UAV APPLICATION IN POST – SEISMIC ENVIRONMENT

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The aim of this work

The entity of the damage caused by the earthquake that struck L'Aquila on April 6 2009, requires a careful planning of the reconstruction of so many important buildings collapsed. Most of the damaged buildings have big historic value representing a valuable heritage that goes from the Baroque to the Renaissance periods.

A so accurate surveying of all building can be performed using different geomatics techniques as total stations, land photogrammetry, and laser scanners. Even if all of these techniques can perfectly fulfill many crucial post hazard needs, there are still many cases where they show some limits. Most of the difficulties are related to the morphological and architectural accessibility, problems typical of a post disaster scenario.

Using micro UAVs for surveying in such particular cases can easily bypass many of these problems. For example there is no accessibility problems for an UAV for the flexible flying capabilities of these instruments that can virtually permit the access of any place.

In the present work a new way to plan UAVs survey will be illustrated, with the aim to obtain stereoscopic vision or monoscopic coverage, which allows to extract a DSM, from necessary acquisitions.

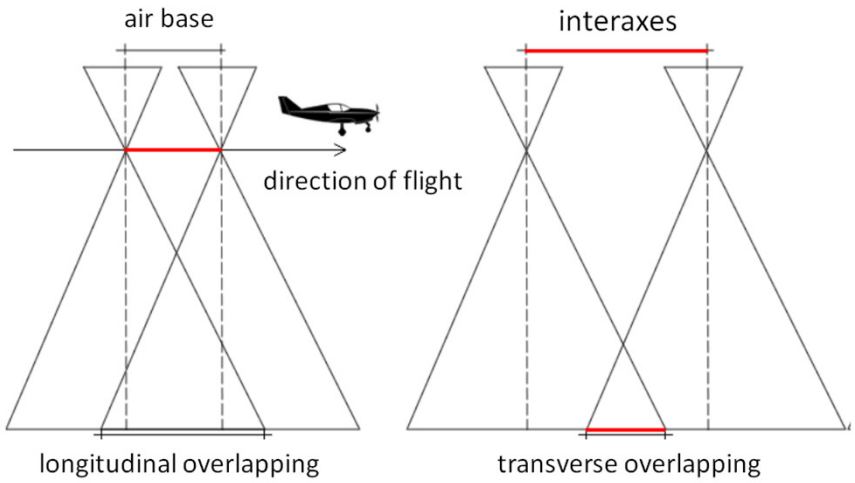
Flight planning

Considering as a guideline, the case of a traditional photogrammetric airplane acquisition, a flight is planned according to predetermined almost rectilinear paths parallel to each other; during the flight, images are taken in succession at regular time intervals, forming what is called a 'swath'.

To determine the number of the needed waypoints some metric information are necessary.

Then, the geometric characteristics of the camera have to be estimated: the focal length, pixel dimensions and the frame format in order to correctly determine the physical area covered by each acquisition.

According to these parameters, the overlap between two consecutive images can be estimated. The overlap related to the same strip is defined as 'longitudinal overlapping'; in this direction usually each frame covers the previous by a quantity equal to at least 60 to 80% of the image size. Considering instead two adjacent strips, parallel to each other, the frames are acquired so to obtain a 'transverse overlapping', equal to at least 20 to 30% of the size of the image.



Why a planning software is necessary?

•Currently planning is performed mainly based on the experience of the operators;

•The characteristics of internal orientation and flight modes originate acquisition geometries different from the traditional photogrammetric airplane acquisition;

•The optimization of flight plans is of strategic importance considering, the current reduced autonomy of some UAV;

•In addition, the planning of the flight plan could allow to:

-Execute multitemporal survey, in fact the flight is repeatable with identical parameters at any time.

- Replace immediately not optimal quality images (due to, for example to unexpected intrusion of other subjects or to sudden changes of light or UAV unexpected instability, etc.).

