Point-Clouds above and below

Challenges of the documentation of the Venetian Port of Rethymno, Crete (Greece) as seen from RPAS, ground and underwater photogrammetry

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Introduction

The Venetian port of Rethymno, Crete (Greece) is a complex structure closely connected to the densely populated old town on the Northern coast of the island.

A recent documentation job, commissioned by the Municipal Port Fund of Rethymno in collaboration with the Ephorate of Underwater Antiquities of Crete (Greece), had the goal to create a digital copy of the current status of the port in view of conservation works to be undertaken in the near future.

What was apparently a relatively easy task, turned out to be quite challenging because of the numerous difficulties and the necessity to integrate and validate data from different sources, namely (underwater, ground and aerial photogrammetry –via Remotely Piloted Aerial System or RPAS-), Terrestrial Laser Scanning and underwater sonar bathymetry.

The result is a complete and detailed replica of the current condition of the monument for future use.

The paper presents here the different phase of data acquiring with the challenge of each employed method and the complexity of integration of large and heterogeneous datasets from different (open and commercial) software solutions.

The Venetian port and its peculiarities

The so-called Venetian port of Rethymno (Μαλαγάρης and Στρατιδάκης, 1995:12) is a complex and multi-phased structure over an area of about two hectares, built around 961 A.D. and flourishing in Venetian period in the 13th - 14th century. The breakwater to the North is made of a high stonewall and a lighthouse at its end showing the entrance to the harbour (Fig. 1).

The lighthouse itself dates to later periods (namely 1838), when the Turks dominating the island gave Crete to Mehmet Ali and the Egyptians. Although the lighthouse and the harbour are not operating anymore, except for the lashing of local fishing boats and small yachts, their shapes are quite well preserved to the maximum height of about 9 meters, despite the strong winds and waves coming from the Cretan sea.

The harbour is one of the main tourists' attractions of the Cretan town of Rethymno and the numerous taverns and cafes facing the mole make it a hot spot during the long touristic season (lasting about 7-8 months).

The above characteristics, defining the Venetian port as an attraction in town, are also translatable in major difficulties and challenges for the mapping of the entire structures. Indeed, the port' main features dictated the special approach for digital documentation as for the following table (Table 1).

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Fig.1. Perspective three-dimensional view -looking South- of the Venetian Port of Rethymno (and part of the old town) from Google Earth. (© Google Earth and DigitalGlobe).

Port's main feature	Challenge for documentation
General shape and extent	Absence of optimal or favourable points of view for proper photogrammetric documentation
Enclosing a water body with docked fishing boat	Water reflection and refraction, together with the slowly moving boats in each photo-frame, are not ideal for image-matching and reciprocal alignment in ground photogrammetry; at the same time, given the risk of falling into water, no professional equipment could be employed for the RPAS survey (resulting in lower resolution still-pictures with high JPEG compression).
Taverns and cafes on one side of the mole	Difficulties in operating during the day, with only few hours early in the morning available for undisturbed survey
Gusty wind and waves	Difficulties in operating the RPAS, especially for the northern side of the harbour and the lighthouse
Main tourist attraction in town	Special precaution and limitations for the flight above people and in urbanized area
Located at the Northern edge of the town with no major building surrounding it	Being on the North coast means that the sun exposition is the longest possible during the day, with sun being visible (and in ground photographs) from early hours when no tourists visit the monument

Table 1: Synthetic description of port's main characters and related difficulties in data acquisition.

Processing and results

Data acquisition consisted on multi-stage approach including several devices and software solutions.

First step consisted in ground photogrammetry: more than 2000 photographs were collected with DSLR camera and 35mm calibrated prime lens; unfortunately, the specific lens, optimal for photogrammetry session, was not the best to capture sufficient overlapping of far objects. The dataset was therefore integrated with photographs with tele zoom lens, which allowed the capturing of details from one side to the other of the port. The processing of this dataset, required accurate image masking to avoid false matching with slowly moving boats and reflection in water body (and obviously a dedicated computer) (Fig 2).

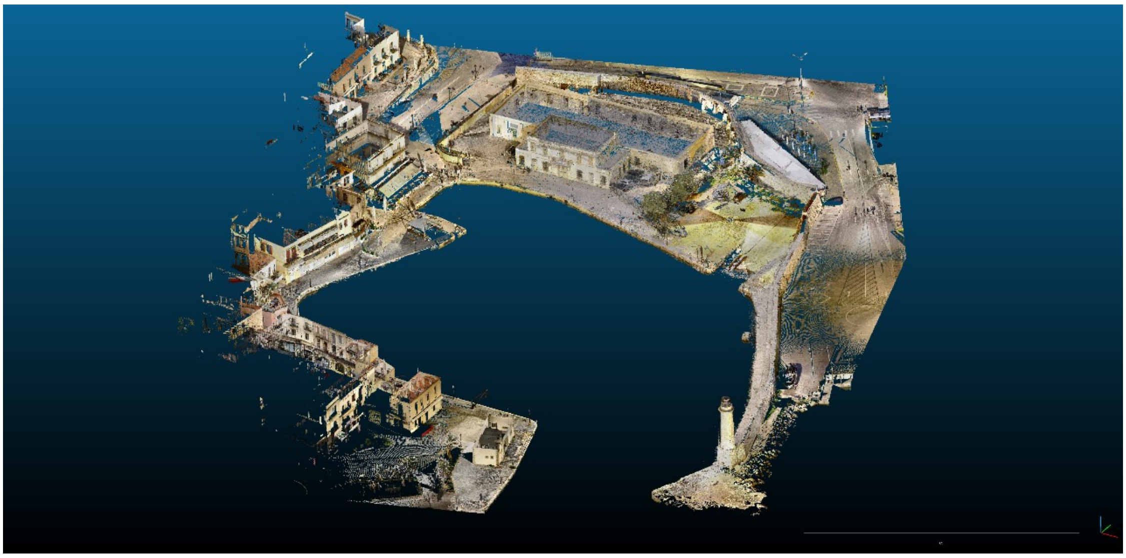

Fig 2. Isometric view of the pointcloud derived from integration of TLS and RPAS photogrammetry.

A trial was then done to combine the ground photogrammetry with the photographs taken with the RPAS (of lower quality and resolution). Given the difficulties of employing measured targets for orientation and scaling of the image-based model, the photogrammetry dataset was aligned and scaled against an extensive Terrestrial Laser Scanning (TLS) of the entire area (Fig. 3.).

Fig. 3. Top-view of the pointcloud from TLS with scan station location (blue circles).

This assured proper scaling and orientation of the different blocks of dense clouds (via ICP algorithm implementation in CloudCompare, see CloudCompare, 2018), providing at once a means of validation of photogrammetric processing (Lague et al., 2013). Ground and RPAS photogrammetry could then integrate the less-detailed or less-complete TLS survey (i.e. which did not include roofs and walls' top or details not in line-of-sight of the scanner) with also better colour assignment.

A later phase consisted in the acquisition (via underwater photogrammetry calibrated and corrected with bathymetric sonar measurement) of the seabed enclosed into the Venetian harbour (between 1 and 5 meters depths).

The result is a complete 3D digital model of the entire Venetian port with detailed information on the above- and below- water surfaces at few millimetres resolution available for precise documentation and digital conservation.

References

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