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Original Contribution

FACADE SURVEYING USING TRADITIONAL ANGULAR-LINEAR MEASUREMENTS AND 2D SOFTWARE

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ABSTRACT: *To solve complex urban planning and architectural-artistic tasks related to the determination of the spatial location of the existing external elements of the building, in practice it is often necessary to carry out geodetic surveying of building facades. Photographing facades is used in reconstructions of buildings or restorations of cultural monuments, preservation of cultural heritage, photographing archaeological sites, carrying out various types of research activities and analyses, designing suspended facades, cladding and joinery, preparing a working layout plan etc.*

KEYWORDS: *Facade architecture, Terrestrial laser scanning, Terrestrial photogrammetry, Conventional methods*

1. Modern methods

1.1. Photogrammetric surveying

Photogrammetric remote sensing methods are a valuable source of data for mapping, surveying and 3D modeling. The most common fields in which images from photogrammetric data are used are agriculture and forestry, environmental studies, archeology and cultural heritage, traffic control and 3D reconstructions. Depending on the chosen approach, two types of photogrammetry are distinguished - aerial and ground.

In case of specific needs for the creation of topographic plans and maps for a given region, the state supporting geodetic networks in it are compressed with

supporting geodetic networks with local purpose (GNLP) – their accuracy is less than that of the state networks.

In aerial photogrammetry, the aerial photogrammetry camera is mounted on unmanned photogrammetry aerial vehicles, most commonly so-called "multicopters". These are remotely controlled aircraft in which the flight takes place thanks to two or more pairs of propellers located diametrically opposite each other, driven in principle by electric motors. They are characterized by high maneuverability and the ability to take off and land in limited spaces, which makes it possible to photograph hard-to-reach objects.

Ground photogrammetry, or so-called close-range photogrammetry, is the more commonly used method in architectural facade photography. For this purpose, successive photographing of the facades is carried out using photogrammetric cameras or cameras mounted on tripods or tripods. With the development of technologies and software, 3D models can now be successfully created with any type of cameras, and georeferencing can be carried out in a variety of ways (placing the cameras on coordinated points on the earth's surface, coordinated marks on buildings, etc.).

Common to both types of photogrammetry is the end result – a dense cloud of points in a defined or arbitrary coordinate system. As technology advances, this method manages to give us a 3D model with an absolute accuracy of less than 1 cm, but this is achieved with expensive measuring and computing equipment, as well as expensive software. Another important caveat about the photogrammetric method is that the model cannot be georeferenced without using classical or GNSS technologies.

1.2 Laser scanning

3D laser scanning is a modern method of creating accurate digital models that replaces or in many cases complements photogrammetric remote methods. Similar to the photogrammetric method, laser scanning finds application in the creation of plans and maps, in the construction and monitoring of facilities, the photography of industrial enterprises, interior and exterior architectural photography, the documentation of cultural monuments, the documentation of accident and crime scenes, and others. Essentially, laser scanning is an advanced technology that obtains an accurate set of geospatial data through light measurements. For this purpose, a high-speed scan is performed (measurement of over 1,000,000 points per second) and the end result is a so-called "cloud of points" with an accuracy of up to 2 mm per point. Like the photogrammetric

method, laser scanning can be done in two ways - aerial and ground. For the purpose of architectural photography of facades, terrestrial laser scanning is mainly used.

The accuracy of the 3D model depends directly on the determination of the external orientation elements of the scanner. For this purpose, various methods are used - instrumental and analytical. Depending on the situation, different approaches are used to solve the problem, each of which has its advantages and disadvantages.

2. Conventional methods.

Nowadays, with the advancement of technology, conventional methods of photographing facades are less and less talked about and paid attention to. Articles are published daily praising new technologies for collecting and processing information. However, few specify all the accompanying details necessary to reproduce this perfect end result. These are the costs of the necessary hardware, software, and the time required to process this data, which sometimes varies from a few hours to a few days. Let's not forget that we as surveyors make the connection between the real world and the computer, as well as who our final product is intended for. Very often, using mostly remote methods of gathering information, we form a final product saturated with redundant information, which we then have to filter, which leads to an additional waste of time.

