Abstract

This dissertation deals with the metrological validation of a digitalization approach that combines the use of photogrammetry and multispectral imaging (MSI) techniques in the field of Cultural Heritage.

Photogrammetry is a technique that is becoming more and more diffused for the creation of 3D realistic virtual replicas of historical artefacts since it allows the extraction of three-dimensional information about the geometry and overall appearance of an item from 2D digital images. On the other hand, MSI techniques are widely diffused, since they allow the detection and identification of the materials used by the artists based on their response to different wavelengths. It is worth noticing that, even if multispectral imaging can provide useful information with a non-invasive approach, it is usually employed as a two-dimensional technique.

Photogrammetry and multispectral imaging are often exploited for the study of historical artefacts but as separate tools. Nevertheless, the integration of data coming from MSI and photogrammetry can greatly increase the information within a 3D model, combining geometric and radiometric information and providing a powerful tool to the experts of the field. It is worth noticing that 3D models can be archived for posterity or shared among researchers, therefore avoiding the acquisition of wrong information from the dimensional point of view is of fundamental importance. However, there is no unique way to assess the dimensional accuracy of 3D models in the Cultural Heritage field.

To address these two issues, this dissertation presents a novel research methodology and experimental setup, that enable the acquisition of multispectral 3D models, combining the outcomes of photogrammetry and multispectral imaging in a single coordinate system. This approach has been developed together with a specific novel reference object, for application in the cultural heritage field. This has the main aim of being employed as a dimensional reference for the assessment of the dimensional

accuracy of 3D models. In addition, this item integrates several pictorial preparations, with materials historically employed on cultural heritage items, thus it can be used as a multispectral reference.

A metrological characterization of the proposed reference object has been carried out. First of all, a comparison among the information obtained through photogrammetry with different sets of data, collected by a Coordinate Measuring Machine and a laser scanner, is performed. These techniques measure the geometry of an object with different levels of uncertainty and therefore they can be used to assess the dimensional accuracy by inter-comparison. In addition, the influence that the selection of different wavelength ranges can have on the quality of a 3D model reconstruction is investigated. In particular, Infrared Reflected images, acquired within different ranges, are exploited for the construction of a 3D model, in place of traditional visible images. Eventually, the materials employed for the realization of the reference object have been characterized through portable Raman Spectroscopy.

In addition, an approach that enables the registration of both multispectral and geometrical data on a single virtual 3D model has been investigated. A 3D model from traditional visible reflected images is constructed, to extract geometrical information of an item. Subsequently, these pieces of information are stored and exploited to integrate textures obtained from several multispectral imaging techniques.

Eventually, the approach developed in this dissertation has then been used for the study of different case studies. In particular, some wooden sculptures from the Museo Egizio di Torino have been investigated, exploiting multispectral 3D models in support of the design of conservation treatments. In addition, photogrammetry has been used for the multi-analytical study of some bronze sculptures of a private art collection, the Collezione Gori at Fattoria di Celle.