

розвиток дослідно-випробувальної бази...»

Також CALS-системи у мікроконтролерних комплексах досить недавно були впроваджені і в Україні. Ми починаємо в цьому розвиватися, представлені технології добре вплинуть на розвиток різноманітних інфраструктур у нашій країні.

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AERIAL PHOTOGRAPHY IN GEODESY: HISTORY AND MODERN COMPUTER TECHNOLOGIES

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Aerial photography is a quite ancient technology that dates back to the first flying devices and primitive cameras. The first aerial photography took place in 1858 over Paris. The French photographer and aeronaut Gaspard-Felix Tournachon, better known under the pseudonym Nadar, produced it. This technology got its active application and development during the World War I and

the World War II, where it was used for reconnaissance purposes.

Aerial photography is understood as photographing the surface of a certain area with reference to coordinate data and creating a series of relief images that are formed with slight overlap. Typically, the longitudinal overlap value in aerial photographs is 60%, although in special cases the values can be changed to meet the requirements of these photographs.

If aerial photography of a wide area is required, then photographing a given area is carried out by a series of parallel routes with transverse overlap. Typically, overlap for this type of photography is 30%.

Depending on the perspective used, aerial photography is divided into two main types:

1) Planned with the camera pointing strictly vertically downward in relation to the earth's surface. As a result of planned aerial photography, photographs are obtained with a flat picture made in an orthogonal projection, which makes it possible to determine the relative position of various objects on the plane without taking into account heights.

2) Perspective or overview aerial photography, performed with the camera positioned at a given angle to the horizon. This type of photography allows obtaining three-dimensional images in an axonometric projection, where the user can see not only the roofs of buildings, but also their side surfaces. Due to this fact, it is possible to determine the exact shape of objects and the height of the relief irregularities.

It is also possible to photograph on a cylindrical surface with a rotating lens. Such photography is called panoramic, but it is rarely used in geodesy.

The capabilities of unmanned aircrafts and equipment provide a wide range of diverse aerial photography products, including:

1) Orthophotomap of the terrain, which is a territory plan of reconstructing a real display of the earth's surface on an accurate geodetic basis.

2) NDVI survey, which is orthophotomap of the terrain, showing the degree of plants and crops health.

3) Digital terrain model (DTM), which is a three-dimensional terrain model, taking into account all the objects on it.

4) Digital relief model (DRM) represents a map of the heights of the earth's surface without taking into account the objects located on it.

5) 3D terrain model - a realistic three-dimensional model of the terrain or the objects with reference on an accurate geodetic basis.

Various software is used nowadays to process materials obtained as a result of aerial photography, some more detailed information is given further.

Although aerial photography has been used as a method for a long time, a real revolution in this field has occurred in recent years due to the development of computer technologies. The use of modern software greatly simplifies both the processing of the initial images and their further application directly to the tasks of the selected area. We will consider some particularly interesting programs in more detail.

AgiSoftPhotoscan is software for photogrammetric processing of aerial photography materials that allows creating 3D models, DTMs and orthophotomaps. This data can be used to create visual effects as well as to measure objects. AgiSoft provides excellent scan results and a user-friendly interface. In addition, this software has no restrictions on the number of images; productivity depends directly on the power of the computer, which is also an indisputable advantage.

RealityCapture is software that has a much higher speed, besides, it also manages a huge number of images at the same time. The main advantage of RealityCapture is the ability to frame images in seconds, even on a laptop with an NVidia GPU. This allows getting the finished result directly on the ground and, if necessary, carry out additional surveys.

TrimbleUASMaster is the software, which is best suited for complete processing of data received from unmanned aircrafts. UASMaster has the latest photogrammetric data processing functionality. A significant advantage is the compatibility of this software with other producer's programs and even some third-

party programs. The interface is clear and easy to use. With its help, it is possible to process data obtained from unmanned aircrafts of almost any producer and of various types of construction. There are fully automatic process of georeferencing, camera calibration, building a point cloud and orthomosaics provided.

Due to the development and widespread use of quadcopters, significant progress has been made. They are the best suited for the purposes and tasks of surveying due to their indisputable advantages, including: relatively small size, the latest electronic filling of copters, which can significantly simplify and automate the process, a wide range of models and software on the market.

To conclude, aerial photography offers tremendous benefits to geodesy. Using its achievements, it is possible to significantly simplify and reduce the number of field and office work carried out when drawing up various maps, terrain plans, outlines, etc., especially for less detailed scales and certain terrain types. In addition, in some situations, when a surveyor cannot come and work directly on the ground for various reasons, aerial photography with computer technologies becomes simply irreplaceable, enabling the job to be done with high quality.

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