Before the advent of remote sensing methods such as photogrammetry and laser scanning, facade imaging could be done with a reflectorless total station, describing all the details of the building (or at least those required for the particular task). The obtained data can be used for drawing architectural plans, research for verticality of supporting elements of the building, working calculations for window frames and suspended facades, working layout plans, etc. This is a wide enough list of tasks that it is worth not completely rejecting conventional methods. Using this method, we can successfully solve the aforementioned tasks with a technique (reflectorless total station) that every surveyor has, and the software can even be two-dimensional (2D), which is a much more affordable option.

Depending on the needs, the resulting model can be georeferenced (if it is the whole building with all its facades), and it can also be in an absolute height system, referred to some reference height system accepted for the area. This depends entirely on whether we will use a working geodetic base with output

coordinates and elevations of the working points. In other cases, we can make measurements in a local coordinate and height system, thus obtaining a scaled model of the facade with working heights, which we can then relate to absolute heights. The subject of this article will be the creation of a model in a local coordinate and elevation system using a reflectorless total station and 2D software.

3. Analysis, evaluation and interpretation of the obtained results.

To photograph the facade of a building, it is necessary to have visibility to high characteristic points of the facade (Fig. 1). If this is not provided, then we must use an identical point on the facade when shooting from different stations.

Fig. 1. Geodetic survey of a facade

To work in a local coordinate system, it is good to use the total station in coordinate mode instead of angular-longitudinal. The angular-longitudinal mode is related to the stabilization of a reference polygon, post-processing and smoothing of the results, which would be useful when making a georeferenced or 3D model of the building. In this case, our feature points are given conditional coordinates and elevations (north, east, elevation) that we need to arrange (Table 1).

Table 1. Detailed points before and after processing

Original survey point					Recalculated survey point		
Local coordinate system							
№	N	E	Z	<--->	№	N	E
1	7.852	-8.160	0.355		1	0.355	7.176
2	12.206	-7.603	0.379		2	0.379	11.486
3	8.227	-8.458	0.383	<--->	3	0.383	7.430
4	11.934	-7.978	0.391		4	0.391	11.125
5	8.209	-8.444	0.529		5	0.529	7.417
6	11.933	-7.968	0.535	<--->	6	0.535	11.126
7	2.597	-10.519	0.321		7	0.321	1.455
8	2.606	-10.559	0.702		8	0.702	1.458
9	3.712	-10.384	0.706	<--->	9	0.706	2.577
10	3.710	-10.379	0.322		10	0.322	2.576
11	6.067	-10.075	0.333		11	0.333	4.952
12	6.079	-10.086	0.692	<--->	12	0.692	4.963
13	7.223	-9.929	0.695		13	0.695	6.117
14	7.219	-9.924	0.413		14	0.413	6.114
15	13.301	-9.139	0.441	<--->	15	0.441	12.246
16	13.326	-9.156	0.883		16	0.883	12.269
17	14.487	-9.007	0.875		17	0.875	13.439
18	14.457	-8.985	0.371	<--->	18	0.371	13.413
19	16.808	-8.679	0.370		19	0.370	15.783
20	16.826	-8.688	0.894		20	0.894	15.800
21	17.960	-8.538	0.892	<--->	21	0.892	16.944
22	17.954	-8.530	0.392		22	0.392	16.939
23	1.169	-10.749	0.214		23	0.214	0.011
24	1.162	-10.757	1.170	<--->	24	1.170	0.000

Creating a 2D model of the facade involves drawing points with two dimensions - north and east. To do this we need to recalculate our local detail points and convert them to 2D. In the case of the recalculated detail points, the north will be the height value from the original ones, and the east will have to be calculated according to the Pythagorean theorem relative to the westernmost detail point of the facade (Table 2).

Table 2. Recalculation of detail points

Westernmost Survey point	***Survey point***	***Recalculated point***
(Local coordinate system)		
W_North	North	North = Heigh (Survey point)
W_East	East	East = $\sqrt{\{(North - W\_North)^2+(East - W\_East)^2\}}$
W_Heigh	Heigh	

After recalculating the detail points, it remains to import and draw them in the appropriate CAD software. For this purpose, in the course of the geodetic survey, we made a manual sketch with marked corresponding detailed points (Fig. 2) or encoded them in the memory of the total station (Fig. 3).

