Chapter 7
3D Reconstruction Challenges Using Structure-From-Motion

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ABSTRACT

Numerous software solutions implementing the structure-from-motion/multi-view stereo (SFM/MVS) 3D reconstruction approach have been made available over the last two decades. Hence, enabling the production of high quality, in terms of geometry and colour information, 3D objects using solely unordered image sequences depicting a static scene or objects from arbitrary viewpoints. Nowadays, SFM/MVS-based 3D reconstruction approaches constitute a popular solution in a variety of applications within many research domains including cultural heritage. However, as with all 3D reconstruction approaches, SfM/MVS has its limitations and applicability challenges. In this chapter, the authors attempt to provide a set of guidelines that are based on the important outcomes of published works that propose solutions to overcome some of the challenges introduced by non-friendly to SfM/MVS scenes or objects.

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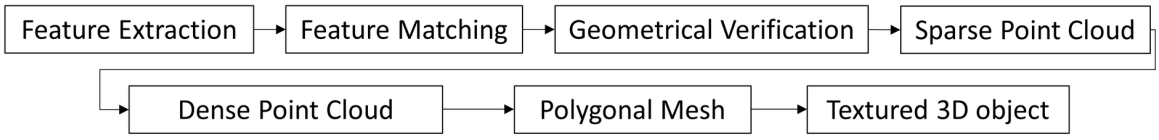
Figure 1. Structure-from-Motion overview



INTRODUCTION

Over the last decades the number of available 3D digital replicas is growing and constitute an integral part of many research domains including cultural heritage, Archaeology, Architecture, Medicine, etc. The key role for this fact is the progress achieved in 3D digitization systems coupled with the ongoing development of real-time 3D graphics. 3D digital replicas can be created through the usage of various methodologies ranging from multi-image photogrammetry (Structure-from-Motion -SfM/Multiple-View-Stereovision – MVS), Laser Triangulation to Structured Light. For the multi-image photogrammetry case, the existence of low-cost software solutions or open source libraries that implement the SfM/MVS pipeline, in combination with the minimum user intervention needs, enable their use as a black box solution. Moreover, its broad implementation relies also on the cost effectiveness in terms of hardware equipment, man-hours spent during the data collection phase and its relatively low background knowledge requirements. Additionally, as far as the generated 3D digital replica is concerned, its quality and accuracy in terms of geometry and texturing satisfies a vast range of 3D digitization projects (Koutsoudis et al., 2014).

Within the cultural heritage domain 3D reconstruction is considered as a common practice (Koutsoudis et al., 2012), an application domain that is very demanding in terms of geometrical and colour accuracy. 3D digital replicas can be used for dissemination and documentation purposes and constitute a valuable tool as well for archaeologists and conservators to conduct their studies. Europeana, the European commission's digital platform for Cultural Heritage (EUROPEANA), recognising the value of 3D digital replicas hosts a significant number of 3D items, ranging from small objects (e.g. a vase) to large scale objects (e.g. an architectural). Numerous European and national research and development projects exploiting the SfM approach (CARRARE; 3D-ICONS; 3D-COFORM), as well as independent initiatives have been conducted to enrich the digital libraries with high geometric accuracy 3D content.

The main scope of this chapter is to indicate challenges that the SfM/MVS approach is facing and subsequently to present significant published scientific works that confront and offer ways to handle the different limitations and drawbacks of the traditional SfM/MVS approach. Additionally, this work attempts to provide a framework to conduct SfM/MVS even in cases that normally are either unable to produce any 3D digital replica or the outcome fails to meet the requirements in terms of geometric accuracy.