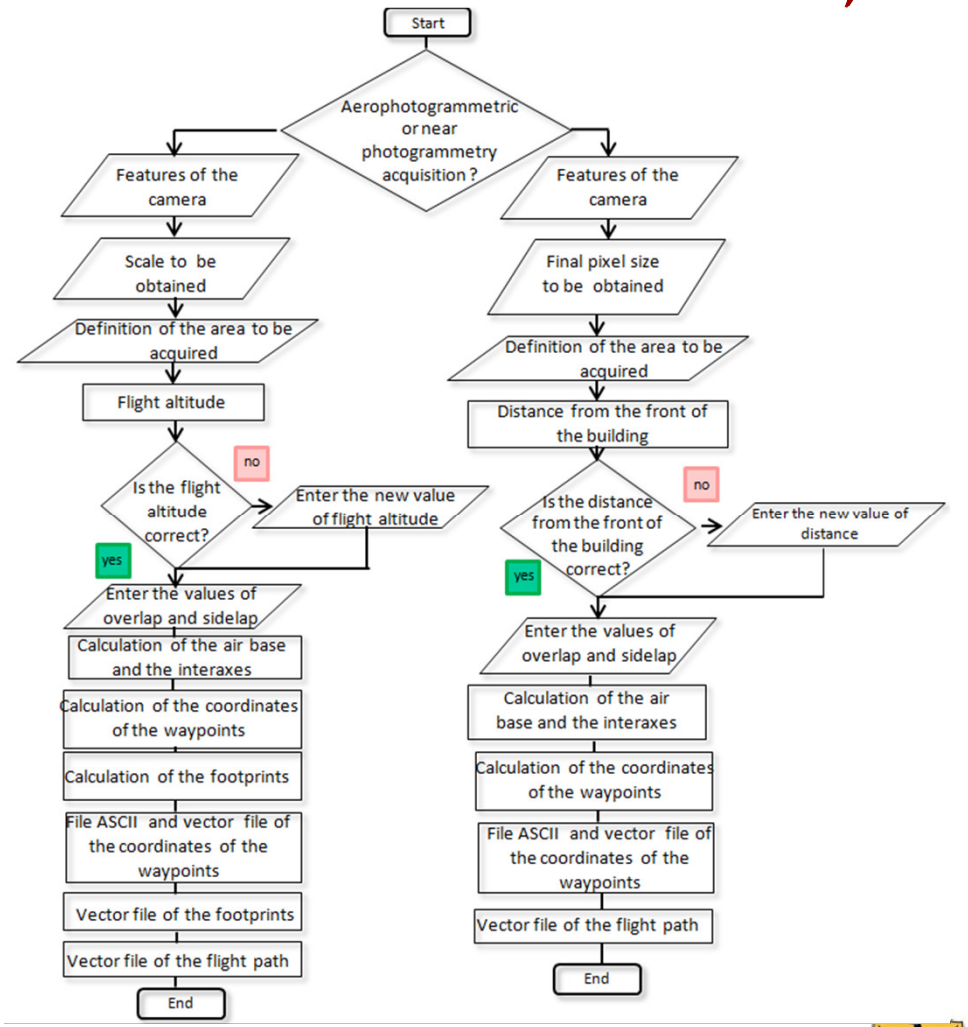
UP23d (UAV planner to tridimensional acquisition)

The software requires as input data the size, shape and position of the area to be acquired, the optic parameters of the camera installed on the drone and the desired final scale of the acquisitions.

From these first input data the package suggest a flight altitude, which is proposed to the user which is free to edit if it's not suitable for the area to be investigated.

Once estimated the flight height and consequently, the final scale obtainable, the values of longitudinal and across overlap have to be inserted in the software to allow the evaluation of the airbase needed to assure a correct stereoscopic restitution. After this step the software proceed to the calculation of the waypoints and footprint of each acquisition.