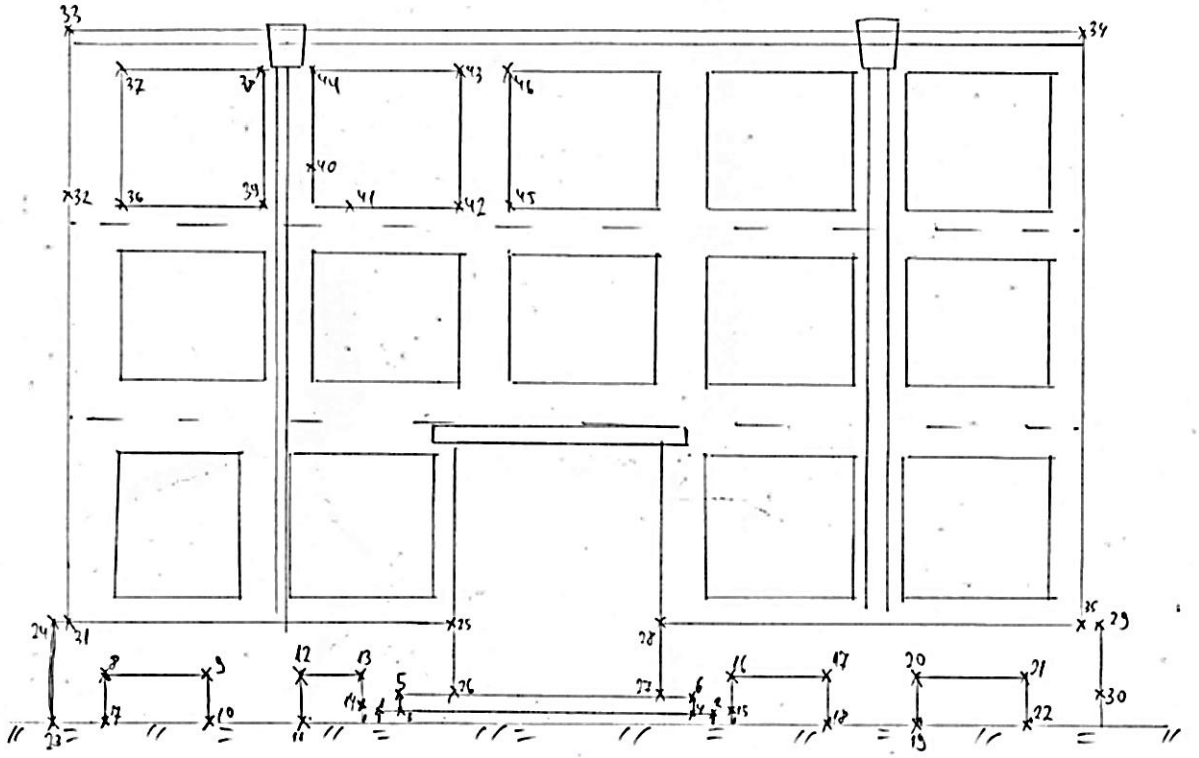

Fig. 2. Hand sketch

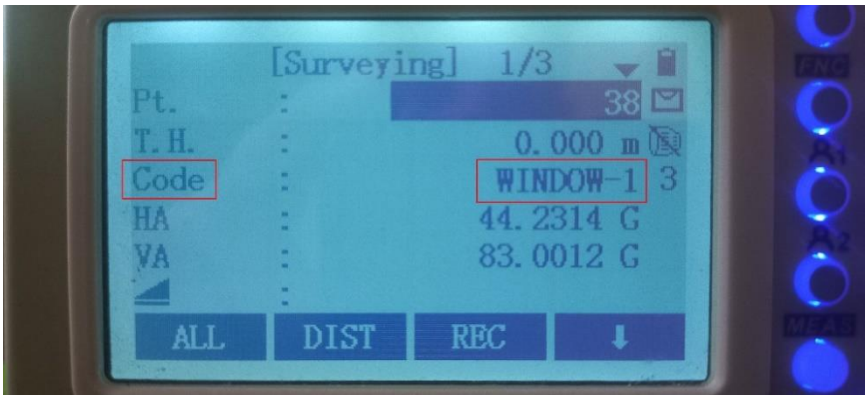

Fig. 3. Coding of detail points

We shape the results according to the task received and transmit them in a format suitable for the user (most often DWG or DXF). The final product must meet the set requirements and not contain any accompanying information unnecessary for the user (Fig. 4).

