The use of 3D Visualization Technology Web-collections for the Formation of Virtual Exhibitions

N. Kalenov[1[0000-0001-5269-0988]], I. Sobolevskaya[1[0000-0002-9461-3750]], A. Sotnikov[1[0000-0002-0137-1255]], S. Kirillov[1[0000-0001-7560-0041]]

[1] Joint Supercomputer Center of the Russian Academy of Sciences - Branch of Federal State Institution "Scientific Research Institute for System Analysis of the Russian Academy of Sciences" (JSCC RAS — Branch of SRISA), 119334, Moscow, Leninsky av., 32 a, Russia
asotnikov@jscc.ru

Abstract. The paper is presents approaches to solving the problem of creating realistic interactive 3D web-collections of museum exhibits. It is shown how electronic copies of library, archival and museum storage objects, presented in the form of texts, graphic images, and audio-video objects, including 3D-models, can be integrated by means of an electronic library. The presentation of 3D-models of objects based on oriented polygonal structures is considered. The method of creating a virtual collection of 3D-models using interactive animation technology is described. It is also shown how a full-fledged 3D-model is constructed on the basis of individual exposure frames using photogrammetry methods. The paper assesses the computational complexity of constructing realistic 3D-models. For the creation of 3D-models in order to provide them to a wide range of users via the Internet, the socalled interactive animation technology is used. The paper presents the differences between the representations of full-fledged 3D-models and 3D-models presented in the form of interactive multiplication. The technology of creating 3D-models of objects from the funds of the State Biological Museum. K.A Timiryazev and the formation on their basis of the electronic library "Scientific Heritage of Russia" of a virtual exhibition dedicated to the scientific activities of M.M. Gerasimov and his anthropological reconstructions, and vividly demonstrating the possibility of integrating information resources by means of an electronic library. The format of virtual exhibitions allows you to combine the resources of partners to provide a wide range of users with collections stored in museum, archival and library collections.

Keywords: Photogrammetry, 3D-modeling, Interactive Animation, Web-Design, Polygonal Modeling.

1 Introduction

One way to represent interdisciplinary collections in a distributed digital library environment is to form a virtual exhibition. A virtual exhibition is a multimedia information resource that shows users heterogeneous information (digital copies of printed materials, archival documents, museum objects, etc.), combined according to specified characteristics. In addition to the presentation of various types of materials in the process of forming digital science collections, there is a need for multimedia objects, namely 3D digital models of museum objects and virtual reality objects [1]. Virtual exhibitions can be presented not only on the Internet, but also become part or even the main element of a real museum exposition.

In recent years, visualization methods based on photogrammetric images and further construction of three-dimensional structures from sequences of two-dimensional images that can be combined with local motion signals are widely used. This method is called Structure from motion (SfM) [2–4]. In biological visual perception, a SfM is an "apparatus" whereby humans (and other living beings) can recover a three-dimensional structure from a 2D motion field of a moving object or scene projected on the retina of the eye. This method is applied in the field of computer modeling related to visual perception modeling. The basic idea of SfM method is following (Figure 1):

Given: m images of n fixed $3D$ points

$$x_{ij} = P_i X_j,\ \ i = 1 \cdots m,\ \ j = 1 \cdots n$$

The problem is: estimate m projection matrices P_i and n fixed $3D$ points X_j from the mn correspondences x_{ij} (Figure 1).

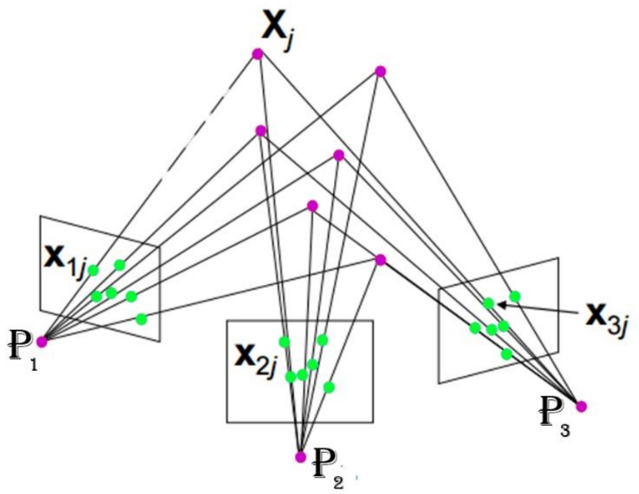

Fig. 1. The basic idea of SfM method.

