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The performance evaluation of multi-image 3D reconstruction software with different sensors

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ABSTRACT

Three dimensional modelling of the objects is one the most discussed issues in Photogrammetry and Computer Vision. One of the factors affecting the accuracy of the obtained model in image-based methods is the software and algorithm to generate the model. Another important factor is the type of imaging sensor. Due to availability of cell phone sensors to the public, popularity of professional sensors and the advent of stereo sensors, a question raised about which imaging sensor can lead to more accurate and complete model. Although many research have been accomplished to identify a suitable software and algorithm to achieve an accurate and complete model, little attention has been paid to the type of imaging sensors and its effects on the quality of the final model. This paper aims to introduce an appropriate combination of a sensor and software to provide an accurate and complete model. To do this, different available software were compared and the most popular ones in each category were chosen. In this test, four small objects with distinct geometric properties were chosen and their accurate models as reliable true data were generated. Images were then captured using Fujifilm Real 3D stereo camera, Apple iPhone 5s and Nikon D3200 professional camera and three dimensional models of the objects were obtained using each of the software. Finally, a comprehensive comparison between the results showed that the best combination of software and sensors for generating three-dimensional models is directly related to the type of imaging sensors, the software and object shape. Generally better quantitative and qualitative results were obtained by using the Nikon D3200 professional camera.

1. Introduction

A detailed three-dimensional model for representation and documentation of different objects are needed in different branches of engineering. Nowadays, due to advances in technology, 3D modelling of objects with significant geometric accuracy with details has become possible [1]. Three-dimensional modelling of scenes and objects in different scales is performed using both image-based methods (passive) and range-based methods (active). Range-based or active methods [2] like structured light systems and laser scanner are common systems for point cloud generation. Image-based or passive methods [3] which have made significant progress with the development of computer vision techniques [4,5] are currently regarded as automatic methods for image orientation [6] and three-dimensional reconstruction in different scales [7,8] (see Figs. 1–4).

A variety of algorithms can be used for three-dimensional modelling of different objects or scenes from images. One of the most common algorithms in this field is SFM (Structure from Motion) [9]. For this purpose, an archive of images of the object or scene is needed. In SFM method, a large number of images is oriented without any knowledge of the interior parameters of the camera [10]. Orientation of the images is performed automatically through a series of specific points with identical features. One of the most commonly used operators in this operation is SIFT (Scale Invariant Feature Transform) [11], which extracts identical features between images with different positions, scales and lighting conditions.

Different software, based on this algorithm or similar algorithms, are available as open source (VisualSFM [12], OSMBundler [13], Apero [14], Insight3D [15], etc.), commercial (AgiSoft [16], PhotoModeller [17]) and Web service (Microsoft Photosynth, Autodesk123D Catch [18], Arc3D [19], etc.) for users [6]. While commercial software are designed for industry applications, most of the open source software are provided for research and web-based three-dimensional software services create three-dimensional models quickly and without any special knowledge for public [20].

In previous studies, comparisons have been performed to recognize software to generate an accurate and complete 3D model [21]. Due to the availability of cell phone imaging sensors for everyone and

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Fig. 1. pictures of studied objects.

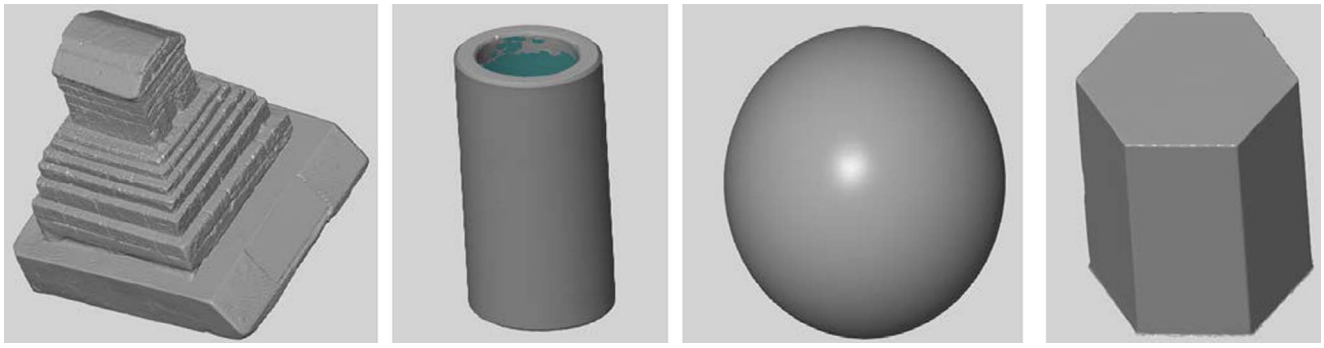

Fig. 2. 3D models of studied objects obtained by GOM.

Fig. 3. Nikon D3200 camera, Fujifilm FinePix Real3D and iPhone 5s.

Fig. 4. the projected pattern and projector used.

progresses in professional sensors and the advent of stereo sensors, comparing these three types of sensors is an effective step in the evaluation and finding optimal workflow to achieve detailed three-dimensional models from different objects.

This paper aims to identify the best software and sensors for generating complete and accurate three-dimensional models from objects. For this purpose, a detailed overview of recent research in this field is presented in Section 2. According to the mentioned three types of imaging sensors and appropriate identified software, precise geometric evaluation is performed based on a standard manner in Section 4.

2. Review of previous work

Active sensors have been used in various fields since 2000. Although these sensors have made significant progress in recent years, some problems such as non-portability and expensiveness motivated researchers to find more suitable methods [22].

Today, the integration of computer vision and photogrammetry methods has led to creation of image-based modelling processes [3]. In this method, multiple images of a scene are turned into point cloud by algorithms such as Structure from Motion (SfM) and then a uniform three-dimensional model of this point cloud is generated. In these