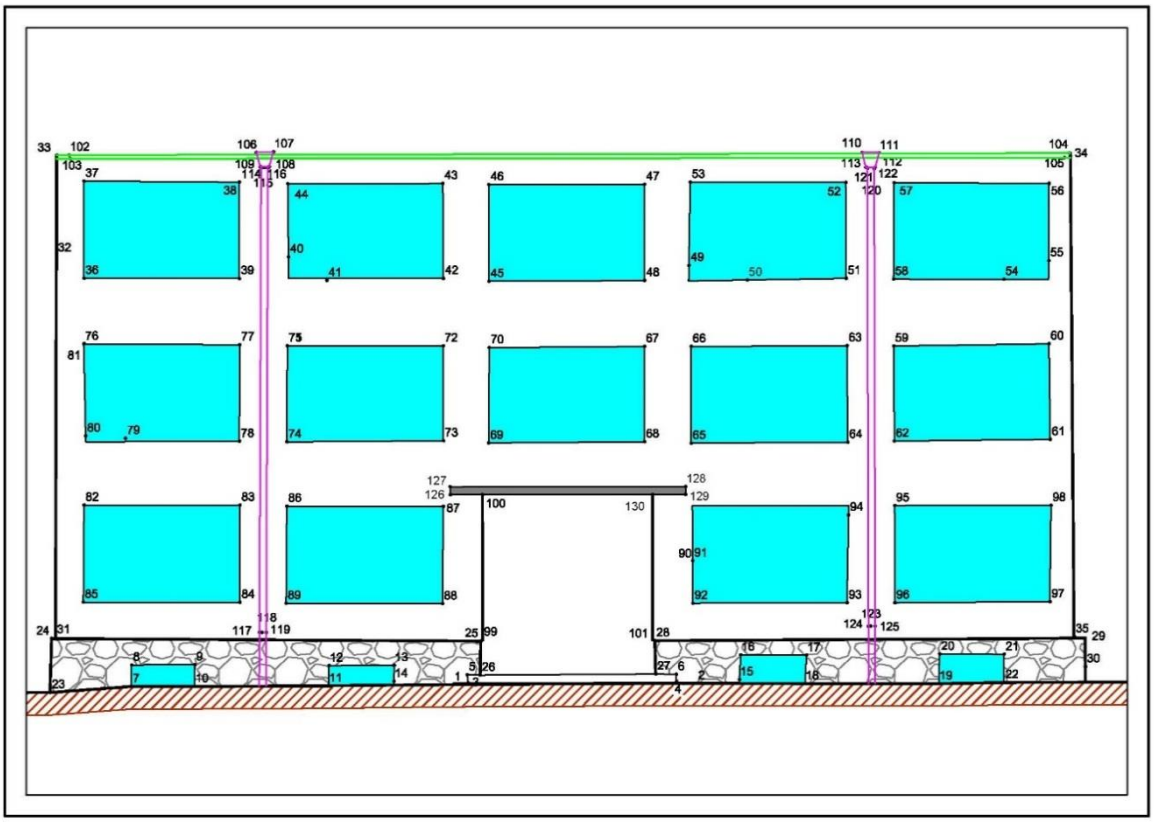

Fig. 4. Drawing the facade in DWF/DXF format

4. Conclusion

New technologies, especially in the field of remote methods, give an incredible perspective and unattainable results compared to traditional and conventional methods. On the other hand, with the use of conventional methods, satisfactory results are achieved for solving some tasks related to the architectural photography of facades. Knowing the different methods and technologies gives the best judgment for solving a specific task, which is crucial for the optimal use of funds and time.

3. Conclusion

At the current stage of the development of marine geodesy, when taking coastal marine photographs, mostly local marine reference geodetic networks are created, included in the reference geodetic network on land. Establishing a

marine reference geodetic network is too expensive and no country has yet fully established such networks.

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