However, there are such boundary conditions under which this method "does not work," for example, in the presence of glass and reflecting surfaces.

For creation of 3D models and elements of virtual exhibition various software and technological solutions are used, in particular, technologies of laser and optical 3D-scanning, computer modeling, photogrammetry, animation 360^0, etc. [5].

2 Laser and optical 3d scanning technologies

Laser and optical 3D scanning technologies allow to create a digital copy of the object, for example, museum, using a 3D scanner [5].

Optical 3D scanners use structured light technology (Figure 2). A projection of the light grid is directed to the object to be scanned. Analysis of the deformation of the grid light lines and allows to calculate the shape of the surface of the scanned object [6].

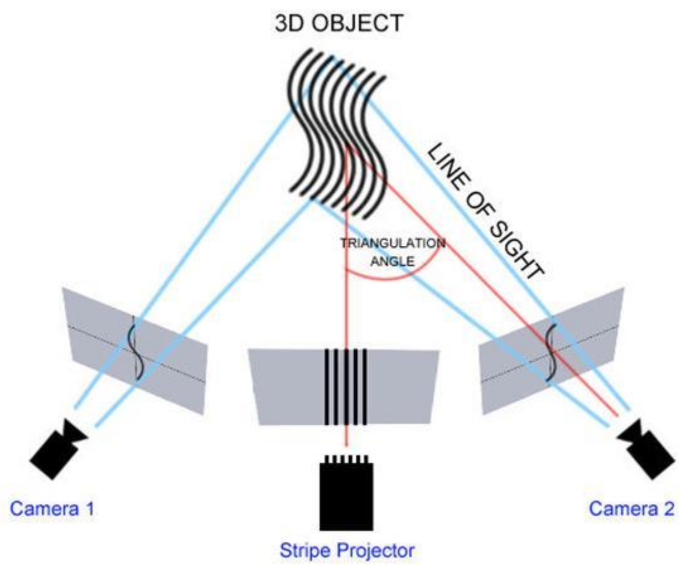

Fig. 2. Optical 3D Scanner Operation Diagram.

Optical 3D scanners are used to quickly digitize various small and medium objects, as they can digitize multiple dots or all of the scanner 's "field of view" at the same time. And the use of special white or blue lamps as a light source allows you to digitize geometry and capture texture in low light. In our project we used hand-held optical scanners from Artec and Creaform. 3D models of museum objects of various nature were obtained: gypsum sculptures, ceramic and glass objects, museum objects of plant and animal origin.

Figure 3 shows a 3D model of a stuffed rattlesnake in the reserves of the State Biological Museum named after K.A. Timiryazev. This stuffed model was chosen as a prototype for creating a 3D model of an object whose surface consists of glossy light-absorbing materials [7]. Figure 4 shows the 3D model of the stuffed duck, also located in the reserves of the State Biological Museum named after K.A. Timiryazev. It was chosen as a prototype to create a 3D model of an object whose surface consists of light-transmitting materials (in this case, feathers).

Fig. 3. Stuffed rattlesnake

Fig. 4. Stuffed ducks

In general, we have received high-quality, finished polygon models that can be used to form realistic interactive 3D collections of museum exhibits. However, some 3D models of museum objects had many noises and errors caused by the transparency or gloss of the material. In particular, feather and wool cover in stuffed birds and mammals do not look very realistic. Therefore, it was decided to carry out additional scanning with a laser 3D scanner.

Laser 3D scanners (Figure 5) provide the most precision and detail when digitizing objects, they are equipped with a specialized laser, which is classified as Class II. This type of laser is safe enough for human vision. A feature of this type of scanner is the use of special markers, which are attached in close proximity to the object or directly on the scanning object. This is necessary for accurate spatial alignment of the laser and the object being scanned.

