

ADVANCED 3D VISUALIZATION OF AN ARCHITECTURAL OBJECT IN THE OPENGL STANDARD

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Commission V

KEY WORDS: Architecture, Camera, Non-Metric, Texture, Rendering, Visualization

ABSTRACT:

High accuracy and quality of photorealistic 3D modeling and visualization of close range objects can be achieved only with 3D scenes generated on the basis of photogrammetric data. Images and geometrical data for testing our original application were obtained from complex photogrammetric architectural object restitution. The object was recorded with a digital camera Kodak DC 4800 with 3.1 Megapixel resolution. Measurement and data processing were carried out in PICTRAN B/D/E/O software. In addition, the vector planes of facades were received as a result of 3D stereodigitizing on a VSD digital stereoplotter. The photogrammetric vector and raster data on the object and their mutual relations provided the information for visualization. A graphic library in OpenGL standard and Delphi programming tools enriched with GLScene components were applied in the present application designed for dynamic 3D visualization of objects registered in close range. The application allows to modify the visualized 3D scene by looking at the object from any viewpoint. It also enables its rotation, translation and scale change, camera position reconstruction, etc. It follows that the application permits dynamic realistic 3D visualization with simultaneous preservation of real geometrical relations.

1. INTRODUCTION

The main aim of 3D visualization used in close range photogrammetry is photorealistic reconstruction of a real object. Currently the most common standards of presenting analytical and digital photogrammetric processing results are CAD systems, e.g. AutoCAD, IntelliCAD, MicroStation (Luhmann, 2000). These programs enable to save vector data in 3D format files: DXF, DWG and DGN, which allow to create additional geometric and graphic constructions using a raster processing module.

Commercial programs used for designing, modeling and 3D presentation, as 3D Studio Max, 3D Studio VIZ, Autodesk VIZ 4, AccuRender and PhotoModeler Pro are closed applications. As a consequence, they are not flexible enough and have limited abilities of importing vector and raster data from photogrammetric elaboration.

Technologies that use API (Application Programming Interface) tools, such as Direct 3D (native Windows technology), Fahrenheit, Java 3D and OpenGL (open standard of significant system platforms) used in computer 3D graphics (Fritsch et al., 2004; Lliang et al., 2004; Wright et al., 1999), as well as Internet tools, based mainly on VRML script language (Cöltekin et al., 2000; Huanhg, 2004; Jędryczka et al., 2001] or other kinds of software, e.g. Macromedia Flash, X3D, GeoVRML, have been recently gaining growing importance in photogrammetric 3D visualization.

Solutions based on the above programming tools enable designing, visualization and Virtual Reality presentation, and

additionally interactions with a 3D model. Digital image data and their processing, and reconstruction and geometrical modeling, are indispensable for professional 3D visualization of an object and its Virtual Environment.

The presentation of results of measurements of objects characterized by complex shapes and structures, which is common in close range applications, requires creating a dedicated application in order to obtain advanced modeling effects and 3D visualization. High accuracy and quality of photorealistic 3D modeling and visualization of close range objects can be achieved only with 3D scenes generated on the basis of photogrammetric data.

2. PHOTOGRAMMETRIC MEASUREMENTS

The subject of our study was a historic two-story building, 39 m×15.5 m×12m, situated in the campus of the Warmia and Mazury University in Olsztyn. The architectural object was recorded with a low-cost, non-metric compact digital camera Kodak DC 4800 with uncompressed 3.1 Megapixel (2.2 K×1.4 K) resolution. Twelve stereograms, nearly normal case, were taken. 49 control points were signalized with targets, 5÷7 pixel in size on the image scale. In addition, 93 natural control points were selected on the object. The coordinates of object points were calculated in one global three-dimensional coordinate system.

Combined bundle adjustment in the object space was carried out with integrated simultaneous on-the-job calibration of a digital camera Kodak DC 4800. Standard parameters of camera interior

orientation, radial distortion A_1 , decentering B_1 and scale C_1 parameters were determined using bundle adjustment. The other parameters, e.g. distortion A_2 , decentering B_2 and shear C_2 , were insignificant in the self-calibration process.

Points of the digital object model (DOM) were measured in the TIN (Triangular Irregular Network) structure and calculated by space intersection. The interior parameters of the camera and the exterior orientation parameters of single images, calculated by bundle adjustment, and the DOM were essential to create digital orthoimages. The measurement of image coordinates, combined bundle adjustment with self-calibration, measurement of DOM points, and digital orthophoto rectification were carried out in the PICTRAN B/D/E/O photogrammetric system.

In addition, the vector planes of all object facades were received as a result of 3D stereodigitizing on a VSD (Video Stereo Digitizer) digital stereoplotter. Non-metric images were oriented by the Direct Linear Transformation method. Stereodigitizing of each facade was carried out in defined thematic layers. The vector data (points and geometric items) were saved in DXF format and transferred to the assigned MicroStation System as CAD-objects, and further generalized and edited on a 1:50 scale.

