FROM THE ROAD SIGN TO THE MAP: 3D MODELING IN SUPPORT OF THE URBAN AND RURAL ROAD CONDITIONS

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ABSTRACT:

Unmanned Aerial Vehicles (UAV), commonly known as a drone, and an Unmanned Aircraft Systems (UAS) have been spreading on a massive scale during the last few years, especially for civilian use. And this situation can have significant repercussions on the ways and purposes with which we make photogrammetry nowadays. In this brief article we take into account the italian road signs as a case study on which to apply the new potential of photogrammetry realized with the aid of drones. Our main purpose is to achieve a specific method which allows the calculation of centimeter precision measurements of solids reconstructed for a mapping of (public and private) road signs which require verification or replacement in urban, peri-urban and rural areas. Our hope is that this new approach to photogrammetry may arise opportunities for dialogue with policy makers especially where the usefulness of mapping could also appear predictive with respect to recurrent issues before they become consolidated.

1. INTRODUCTION AND AIM OF THE RESEARCH

Over the last two years, among the Earth observation instruments for civilian use, the Unmanned Aerial Vehicle (UAV), commonly known as a drone, have been spreading on a massive scale. The purpose of the data acquisition from those systems is to reconstruct reality (objects, properties, or a portion of territory) through the implementation of 3D numerical models which reflect as closely as possible the proportions, measurements and locations of the entities detected. In some cases, the objects analyzed and photographed during a survey have very minute details, which are not easy to reconstruct despite the power of the algorithms used and today's computing tools.

The main purpose of this brief discussion is to achieve a specific method which allows the calculation of centimeter precision measurements of solids reconstructed for a mapping of (public and private) road signs which require verification or replacement (because they have deteriorated, are missing or not up to date) in urban, peri-urban and rural areas. The same methodology could at a later time also be applied to other small-sized anthropogenic works for which a very detailed model would be necessary.

2. AERIAL PHOTOGRAMMETRY FOR ROAD SIGN

Scientific and technological knowledge usually evolve jointly but not always in the way we might expect. The unusual combination of an SLR attached to a pigeon with which the nineteenth century ended is certainly one of the clearest examples of the curious way in which high-technology services with many different applications can arise. Environmental monitoring, generating immediate risk maps, agro-forestry monitoring, fisheries surveillance, the security of the borders between states, or traffic management are just a few examples of the areas of the application of scientific (photogrammetry) knowledge and know-how that would probably never have developed without the first tests of heliography in 1821. It was only in 1856 that Nadar went from ground to aerial photography thanks to the use of a balloon.[1]

While the first instance, strictly speaking, of photogrammetry did not occur until the advent of military double shot cameras (with self-timer programmed to 30 seconds) attached to carrier pigeons as mentioned above.

The programming for the coverage of photogrammetric strips proposed here is not substantially different from that used in the last century: the flight plan must be carried out in order to obtain strips, which are adjacent, parallel and overlapping at least 60% longitudinally and 30% transversally both when using avifauna (with the ability to fly along the geodesic and return to the starting point) and piloted or remote-controlled aircraft flights.

The aspect that we wish to consider in greater detail in this venue, and which is instead significantly far removed from traditional photogrammetry, is represented by the manoeuvre versatility of the hardware used for filming: a drone weighing less than two kg is in fact able to carry out the filming at 360° even around a very small object (1 meter * 1 meter) at a very close distance from the lens (1-5 meters). Even if the payload of a UAV of that size does not permit the use of very heavy high resolution cameras, the ability to take many shots and at lower altitudes than traditional photogrammetry partly offsets (if not completely considering the size of the pixels at a low altitude) the problem.

If we combine these potentialities with the enormous computing power of the algorithms most widely used today to process point clouds[2], we can also get, for example, true to life 3D reconstructions of road signs, constantly updated quickly and at very low cost (thanks to open-source software).

