Non-contact photogrammetric system to capture digital image of Ignatievka Cave

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Targets and code marks of photogrammetric system. Credit: Viktoria Matveichuk

Scientists of South Ural State University have engineered a unique photogrammetric system for high-precision, noncontact measurements

of 3-D coordinates, which can create 3-D models of ancient cultural monuments. The researchers plan to use this system in archaeological studies of Ignatievka Cave, located in the southern Ural Mountains, where cave drawings were found in 1980.

Ignatievka Cave is a significant natural cultural monument located in the vicinity of Serpievka village, Katav-Ivanovsk District, the Chelyabinsk Region. The cave walls have drawings on them, which were created as long as 15,400 to 18,900 years ago. The drawings depict animals (mammoths, horses, ox, fantastic beasts), anthropomorphous figures, signs, separate lines and spots of paint. This cave is a popular tourist attraction in the Ural region, but as a result, its microclimate is being disturbed, which complicates the preservation of the ancient images. The archaeologists note that to save the drawings from vanishing completely, it is necessary to limit access to the cave, as well as to create 3-D images of the drawings themselves by means of photogrammetric survey and 3-D scanning.

"The photogrammetric system can be used to create a digital image of the cave. Its 3-D reconstruction will allow us to recreate the dimensions and location of the drawings with pinpoint precision, and to view them in a high-resolution and in 3-D format. Thus, we will get an opportunity to recreate three-dimensional cave drawings in a place accessible for all those willing—for instance, we could exhibit them in a special cave-like pavilion. This way, we will preserve priceless artifacts for future generations. Significantly, the digitalization of the drawings in a 3-D format gives us an opportunity to study the unique cave paintings remotely from anywhere in the world, provided we have a specialized device and the Internet connection," says Gayaz Samigullov, senior research fellow of the SUSU Eurasian Studies Research and Education Centre, Candidate of Sciences (History).

This system is also widely used in aerospace engineering, mechanical

engineering, aircraft and satellite engineering, construction, forensics, and analysing road traffic accidents—situations in which the positions of certain objects relative to others is required. In construction, the photogrammetric system is used to measure the alignment of high-rise buildings' supports: it allows engineers to determine to what degree these supports decline from the vertical position, or relative to each other.

In forensics, the photogrammetric system could be used to recreate accident scenes in 3-D based on a photo, and allow investigators to mark certain spots and determine coordinates and distances. Additionally, it could allow the caluculation of the damage a car experiences as a result of a road traffic accident. The road traffic accident scene is labeled with code marks and targets is thereby reconstructed.

Credit: Viktoria Matveichuk

The system is based on taking special measurements using a common photo camera or even a phone camera. The software quickly and accurately computes the 3-D coordinates of the control points of an object, distances, and the shape of the surface, without the need for direct contact with the object being measured.

"The methods of measuring photography are accurate, quick and convenient. Certain points are marked with targets and then are photographed from several angles; the software processes the photos and produces 3-D coordinates of these points. These are used to find out how certain constructions are positioned in space, and the positioning of the elements of these constructions is controlled. Our system allows us to do it with high accuracy," says project lead Boris Sukhovilov.

At present, the photogrammetric system by the scientists of South Ural State University is used by a leading Russian aerospace corporation Academician M.F. Reshetnev Information Satellite Systems. The scientists took part in engineering a high-technology, low-floor tram, jointly with Uraltransmash enterprise, for which they created a high-precision system of measuring coordinates of a system of measuring the coordinates of a low-floor tram frame.

The photogrammetric system is unique because it can be used without a special graduated scale, which makes its use significantly cheaper. Besides that, it can be used both with a professional photo camera and a phone camera, while other systems are compatible only with certain phone camera models. The unique photogrammetric system algorithms are patented (have computer software registration certificates).

Provided by South Ural State University