Results of a complex photogrammetric evaluation (the parameters and accuracy are presented in Table 1) provided the basis for modeling and 3D visualization. The coordinates of signalized and natural control points, calculated parameters of exterior orientation of images, points of DOM (triangles), the vector planes of facades in DXF format, and selected orthoimages were input data for the generation of a 3D scene.

PARAMETERS OF PHOTOS	
Digital camera	Kodak DC 4800
Pixel resolution	2160×1440
Focal length	6 mm (Fix Focus 0.5 m÷∞)
Zoom	1
Number of photos	24
Object distance Y_F	~ 16 m
Image scale 1: M_p	~ 1: 2600
Base ratio v	1/4÷1/5
Overlap p_x	~ 80 %
ACURACCY OF MEASUREMENTS	
49 signalized control points	$m_{p_{CPs}} = \pm 7.8$ mm
93 natural control points	$m_{p_{CPn}} = \pm 13.2$ mm
Image point measurement	$m_{x,y} = \pm 0.33$ pxl
Orthoimages	$m_{p_{Ort}} = \pm 23$ mm
DLT orientation	$m_{p_{DLT}} = \pm 15.7$ mm
3D stereodigitizing	$m_{p_{Sd}} = \pm 25$ mm

Table 1. Parameters and accuracy of photogrammetric measurements

Referring to the experience gained during photogrammetric reconstruction of an architectural object on the basis of non-metric digital images and creating an application in the OpenGL standard for dynamic 3D visualization of close range objects, the authors proposed a technological scheme of the process (Janowski et. al., 2005).

3. APPLICATION IN THE OPENGL STANDARD

The OpenGL standard was used in our original application for dynamic 3D visualization, since this graphic library is available for all major hardware and system platforms, and has rich documentation. Delphi (Jacobs, 1999) programming tools enriched with GLScene components (Sechidis et al., 2004) were used in order to simplify the procedures of creating real 3D scenes.

The Delphi programming language was applied due to three principal features:

- it is RAD (Rapid Application Development) type programming tool, which affects the speed and simplicity of creating an application.
- it provides an effective result code
- it has calibrated access to database, which is an important argument as regards further development of the application; it also has native components cooperating with Interbase/Firebird, on which future operation of the system will be based

A wire frame model of the object was built at the first stage of creating 3D visualization. Due to a relatively simple shape of the building, the application of wire frames was limited to primitives in the form of rectangular segments of planes (Figure 1), which represented elements of the facade. The Digital Object Model, vector facade maps and control point coordinates provided the basis for measuring defining facades fragments and determining their spatial position in the global coordinate system of the object.

The wire frame model and defined polygons were used as a base for texture superimposition. Texture areas corresponding to the primitives of the wire frame model were removed from individual orthoimages. Extensive overlap of photos allowed to choose the middles of images, and eliminate considerable perspective distortions. The fragments of images not representing the facade were filled with transparent background.

The next stage included changing of the size of textures, to adjust them to the size required by the OpenGL standard. The size of textures must be equal to any positive natural power of the number 2 (2, 4, 8, 16...), so textures were resampled to the optimal size of 1024×1024 pixels. This conversion did not noticeably deteriorate the final effect of visualization, and significantly reduced the amount of data needed to process each animated frame. In order not to lower the accuracy of measurements, it was assumed that they will be performed on textures collected from original photogrammetric photos. Textures saved as 24 bit BMP files, with a description of transparency features (additional 8 bits), were used to map a previously developed wire frame model.

The distinguishing elements of the visualized scene were indicated by means of single spheres. They were stations of the camera used for photo recording, and the center of a three-dimensional coordinate system of 3D scenes (Figure 2). The system allows to locate the projection center of the visualized object in these points.

A number of functions enabling to modify the visualized 3D scene and make it dynamic were introduced into the created application, referred to as „3D Visualization“. The choice of a given option is made in the unrolling menu, using scroll and mouse buttons.