In a post seismic environment UAVs can also be used to acquire facade of buildings for near photogrammetry, in this case as input data the size of the area to be acquired, the optic parameters of the camera installed on the drone and the dimension of the pixel in the acquisitions are needed.



Case of study

To validate our approach a comparison with an actual UAV flight executed for near photogrammetry in L'Aquila was performed. In this first test the facade of "The Basilica di Santa Maria di Collemaggio", was acquired; the church is an important place of Catholic worship in the city of L'Aquila.

Established in 1287 by Pietro da Morrone, is the most important religious monument in the city in fact it's an UNESCO world heritage site. Contains the first Holy Door of the world and is home to a jubilee year unique of its kind. The basilica is the result of a complex blend of Romanesque architecture, the suction Gothic and Baroque style. During the earthquake of 2009, the Basilica was impressed so extremely serious. Part of the vault of the basilica collapsed causing the destruction of the terminal part of the nave. For this reason a complex work of restoration is going to be performed on the church.

The platform used

This experimentation is the result of a collaboration between the Faculties of Engineering of L'Aquila university and "La Sapienza" university of Rome, and Aermatica company, that gently provided platform ANTEOS A2-MINI/B, including all on board sensors like optic commercial camera CANON S100 with focal length 5.2 – 26.0 mm (35 mm equivalent: 24 – 120 mm), Infrared Camera Flir Tau320 and GPS navigation receivers to enable the automatic flight mode also with the necessary transmitters able to send all telemetry data in real time to the ground control station.

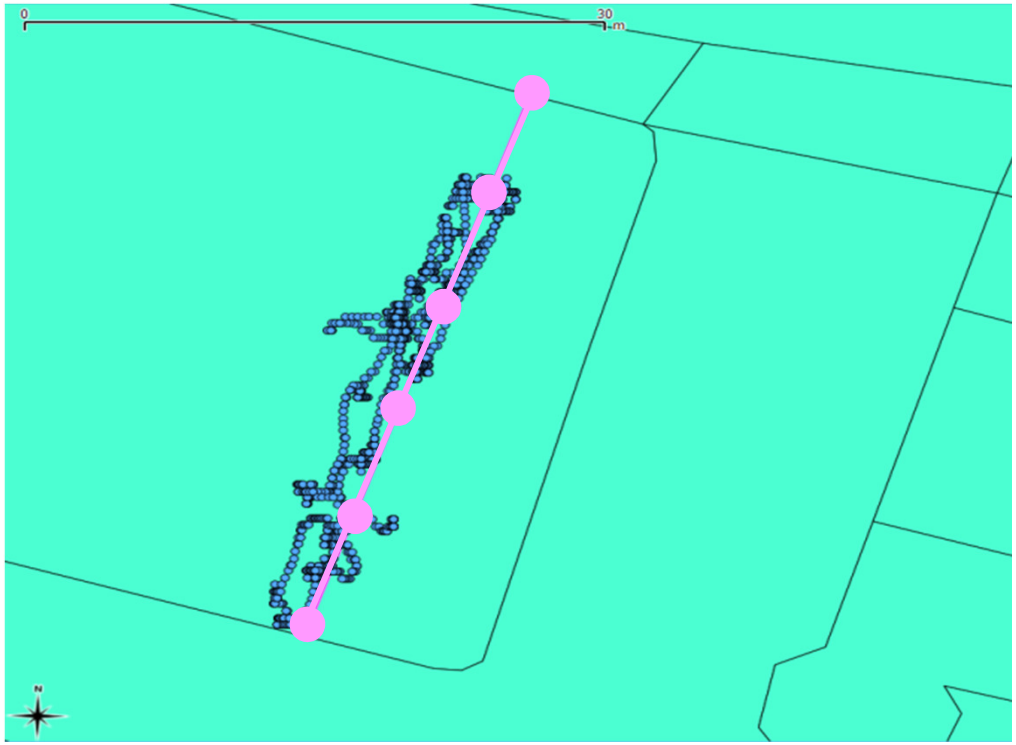
The choice of this platform was made trying to achieve excellent flying characteristics that can allow an optimum stability even in presence of wind or other non optimal climatic conditions and according to the payload specified by the manufacturer, which allows carrying all board sensors.