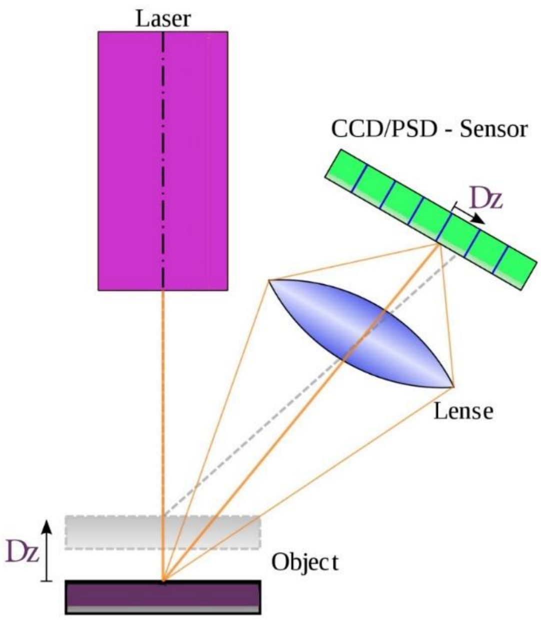

Fig. 5. Operating principle of laser scanner

In the work on formation of collections of museum objects the laser 3D scanner Creaform HandySCAN 700 was used. This scanner is equipped with 7 high-precision lasers and TRUacuracy dynamic binding system [8], which provides scanning accuracy up to 0.03 mm with 0.05 mm resolution.

The main disadvantage of the scanner is its inability to transmit the color of the object 's texture, but it provides quite satisfactory results when solving problems to build the most detailed surface of the object being scanned. The use of this type of scanning device provided high quality 3D models of gypsum anthropological reconstructions performed by M.M. Gerasimov http://acadlib.ru/index.php/. The experience of 3D digitization has shown that some museum objects have proved too complex to be processed by existing 3D scanners. Thus, the results of the scanning of the wool cover of the stuffed mouse proved unsatisfactory, their improvement would require the treatment of "problem zones" (light-absorbing wool or retro-reflective eyes) with a special spray, which could be detrimental to the objects being scanned. One of the main requirements for digitization of museum objects is to ensure maximum preservation of the object during scanning, the solution of this problem requires the development and application of computer modeling and/or interactive animation technologies 360^0.

3 Computer modeling technologies

Computer modeling technologies allow to solve problems on visualization, for example, permanently lost or damaged museum objects, to perform detailing of reconstructed objects, to restore the situation of historical premises, etc. In our project, this technology is used when editing scanned 3D models with problem areas. In such cases, the operator in the 3D modeling program has to re-create individual 3D model elements.

Fig. 5. Bust of astralopithec with "defect"

Fig. 6. Bust of astralopithec without "defect"

Figure 5 shows a digital copy of an astralopithec bust, an anthropological reconstruction performed by M.M. Gerasimov. A red arrow indicates an object defect. Figure 6 shows the same object, but after manual digital "restoration."

4 Photogrammetry technologies

Photogrammetry technology [9, 10] allows you to build a high-quality 3D model. This technology has been actively developed since the 1970s and was originally used to draw relief maps from aerial photographs. Photogrammetry uses the methods and techniques of various disciplines, mostly borrowed from optics and projective geometry. In the simplest case, spatial coordinates of points of an object are determined by measurements made from two or more photographs taken from different positions. The main task in this case is to define common points on two neighboring images. After you create an array of shared points, you create a set of lines through each shared point and camera location (survey points). The intersection of these lines and determines the location of the point on the surface of the original object in space. More sophisticated algorithms can use other pre-known object information, such as object element symmetry, which in some cases allows the spatial coordinates of object points to be reconstructed over a limited number of photo images.

5 360^0 interactive animation technology

Interactive animation technology [11] can be used to create a virtual collection of 3D models to provide them to a wide range of users. This technology does not involve building a polygon 3D model, but is based on a software change of a fixed set of frames using specialized interactive display programs that simulate the rotation of an object. Importantly, a high-quality 3D model can be built from the same data set (individual exposure frames) using photogrammetry techniques.

For such works, in particular, 3D digitization complex based on Recam T-50 turntable, 3D-Maker control program [12] and Canon EOS600D digital camera is used, which allows to perform automatic shooting of museum objects up to 150 cm high and weighing up to 50 kg.

Figure 7 shows the sequence of frames from which the digital 3D model is displayed.

Fig. 7. Sequence of frames from which the digital 3D model is displayed.

6 Conclusion

The development of methods of 3D models formation in the direction of obtaining realistic representation of collections of various objects opens up opportunities for formation of 3D collections of museum objects of high quality, both to ensure preservation of originals, and to expand availability of high-quality digital copies of museum exhibits [13, 14].

The obtained results formed the basis of formation technology of 3D-models collections of objects from funds of the State Biological Museum named after K.A. Timiryazev and formation on their basis of virtual exhibitions by means of digital library "Scientific Heritage of Russia" [8], in particular, virtual exhibition devoted to scientific activity of M.M. Gerasimov and its anthropological reconstructions, available at http://acadlib.ru/.

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