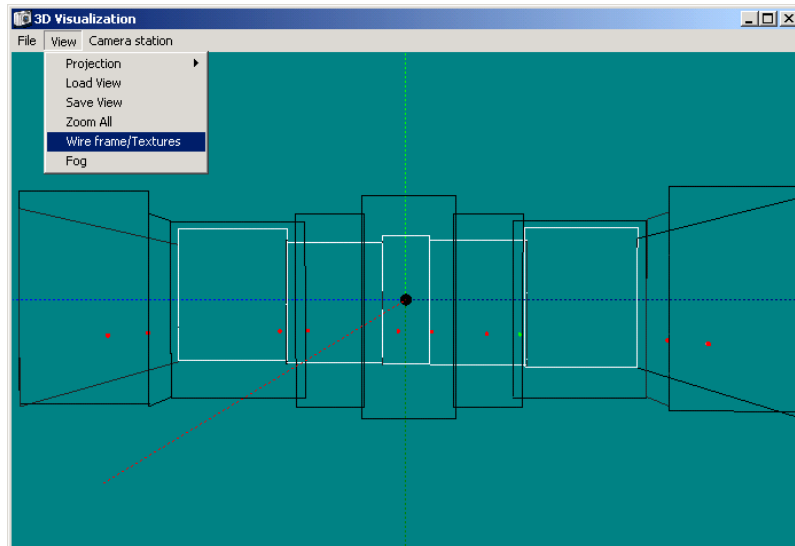


Figure 1. 3D Visualization program window – primitives of wire frames model

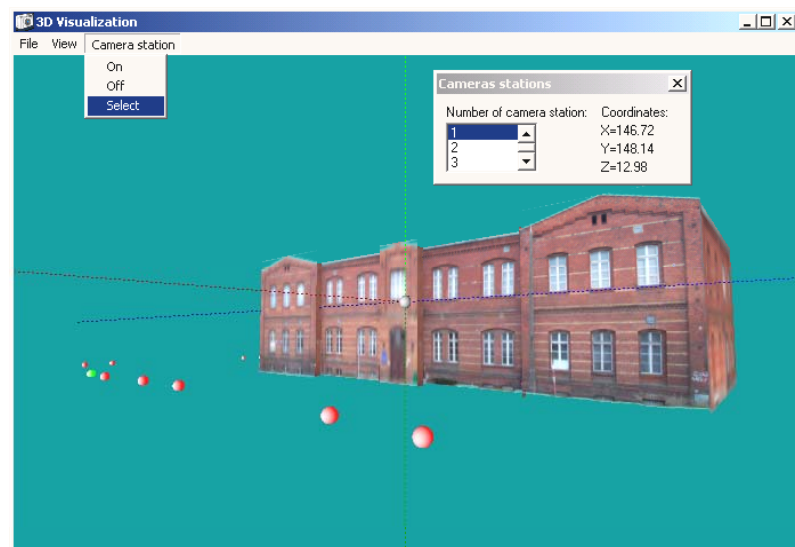


Figure 2. 3D Visualization program window – visualized object and camera position indicators

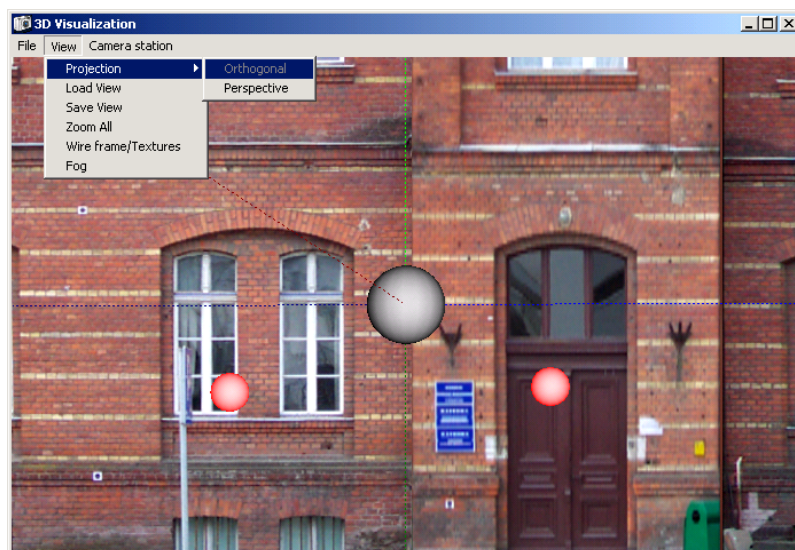


Figure 3. 3D Visualization program window – orthogonale projektion

It is possible to:

- choose and import a project
- switch on/off camera station location indicators
- switch on/off the axis of the model coordinate system
- set the projection center in one of camera stations
- import/save the coordinates of the projection center and projection angles
- change the visualization scale
- change the type of orthogonal or perspective projection (Figure 3)
- translate and rotate the presented 3D model
- add extra visual effects, e.g. fog, changeable lighting (pointwise, dispersed)

4. CONCLUSIONS

Integration of photogrammetric methods, digital image processing, and computer graphics or Internet techniques, sets new standards of photorealistic 3D visualization and VR presentation of photogrammetric evaluations. Consequently, the presentation of photogrammetric processing results becomes more and more attractive.

High accuracy and quality of photorealistic modeling and 3D visualization of close range objects can be achieved only with 3D scenes generated on the basis of vector and raster photogrammetric data. Specialized 3D visualization techniques, especially in close range photogrammetry, require using dedicated applications, which are capable of operating on non-typical parameters.

A graphic library in the OpenGL standard was used in our original application designed for dynamic 3D visualization of objects registered in close range. Delphi programming tools enriched with GLScene components were used in order to simplify the procedures of creating real 3D scenes. The program was tested basing on the results of an analytical and digital evaluation of an architectural object. The application proposed in the study enables dynamic and photorealistic 3D visualization of objects recorded in close range.

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