Acquisition of Ground Control Point

To obtain stereoscopic vision for the extraction of DSM is necessary to reconstruct the geometry of the two images in relation to the surface, calculating position and orientation of the camera relative to the ground at the acquisition time. In the case of "The Basilica di Santa Maria di Collemaggio", 63 control points were acquired with an high accuracy topographic survey.

Software optimization of the flight plan: results

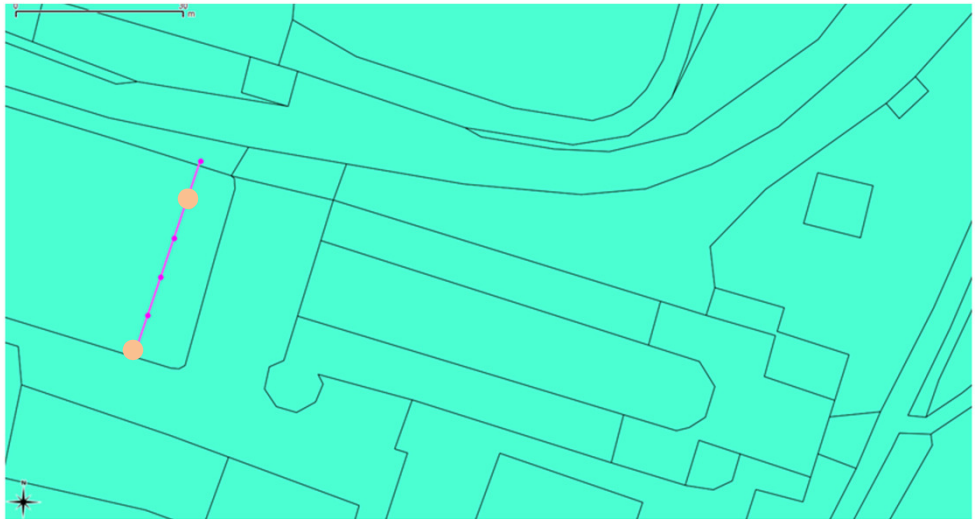
We can observe the difference between the actual acquisitions (light blue) and the planned acquisitions . From this first analysis, we can note, that the number of acquisitions executed by the pilot was extremely redundant and this (as we explained) is presently the most diffused way to acquire.



Choice of stereopair

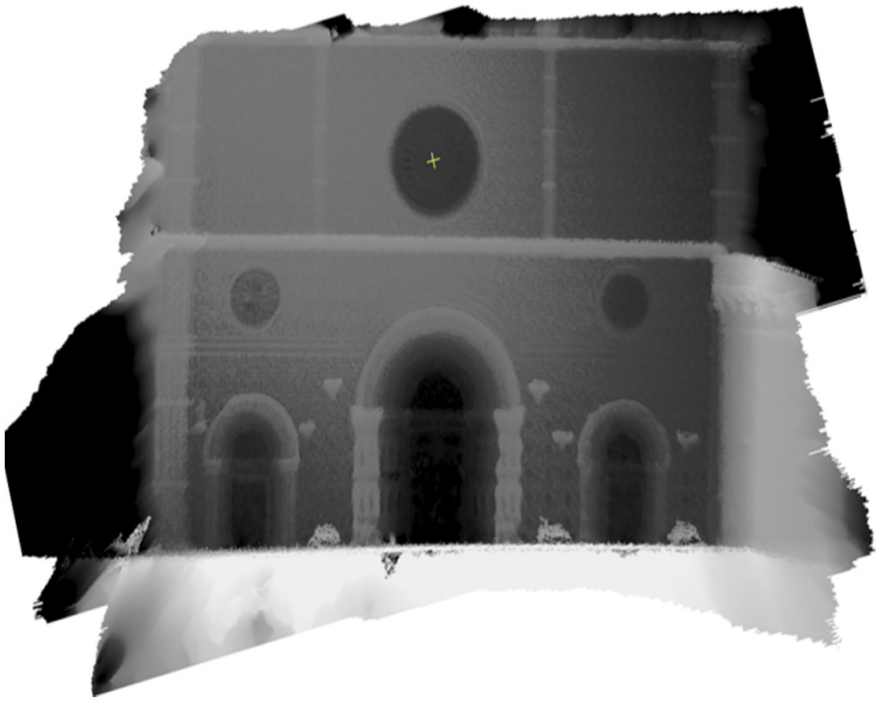
To simulate an acquisition based on our planning software we looked for two acquisitions that simulate those calculated by the software UP23d. So we found some stereopairs that have nearly the same geometry planned by the software.

