# Chapter 1
# 3D Documentation of Cultural Heritage:
## Design and Exploitation of 3D Metric Surveys

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## ABSTRACT

*Metric surveys have a key role in managing Cultural Heritage. They are needed for a wide range of activities like documentation, study, restoration, and valorization. The importance of the 3D description of objects is widely accepted considering costs/benefits ratio and the opportunities it offers. In recent years, laser scanning and digital photogrammetry offered new perspectives, widening the options in 3D CH recording. Scientific research tends to see their integration as the best approach to CH description. 3D surveys are offering extra opportunities respect to the traditional production of metric supports as 3D models are the ideal base for true 3D information systems and open the way to immersive virtual reality environments. Digital technologies provide new ways to collaborate, record excavations, and restore artifacts in such a way, they are transforming the way CH practitioners work. This chapter attempts to review the methods for 3D digitization that are today available and discuss the possible use of 3D models beyond the pure extraction of reliable and accurate measurements.*

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## INTRODUCTION

Cultural Heritage can be defined as artifacts, monuments or group of buildings of "*outstanding universal value from the point of view of history, art or science*" beside sites of "*outstanding universal value from the historical, aesthetic, ethnological or anthropological point of view*" (UNESCO, 1972). These sites have to face continuous atmospheric and anthropic attacks; they are often under threat from natural hazards (earthquakes, floods, fires), adverse environmental conditions, structural instability, increased tourism and development that raise the pressure they have to face, and they are most likely under-funded, and hence, inadequately documented and maintained. Their geometric documentation is of the highest importance as it is a necessary step to describe their as-it-is situation and also in order to build the base of a proper information management system; in the digital recording of Cultural Heritage the three-dimensional (3D) digitization of objects and monuments is a key issue. 3D digitization is now applicable to artifacts ranging from the smallest (e.g. small prehistoric findings) to the largest (e.g. buildings or entire historical sites), aiding researchers by providing them better resolution (sampled surface density) and improved accuracy. The needed acquisition time, and the available post-processing tools, are continuously improving. This spatial information forms not only an accurate record of these rapidly deteriorating sites, which are a legacy of the past and have to be saved for posterity, but also provides a comprehensive base dataset, by which site managers, archaeologists, and conservators can monitor sites and perform necessary restoration work to ensure their physical integrity. 3D models offer both the possibility to extract the needed metric information, and also the base for a wider exploitation for Cultural Heritage Information Systems, multimedia representations and reproductions (base for Cultural Heritage digital content).

Today, the available survey techniques have the potential to truly advance Cultural Heritage documentation, similar to photography at the end of the 19th century. Available digital solutions provide effective ways of exploiting 3D models. This chapter attempts to review them.

## 3D DIGITIZATION OF CULTURAL HERITAGE

3D digitization of Cultural Heritage has been attracting the attention of many researchers since long time and the literature about it is huge. Just considering the two last big innovations in the production of 3D models, the application of laser scanners to Cultural Heritage and the image matching approach or Structure from Motion (SfM) technique, many papers may be found.

Pieraccini et al. (2001), Pavlidis et al. (2007) or Agosto & Bornaz (2017) try to summarize most of the available methods for 3D digitization that can be applied to the digital recording of Cultural Heritage. Boehler et al. (2002) highlight the potentiality of Laser scanning instruments, that were mainly developed for industrial applications, for Cultural Heritage recording as well: in the vision of the authors this method would complement, and, in certain applications, replace currently existing methods. The advantages of laser scanning approach are evaluated against photogrammetry. Lichti and al. (2002), highlight the high acquisition rate, the relative high accuracy and high spatial density as the three key advantages of laser scanning adoption; besides, the authors, just like Kadobayashi et al. (2004) and Boehler et al. (2004), compare laser scanning and photogrammetry and their combined use to produce accurate and expressive models of Cultural Heritage objects and of the efficiency of the data processing pipeline; as a result, due to the great variety of Cultural Heritage objects, no single method is applicable to recording every