Our interest in road signs is not completely random, especially in the current era of emphasis on aspects of more and less sustainable mobility, but also of the erosion of the economic resources necessary to make it so. In fact we can even say that this field of applications could prove to be particularly interesting in view of resource optimization because we are seeing an increase in neglect phenomena (cuts in public funding including road maintenance) and continuous poorly planned interventions on road signs (shifted, in a state of deterioration, incorrect placements).

[1] A technique still used today when there are particular regulatory restrictions regarding the use of unmanned systems - http://www.agisoft.com/pdf/articles/3deffe.pdf.

[2] Structure from motion - SfM: http://ccwu.me/vsfm/vsfm.pdf.

Traffic management is now of international interest because it is forced on to the political agenda by the increasing urbanization; an interesting case of photogrammetry from UAV in this sense is represented, just to give an example, by the Anglo-Iraqi study by Smith et al. (2013) in which the Road Surface Monitoring (RSM) supplemented by geo-tagging is used to detect potholes (Fig.1). Thinking about the Italian situation, given the widespread backwardness of the transport system, we felt it was more appropriate to think in more elementary terms and focus, rather than on the streets, on the traffic directing tools on the roads themselves: roads signs.

Figure 1. Example of a 3D model for UAVs road monitoring [by A. Palummo]

Against this background, it seems appropriate to go into greater detail in two different directions (Fig.2):
(1) more technical, providing for data acquisition and processing from aerial photogrammetry in combination - where possible - with the remote steering flying techniques for creating 3D models, orthophotos of detail, etc .;
(2) theoretical and practical, which consists in analyzing, with the urban-planning and territorial programing instruments, the traffic plan and road network maps.

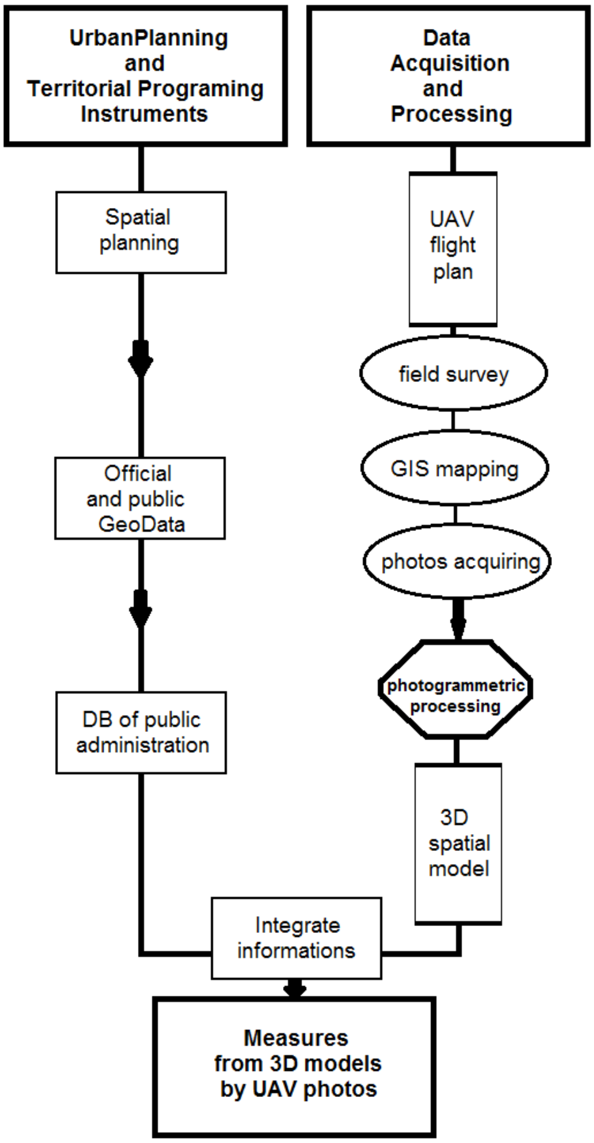

Figure 2. WorkFlow for a data analysis by UAV photogrammetry [by A. Palummo]

The second analytical level is undoubtedly necessary to detect the inconsistencies which over time have been created with respect to what had been mapped during previous surveys. But, in this paper, we mainly focus on the first level, regarding the acquisition of new information, which is of interest to us here as it covers flight planning with drones.