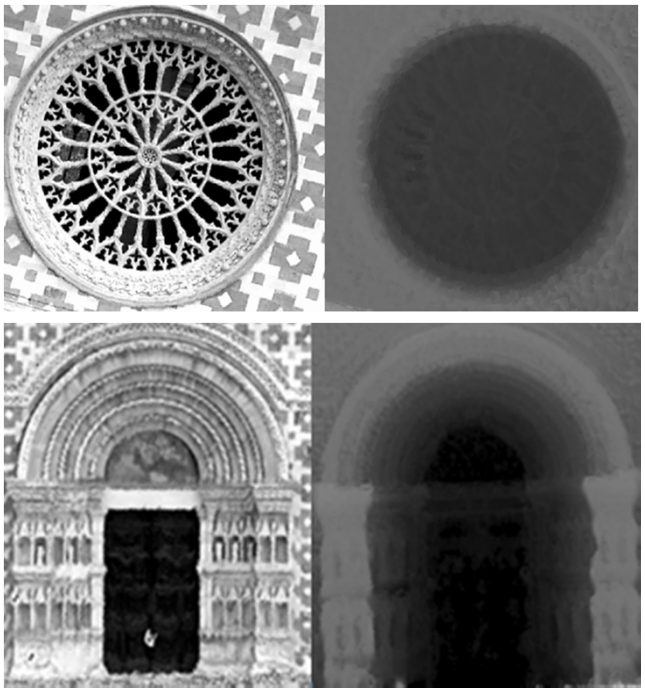
We can observe two acquisitions that show similar geometry to one of the stereopair planned: they were acquired at lightly different flight altitudes, respectively, 18.9 and 18 meters, but this is correct for simulate an actual planned acquisition where the position of the UAV depends on the limited accuracy of the onboard GPS system.



DSM obtained

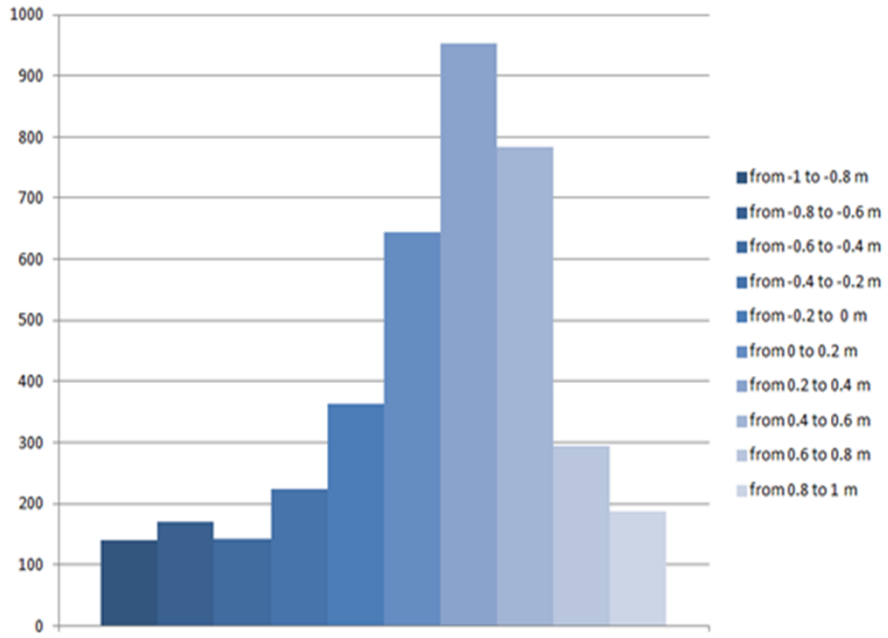
We can observe that an impressive precision characterize the obtained DSM, we can see that a precision of one decimetre and in some cases also a centimetre is possible to be achieved.





