Chapter 21
Integrated Multi-Scalar Approach for 3D Cultural Heritage Acquisitions

Michele Russo
Politecnico di Milano, Italy

Anna Maria Manferdini
University of Bologna, Italy

ABSTRACT

This contribution presents the results of investigations on the reliability of techniques based on the Structure from Motion approach used for 3D digitizations of build heritage. In particular, we tested the performances of different SfM technologies within an architectural survey context and we developed a procedure with the purpose of easing the work of surveyors called to restore digital representations of artifacts at different scales of complexity. The restored 3D models were compared among each other and with a gold standard acquisition. These analysis led to qualitative and quantitative evaluations and to considerations on times and skills required by all tested technologies. In this work strengths and weaknesses are highlighted and the integration of different technologies is presented, as it represents the best solution in many and recurrent multi-scalar contexts.

INTRODUCTION

During the last decade, the developments in the high-resolution digital photogrammetry field led to the use of 2D images as tools able to derive detailed and accurate 3D reality-based information. These achievements and the contemporaneous lowering of costs of range sensors are actually encouraging the widespread of 3D high-resolution digitization and are stimulating investigations on the possibilities of their integration aimed at optimizing both final results and the whole pipeline. This last aspect is particularly important in the field of Cultural Heritage surveys, since artifacts usually present multi-scalar geometrical complexities which don't suggest the definition of standard methodologies and procedures for every situation and context that it is possible to meet.

DOI: 10.4018/978-1-5225-8054-6.ch021

In this direction many interesting applications have been developed in the last years aiming at both optimizing results and meanwhile overcoming some critical aspects such as the need of expertise, time consuming and difficulties in the management and exchange of huge data along the whole pipeline. For example, in the Computer Vision field, researches based on the Structure from Motion approach developed applications that allow the reconstruction of 3D scenes through the automatic markerless orientation of sets of 2D images.

Despite these achievements in the simplification and automation perspective, some aspects that are mainly due to limitations in the possibility to control each step of the processing of data still do not enhance the use of these survey technologies for scientific purposes. In addition, their use often produces unpredictable results that are related to shooting problems (lighting changes, bad sequence of images, poor overlap, repetitive elements, homogeneous textures, etc.).

These considerations motivated our investigations, aimed at evaluating whether some of the most widespread SfM technologies could be adopted as reliable survey instruments in the architectural field, where accuracy and resolution are generally under pre-defined thresholds and the multi-scalar geometrical complexity is a crucial aspect to pay attention to.

In order to reach this purpose, we developed a methodology and tested it on a case study (a richly ornate façade of an historical architecture) that is rather representative of occurrences that it is possible to meet in the field of Cultural Heritage surveys performed at architectural scale.

Within our methodology, 3D models built using photographs were compared among each other and with a 3D laser scanner gold standard acquisition. Strengths and weaknesses of all adopted approaches are highlighted in this paper, as well as evaluations on times and skills required by all tested technologies, suggesting the best solution with respect to the optimization of all considered aspects. Finally, integration of different technologies is presented, as it actually represents the best solution for most multi-scalar purposes.

BACKGROUND

One of the most important consequences of the widespread use of range-based technologies in the Cultural Heritage field is the possibility to easily and quickly acquire huge amount of 3D information which can be used for different purposes that can change through time. These possibilities are actually modifying the expectations of users called to collect information about sites and artifacts, since they are widening the need to acquire complex and versatile data to be used in different contexts and for different communication aims. Despite these achievements, range sensors are still very expensive, need expertise and present persistent bottlenecks both in the reverse modeling process and in time consuming that often limit the possibilities of their widespread use.

During the last decade, the developments in the high-resolution digital photogrammetry field showed that 2D images can be used as tools able to derive detailed and accurate measures, as well as to record information on the radiometric characteristics of artifacts. These achievements, together with the lowering of costs of range sensors are actually offering the possibility to widen the digitization of sites and artifacts and are also stimulating investigations on the possibilities of their integration with the purpose of optimizing both final results and the whole pipeline [Velios and Harrison 2002; Guidi et al. 2002; Böhler and Marbs 2004; El-Hakim et al. 2004; Remondino 2011; Manferdini and Remondino 2012].

The possibility to use integrated approaches and technologies represents a crucial aspect in the field of Cultural Heritage surveys, since artifacts usually present peculiarities that do not allow the definition