

3D Diagnostic Tools for Cultural Heritage

The use of Photogrammetry to support Conservation and Preservation Strategies

Abstract

In recent years, the integration of three-dimensional digitization techniques into the field of Cultural Heritage has significantly enhanced the documentation, preservation, and study of artworks. Among these techniques, photogrammetry and multi-band imaging have emerged as powerful, non-invasive tools that provide complementary spatial and radiometric information. However, they are often applied separately, and the potential of combining them within a unified workflow remains largely unexplored.

The primary goal of this dissertation is to employ photogrammetry as an active support tool for the definition of conservation and preservation strategies in the Cultural Heritage field. Beyond its traditional role as a documentation technique, photogrammetry is here investigated as a method capable of detecting and monitoring surface changes and deformation phenomena that can affect artworks over time, thus contributing to preventive conservation practices.

The proposed workflow was first validated through the acquisition of a dimensional reference object, characterized by a well-defined geometry and measured using metrological instruments such as a Coordinate Measuring Machine and a laser scanner. These reference datasets were used to verify the reliability and consistency of the photogrammetric reconstructions. The comparison confirmed that, when properly calibrated and scaled, photogrammetry can produce geometrically consistent 3D models suitable for applications in Cultural Heritage documentation and monitoring.

Following the validation phase, two representative samples, one wooden and one painted wooden, were subjected to thermo-hygrometric aging to simulate deformation phenomena such as warping, cracking, and shrinkage. The samples were acquired before and after the aging process using both laser scanning and the proposed multi-band photogrammetric approach. In this context, the influence of different wavelength ranges on the reconstruction quality of 3D models was assessed in general terms, taking into account how variations in object shape and surface characteristics could affect the performance of the photogrammetric process. The results highlighted the consistency of the proposed workflow and its ability to provide reliable reconstructions suitable for monitoring deformation phenomena over time.

To demonstrate the versatility and applicability of the methodology, several case studies were carried out within the framework of a broader collaborative project between the Politecnico di Torino, the Centro per la Conservazione e il Restauro dei Beni Culturali “*La Venaria Reale*” (CCR), and the participating museums.

These include the photogrammetric reconstruction of gilded and non-gilded bronze sculptures from the Museo delle Civiltà (MuCiv) in Rome, where cross-polarization effectively reduced reflections on metallic surfaces; a comparison between photogrammetry and laser scanning applied to the skull of an Egyptian mummy from the Museo Egizio of Turin, used to design a custom display support; and the multi-band documentation of Chinese polychrome wooden sculptures from the Museo di Arte Orientale (MAO) of Turin, later featured in an innovative exhibition project.

The results confirm that photogrammetry, when properly calibrated and combined with multi-band imaging, is a reliable and versatile technique for the documentation and monitoring of cultural heritage artifacts. It enables the creation of geometrically accurate and radiometrically enriched 3D models that can actively support preventive conservation, restoration planning, and museum dissemination. Future developments should focus on improving the automation of the photogrammetric workflow and on the integration of artificial intelligence, enabling more efficient and continuous monitoring of artworks over time.