The flight plan from UAV can, in turn, be structured into different phases: calculations of the coverage parameters (area covered, number of strips, photo shoot per strip, shots interval, etc.) and of the shooting parameters (flying height, photogram scale, GSD, GPC positioning, etc.). These phases could be replicated for each flying session that is expected to be performed. In a case such as signage (or advertising board) or other detailed objects (scales 1:100, 1:50 and also lower) it is considered essential to carry out at least 3 flight sessions: the first for normal shooting, the second for nadiral shooting and the third for the inclined shooting with a 360° sweep around the object of interest. The third flight session is not always possible when there are obstacles on one or more sides, it can however be done in a partial manner, for example only for 180° (Fig.3).

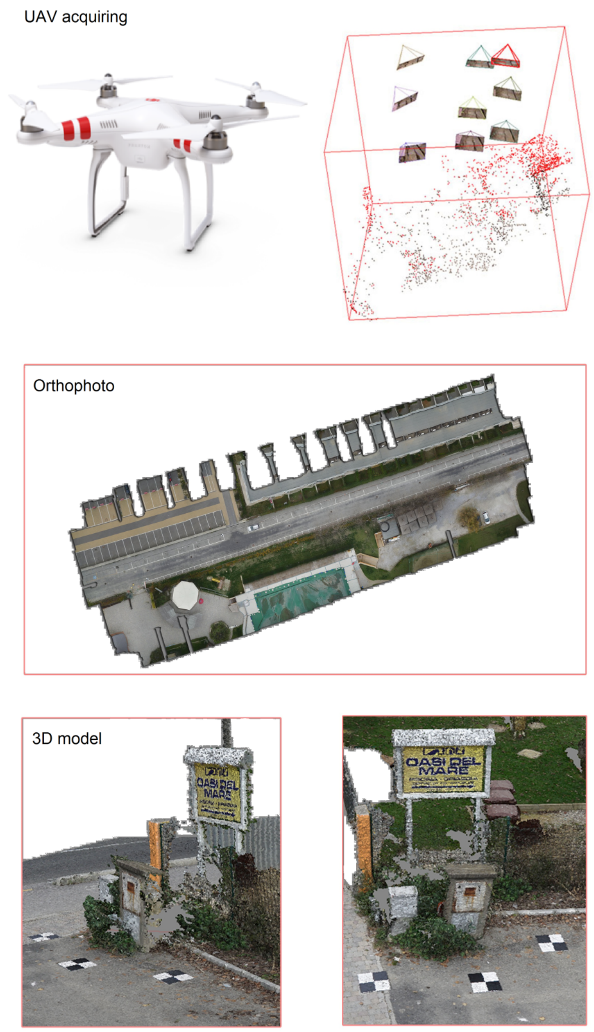

Figure 3. Application case of the proposed methodology [by A. Palummo]

The experimental data which we are referring to in this venue were obtained with a 25m flight altitude for a drone speed of 8 m/s (about one shot per second and a focal length of 35mm) for nadir shooting, and 10-15m for the inclined shots with a speed of about 12 m/s (shots every 3sec), with a maximum error in the order of a centimeter.

3. CONCLUSIONS AND RESULTS

The high degree of correspondence with the actual measurements of the tests in an urban environment on firm and stable objects seems an encouraging result: in fact the error tends not to deviate significantly from a centimeter and the point cloud reaches a coverage even higher than 80% of the surface area of remote sensing surveyed.

The short-term perspective is to continue with the same method on more complex and less defined objects (trees, rocks and debris in the vicinity of rivers, low walls, prestigious agricultural accommodation, etc.) but, in the medium and long term, one cannot exclude opening a channel of dialogue with political decision-makers where the usefulness of mapping could also appear predictive with respect to issues which could prove to be relatively consolidated and recurrent (for example, to suggest better signage placement to make it more visible, etc.).

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