

# Chapter 41

## Digital Photogrammetry and Structure From Motion for Architectural Heritage: Comparison and Integration Between Procedures

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### ABSTRACT

*The goal of this paper is to focus on multi-image monoscopic digital photogrammetry, illustrating several types of applications used in a single case study chosen for its unique characteristics: Palazzo dei Capitani del Popolo in the main square in the old town centre of Ascoli Piceno. The description of this experimentation will be illustrated in the paper not only to assess the potential and limits of these systems, but also to place them in a scientific context and recall the theoretical fundamentals of this method, since we believe these in-depth studies to be increasingly necessary in order for these digital technologies to be used properly.*

### 1. INTRODUCTION

The first procedural changes in the field of photogrammetry took place in the eighties thanks to developments in the computer world. However, only when digital photography was perfected and personal computers improved their processing power was there any significant change in the applications, which then became popular and widespread.

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These purely technological improvements – calculus algorithms and digital photographic materials – made it possible to fully exploit the scientific, geometric, projective and analytical fundamentals already inherent in the method, which in fact remained practically unchanged.

In moving to the digital realm, the main geometrical/projection and analytical principles forming the basis of photogrammetry remain largely unchanged. In general, to attain a description of the photographic object, one still has to establish a spatial relationship between the points of the subject, the points represented on the plate/film/sensor, and the positions and inclinations with respect to the centres of projection and optical axes of the photographic equipment. The combination of such operations, called “orientations”, aims to identify, when known, the intrinsic parameters (principal distance, position of the centre of projection with respect to the plate/sensor, lens distortion parameters, etc.) and extrinsic parameters (position and orientation of the photographic apparatus with respect to the points of the photographed subject) that characterise the photogrammetry model (Carpiceci, 2012; Cundari, 1983; Docci, 1964; Docci & Maestri, 2012; Fondelli, 1992; Girelli, 2007; Ippoliti, 2000; Paris, 2014; Saint Aubin, 1992).

In fact, albeit with some differences, digital photogrammetry systems and software make substantial reference to theoretical principles, so it can thus be termed “classic”. It utilises, in particular, both the collinearity equations, which allow the photogrammetry system to be described analytically with known and unknown variables, and epipolar geometry, with which it is possible to reduce the space in which correspondences between homologous points are sought.

This is the reference framework of this paper which will focus on multi-image monoscopic digital photogrammetry systems and software, i.e., all applications which use restitution methods in which the photographic shots are digital, superior to one, and restitution (even when guided by a restitution operator) is achieved without the assistance of stereoscopic observation. There are two main groups of applications depending on whether or not a restitution operator is required.

The first group includes so-called photomodelling software where the operator is tasked with identifying homologous points for orientation as well as the characteristic points on which to base the geometric and texturised modelling processed by the software itself (De Luca, 2011).

The second group includes structure from motion systems (developed even more recently than the ones in the first group) in which the elaboration of different ad hoc algorithms has led to the automation of several stages: from orientation, including self-calibration, to the extraction of more or less dense points clouds, according to specific criteria of precision, used to construct a model, including a texturised model (Sicuranza, 2013; Remondino & El-Hakim 2006; Remondino, Del Pizzo, Kersten & Troisi, 2012).

The structure from-motion systems make it possible to automate the restitution process but, unlike manual systems, the points are not chosen by the operator. The latter, however, is responsible for controlling the input data (photographic campaign, quality of the photos, checking the self-calibration) and output data (precision and density of the points clouds, presence of gaps and their treatment during conversion into a polygonal model, etc.).

Within this reference framework, the goal of this paper is to focus specifically on multi-image monoscopic digital photogrammetry, illustrating several types of applications used in a single case study deliberately chosen for its unique characteristics: Palazzo dei Capitani del Popolo in the square with the same name in the old town centre of Ascoli Piceno.

The compact and massive block of the Palazzo as we see it today was built in the thirteenth century and evolved over the years; in fact, several different styles coexist in this building with its very varied geometric and formal volumetric parts, architectural elements and sculptural decorations. The extremely varied operational conditions created by the unique surroundings around the building was another reason

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