From photogrammetry to 3D reconstructions

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Introduction

Photogrammetry, born as a specialised branch of traditional photography, has evolved over the years to become one of the most powerful tools available to those involved in land documentation. The advent of digital photogrammetry (Fig. 1) has further enhanced this tool, making it even more accessible. In fact, in order to document even very large portions of the territory with zenithal shots, it is no longer necessary, except in rare cases, to resort to specialised companies equipped with traditional aircraft with personnel on board and camera systems consisting of metric or semi-metric cameras. It is sufficient to equip oneself with UAVs (Unmanned Aerial Vehicles), the so-called drones (Fig. 2), which often, have excellent optics on board already in their standard configuration. Moreover, in the case of customised configurations, they can be equipped with sensors that are not only RGB but also Multispectral, Thermal Infrared and/or Lidar. The data acquisition system can be managed through the use of software released by the UAV producers, generally free of charge, or through dedicated third parties' softwares in 'licensed' versions, purchased, rented, or in a totally free mode (Open Source).

In addition to the acquisition of data, in recent years there has also been a real revolution in its restitution. Softwares capable of processing the ever rather abundant quantity of photographic captures (in fact, we generally speak of sets of photographs) are now considerably cheaper and their producers have designed and conceived them to be suitable for running on personal computers that are not exceptionally powerful, perhaps even more easily transportable as laptops (portable workstations).

The method used by these softwares, a kind of photo-modeling, is known as 'Structure From Motion'. It is a 'range imaging' technique inherited from Computer Vision, used for both topographic and high-resolution architectural restitution that works according to the same basic principles as stereoscopic photogrammetry, but differs from it for a semi-automatic resolution of scene geometry, camera positions and orientation. As mentioned earlier, this type of approach is ideal when one is dealing with large sets of high-resolution images, taken with a high degree of longitudinal and lateral overlap, to be set up in the flight planes useful for covering the entire survey area with an adequate number of swipes. The greater the overlap, the easier it will be for the software to capture the three-dimensional structure represented in the scene, which is simultaneously observed from many different viewpoints.

The Acquisition

Many factors, including the number of flights (Fig. 3) required to cover the portion of territory or built-up area to be documented, as well as the calculation of the ideal altitude from which to take the image sets (Fig. 4), the 'flight times', the scale of representation at which the final photogrammetric work is to be used, condition and guide the operator in the planning phase of the survey (Fig. 5).

Derived Products

The raw data obtainable with any 3D survey system is the so-called point cloud (Fig. 6). The surfaces that one seeks to survey and represent are in fact described by a set of points distributed in three-dimensional space. All subsequent work, such as meshes (continuous polygonal surfaces), the 3D solid model, or DEMs (Digital Elevation Models) are derived from the point cloud. However, this is not always adequate. Sometimes, when operating in particular environmental conditions of coverage (presence of obstacles to photographic documentation) or poor lighting, as in the case of the survey of interiors and/or hypogeum environments, the use of SfM systems should be flanked by 3D laser scanning survey methods (Fig. 7).

3D Modelling

The only real limitation to the use of the SfM technique is the impossibility of documenting what cannot be photographed. Sometimes, especially in the archaeological field, the smallness or even insubstantiality of the remains does not allow for an adequate capture of remarkable points from the photographic series, such as to make it possible to 'reconstruct the volumes' and thus the overall layout. In such cases, in order to facilitate the understanding of the remains themselves, there is no other option but to employ traditional 3D polygonal modelling, rendering and post-production techniques (Fig. 8).