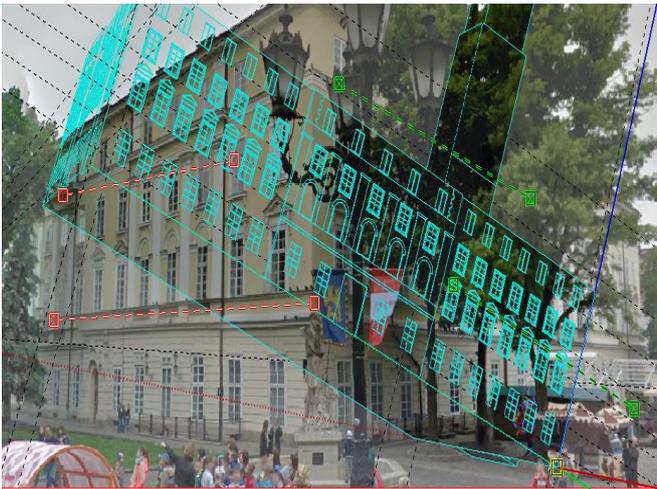
Fig.10 New image based on match photo technology

Next, you need to place the center of the axes at the same angle of the building where they were located in the previous image, and with green and red axes orient our model so that its contours coincided with the contours of the building in the image, as shown in Fig. 11.

Now that the building is tied to the snapshot, you can proceed to vectorize the new facade, which was not visible on the previous photo. On it we also vectorize windows, columns, doors and other elements of the building. Thus, all buildings of historical and cultural significance located at the Market Square and listed on the UNESCO objects are processed.
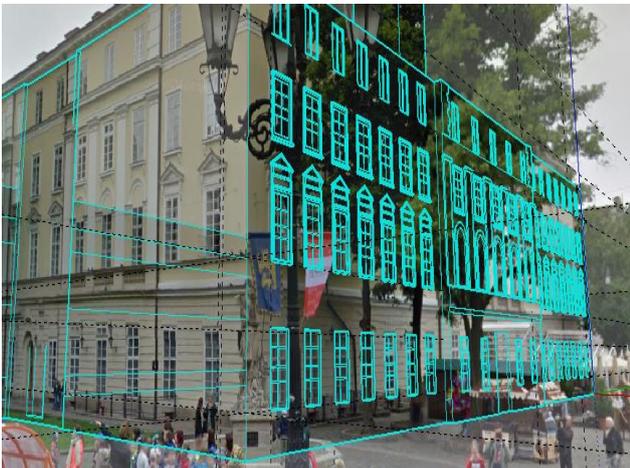

Fig.11. The building model is oriented with the image of the building

Once we have created the model of the building, all its elements need to be grouped together in order to further scale and move it. After uploading the model to the main file, it must first be reduced to a certain scale. In order to do this, you need to put it on a digitized foundation, that is, all four corners of the building should be tied to the horitic corners of the foundation of this building (Fig. 12)

Fig.12. The mock-ups of the buildings are tied up to the vectorized from the space image of the foundations

This is all the basic steps you need to take to create a 3D model of an area object. Similar operations are carried out with other buildings on the space shot.

Conclusions

Google SketchUp has created a digital model of the locality of the central part of Lviv, a historical and cultural heritage, protected by UNESCO.

Vectorized and formed 3D models of houses for 34 objects of historical and cultural heritage with subsequent drawing of textures on them.

The obtained CMM in the central part of Lviv can be used for historical and tourist purposes.

References
1. Arnoud de Boer . Processing old maps and drawings to create virtual historic landscapes / e-Perimetron. - Vol. 5, No. 2. – 2010. – P.49-57
2. Bartoněk D. Prediction model to identify the significant development periods of the historical objects / D. Bartoněk // FIG Working Week 2012. - May 6-10. 2012, Rome, Italy
3. Garouani A. El, Alobeid A. Digital Surface Model generation for 3D City Modeling (Fez, Morocco) /   A. El Garouani, A. Alobeid // Eighth National GIS Symposium in Saudi Arabia – April 15-17, 2013, Dammam
4. Matejicek L. Processing of Environmental Data for Air Dispersion Numerical Models and Aerodynamic Research in Wind Tunnels / L.Matejicek //   International Environmental Modelling and Software Society (iEMSs) 7th Intl. Congress on Env. Modelling and Software, San Diego, CA, USA.
5. Matoušek V. The thirty years war battlefields plans in the Czech Republic in the Theatrum Europaeum   /   V.Matoušek,   T.Blažková,

T.Soudná, R.Zimová // Geographia Technica. - No. 2. - 2011. - P. 56-64.

6. Колб І. Комп'ютерне моделювання елементів історико-культурного ландшафту селища Східниця / І.Колб, Ю.Шкурченко, Л.Дичко// Геодезія, картографія і аерофотознімання. – Вип.71. – 2009. – С.49-59.

7. Електронний ресурс: http://www.tustan.ua.

Methods of creation of digital terrain model of the central part of the Lviv

Chetverikov B., Rega R.

The article considers the method of creation a digital terrain model of the central part of the city of Lviv, whose objects belong to the historical and cultural heritage of the Ukrainian people and entered into the UNESCO registry.

The DTM is built using the Google SkrechUp software with the "match photo" technology.