CALIBRATION OF A MULTI-SENSOR SYSTEM FOR CULTURAL HERITAGE RECORDING

David Hernández[a], Miriam Cabrelles[b], Beatriz Felipe García[a] and José Luis Lerma[b]

[a] Institute for Regional Development (IDR), Albacete, University of Castilla La Mancha, Spain
[b] Departamento de Ingeniería Cartográfica, Geodesia y Fotogrametría, Universitat Politècnica de València, Camino de Vera, s/n. 46022 Valencia, Spain

Corresponding author: José Luis Lerma <jllerma@cgf.upv.es>

-Paper review track-

Abstract

Recording of cultural heritage is a discipline that requires both easy to use and low-cost data acquisition tools to satisfy conservation, restoration, research and dissemination. Furthermore, there is a large amount of information, the resources are limited and maximum benefit of the equipment is expected from the users. The traditional way of carrying out close range photogrammetric surveys is by means of control points. To overcome this need and to simplify the spatial orientation of the cameras, an image-based multi-sensor system that integrates two consumer-grade cameras, one GNSS and one low-cost INS is developed to yield the exterior orientation parameters of the two cameras.
This paper presents the methodology carried out to determine the calibration parameters of the multi-sensor system, namely the camera calibration parameters, the lever arms and the boresight misalignments offsets. For that purpose, (self-calibration) bundle block adjustment is followed in multiple stages on two test fields at the Universitat Politècnica de València, one indoors and another outdoors (Fig. 1). The outdoor test field is an upside down pyramidal sculpture and is used to evaluate the performance of the multi-sensor system to deliver both accurate 3D points and high resolution 3D models. The precision of the exterior orientation parameters comparing the direct approach (with VRS-GNSS and INS) and the indirect approach (with bundle block adjustment) are within 4 mm and 0.15 gon for the two cameras on eight stop-and-go stations. After image matching, spatial intersection is undertaken to determine the quality of the point cloud considering the two sets of exterior orientation parameters, indirect and direct. The maximum RMS of the image coordinates are 0.69 pixels for the former and 13.44 pixels for the latter, and maximum standard deviation in object space of 5 mm (X), 3 mm (Y) and 7 mm (Z), and 100 mm (X), 25 mm (Y) and 40 mm (Z), respectively. Fig. 2 displays a colour point cloud delivered from a single stereo-pair after dense image matching with a high-resolution SLR digital camera (resolution 20.1 MPix). In addition, some statistical analysis show the metric differences on the digital surface models for the two different solutions, direct referencing and indirect referencing (Fig. 3). Precision achieved allows us to confirm that 43.2% of the digital surface models are in the range of 0 and -2 cm, with maximum differences balanced in opposite directions up to 2 cm (24.9%) and -10 cm. Therefore, the output results coming from direct referencing are very good as input for the exterior orientation solution as well as for visualisation purposes but not good enough to achieve accurate 3D models in close range applications.

Keywords: Multi-Sensor System, Calibration, Orientation, Matching, Cultural Heritage

a b

Fig. 1. Test fields used to calibrate the multi-sensor system: a) Indoors; b) Outdoors

Fig. 2. Colour point cloud achieved with multi-image matching

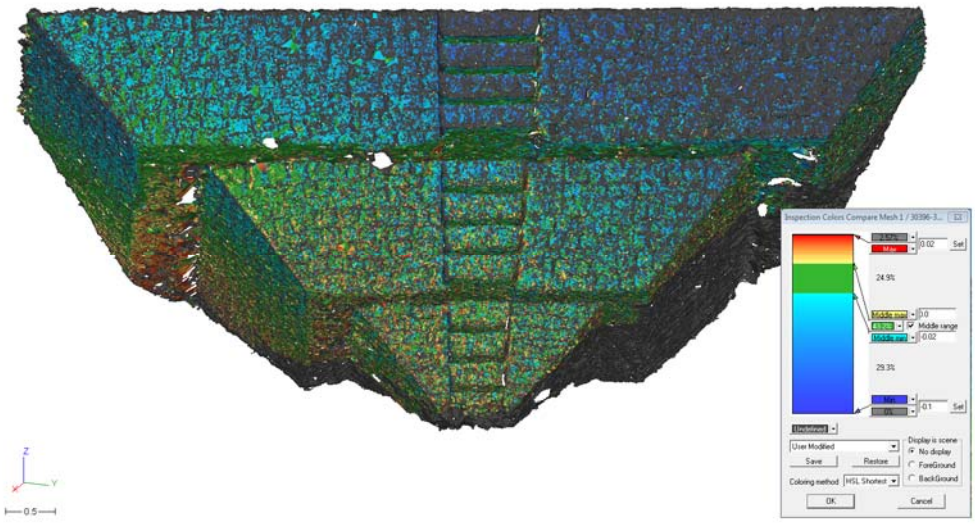

Fig. 3. Comparison of the digital surface models coming from direct and indirect georeferencing