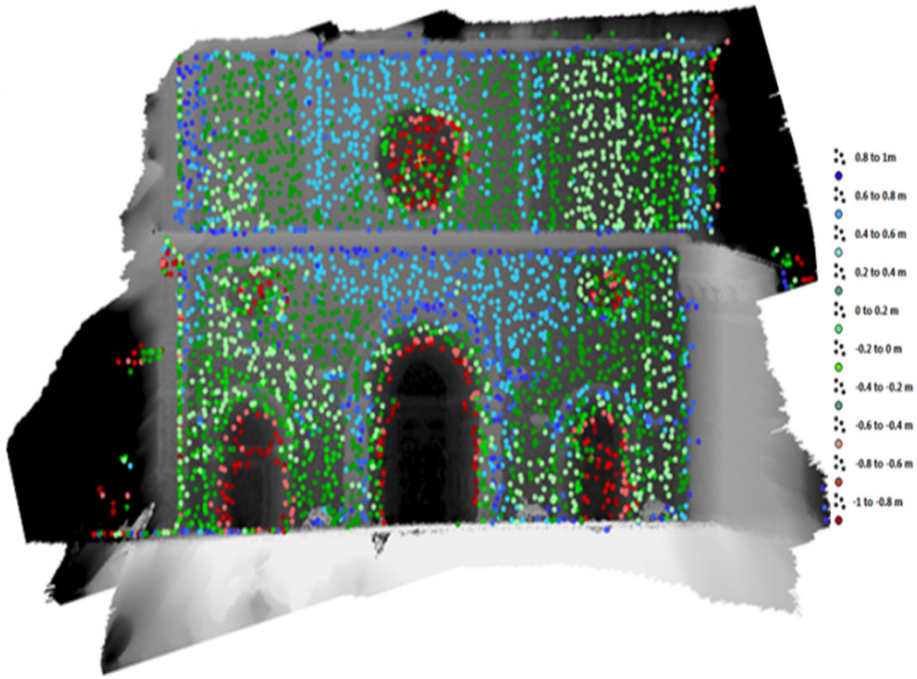
Evaluation of the accuracy 1/2

To evaluate the accuracy of the DSM obtained, we use a laser scanning survey. We compared the differences in height of the DSM obtained and the laser points, considering a set of 3903 points. The results obtained were then plotted in a histogram, as shown in figure. The histogram has been built considering a range from -1 to 1 meter, with a step of 0.2:



Evaluation of the accuracy 2/2

We represented the distribution of these differences on the facade to understand the possible causes. Greatest differences concentrate in some areas, it can be due to different exposure to sunlight or to other systematic errors, but this is still under investigation.



Conclusions and future developments

The use of a UAV platform for the study of post-seismic scenario is of strategic importance when considering that in this way parts of structures otherwise hardly accessible can be detected

Some first results confirmed that the geometric conditions hypothesized are correct to automatically extract DSM, but further and more extensive tests have to be performed.

Some tests of DSM extraction were performed and the precision appear to be comparable to other techniques. It seems that biggest differences are localized in some areas (as the centre of the facade). The possible causes are presence of shadows or other systematic biases that are still under investigation.