Chapter 5
From Spherical Photogrammetry to 3D Modeling

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ABSTRACT
The introduced research is about 3D modeling technique that can be considered as an assembly point of photography, topography, photogrammetry, and computer graphics. The chapter presents survey methods based on spherical panoramas produced by image stitching techniques, which are proved efficient in order to obtain a high metric quality. It is an interactive survey system to generating 3D models of architectural structures and urban scenes. Photogrammetric fundamentals are applied using two different approaches to obtain the 3D model: the first one is by using texture-mapping techniques in the way of creating the virtual models; while the second is by using parametric visual programming process.

INTRODUCTION
Photogrammetry is being developed rapidly; many commercial Image-based modeling programs have been released during the last few years, especially dense match or (Structure from motion) algorithm-based applications (Dellaert, Seitz, Thorpe & Thrun, 2000). In this chapter, the panoramic image-based interactive modeling will be discussed. Proposing techniques start from oriented panoramic photos to model an architecture using commercial 3D-modeling programs. The metric value of oriented spherical panorama is very useful to be used for a survey that could be carried on by means of triangulation or by using geometrical constraints to create 3D shapes and volumes.

The proposed techniques are suitable for the architectural survey because it is not a “point by point” survey as what the laser scanning produces, and it exploits the geometrical constraints of the architecture’s geometry to simplify the 3D modeling process. Therefore, the surveyor in those techniques has to comprehend the geometry of the architecture before modeling it. Then, depending on some factors such as the Type of input, work process and the available instruments, the process can take one of two forms, mapping-based modeling or parametric programmed triangulation.

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BACKGROUND

The most widespread use of the close-range photogrammetric techniques was for the representation of the facades or elevation of the historic buildings and structures. The most common product was the line drawing, which delineates architectural form. Such surveys are needed by the various disciplines involved in building repair and conservation. However, this field has changed a lot since the early years of development. Similarly with other close range applications and indeed the whole of photogrammetric methodology, the introduction of computers have progressively changed the ways in which the technique works and is applied (Dallas, 1996). In addition, photogrammetry can be used with other technologies in some cases since the barriers between the different surveying disciplines are being broken and integration of the technologies is taking place.

Image-based modeling (IBM) is a photogrammetric application field that intends to obtain, not only the metric data, but also the 3D model directly collimating points on photos. This method is used for geometric surfaces of architectural objects or city modeling. In most cases, the most impressive and accurate results remaining are those that are achieved with interactive approaches. Recently, image-based models can be used also for virtual reality, digital cinematography and urban planning applications.

The research is based on spherical panoramic photos, which are exclusive outcome of the digital image. R. Szeliski has developed the digital multi-image panoramic photo in 1994 for Apple Computers, then, many stitching software came out to combine panoramas by registration, calibration and blending images (Szeliski, 2005).

The interest in panoramic images is growing rapidly. Currently they are used widely and mainly as documentation in several applications such as 3D virtual tours and Street Views. Furthermore, by providing the panorama with accurate information of its location and orientation, it will add a great metric value allowing the users to acquire metric information of the scene. Moreover, they have metric capabilities enabling the 3D evaluation of an architectural object provided at least two panoramas (Fangi, 2007, 2008). The procedure already very well tested, is highly efficient and fast, and has been applied for the metric documentation of many cultural heritage structures (Fangi, Piermattei & Wahbeh, 2013).

PANORAMIC IMAGE-BASED MODELING

Panoramic Photo and Equirectangular Projection

Spherical photogrammetry is a modern form of photogrammetry that is based on the multi-image spherical panoramas. For the formation of the plane image of the spherical panoramas “the equirectangular projection” is used. The spherical panorama can be regarded as the analogical recording of the angular observations of a theodolite having its center in the center of the panorama (Fangi 2007).

A panoramic image is characterized by the large field of view, which can reach also 360°, and the high resolution obtained using long-focus lenses. Different techniques are used to produce such kind of images. The possibility to obtain panoramic imagery just by merging a set of planar pictures is very practical.

The sphere mapped on the cartographic plane with the so-called latitude-longitude representation or equirectangular representation where:

\[ x = r \, \theta \quad \text{and} \quad y = r \, \phi. \]