Final dissertation: Master of Science in Geomatics A.Y. 2022/2023

09th February 2024

Dr. Giuliano Ambrosetti

The Castle of Sarteano: a 3D model for conservation and tourist promotion

internship at Centro di GeoTecnologie dell'Università di Siena (San Giovanni Valdarno - AR)

This work aims to produce a 3D model, scaled and georeferenced, of the Castle of Sarteano (SI) through the processing of data coming from photogrammetric survey with drone and from terrestrial LIDAR survey. The data were framed in an absolute reference system using GNSS and total station.

The survey at the structure was carried out at four different times. In a first phase, during the practical exercise of the drone course, during the master's course, the coordinates of 11 ground points (RDN2008 UTM32N reference system) were taken with GNSS instrumentation and the photogrammetric survey was carried out with nadiral and oblique photos of the exterior of the castle using a drone. At a later stage, this time during the LIDAR course exercise, having detected two GNSS points, one on the square and the other on the terrace located on the top of the castle, the acquired scans of the rooms of the top floor were framed with the total station. The Trimble laser scanner used, however, revealed the operational difficulty in proceeding with the survey of all the internal spaces of the castle.

The possibility therefore arose to proceed with a Matterport laser scanner, lighter and more agile and quicker to use, and on a third day, with the execution of more than 130 scans, it was possible to complete the survey of all the rooms (with the exception of those on the ground floor and the internal spiral staircase that connects them to the top floor) and the main staircase. The excluded spaces were too narrow and very "noisy". It was therefore decided to dedicate one last day to solving this problem, trying three different technologies: a slam-type laser scanner, a drone for indoor spaces with Lidar and the iPhone 13's standard laser scanner. While the first has produced the best results for the rooms on the ground floor, the latter proved to be the most effective tool in the case of the spiral staircase.

The data collected on these occasions were finally processed and brought together for processing and making available on a web page, through the Potree platform, for the tourism promotion and conservation of the Sarteano castle.

Dr. Giulio Donati Sarti

Photogrammetric acquisition and processing of multispectral and thermal data - assessment of soil moisture content in agricultural environment

internship at Centro di GeoTecnologie dell'Università di Siena (San Giovanni Valdarno - AR)

This project presents an analysis of the correlation between multispectral and thermal data, processed by photogrammetric techniques, and soil water content, focusing on two pilot sites with horticultural and viticultural crops. The research is part of a crucial context, where efficient management of water resources is central for agricultural production.

The main objective was to verify the reliability and accuracy of photogrammetric processing by examining temperature, NDVI and SAVI variables in relation to soil water content. The project focused on three main phases: (i) planning and data acquisition, (ii) data processing and (iii) validation of results.

The results show that the data from photogrammetric processing, carried out on the information acquired by the multispectral camera, tends to be in accordance with the percentage of soil moisture present in the samples analysed in laboratory. The thermal camera data, instead, showed a lower correlation, probably due to the difficulty in the images alignment phase.

Overall, the results indicate that the photogrammetric approach, particularly using the multispectral camera, provides reliable estimates of soil water content. This study contributes to the understanding of the potential and challenges of these techniques in agricultural monitoring.

The in-depth analysis and validation with laboratory data and ground-based sensors provide a solid foundation for future developments and practical applications in land monitoring and management.

Dr. Stéphanie Lucatelli

Laser scanning and 3D modeling for the enhancement of archaeological heritage: the Roman Domus on the Celio Hill

internship at Centro di ricerca DigiLab (Roma)

This study is the initial phase of the "ArcheoVerso" project, born from the collaboration between the "Digilab" Interdepartmental Research Center of the University of Rome La Sapienza and the "Coopculture" cooperative, with the aim of creating environments of virtual visits aimed at implementing the possibilities of using an archaeological site. The "ArcheoVerso" pilot project, presented here, consists of the Roman Domus of the Celio, an extraordinary archaeological context with continuity of life from the 1st BC. to the 4th AD undergoing numerous structural transformations over the centuries. Through the use of integrated methodologies and techniques, a survey was first carried out with a laser scanner and a photogrammetric measurement, in order to obtain a metrically accurate 3D model, on the basis of which the reconstruction of the rooms was carried out, for now, in the two main phases of the 2nd and the 3rd centuries AD.

This modelling work therefore included not only the acquisition phase but, at the same time, also a long phase of study of the context which presents a rather complex stratigraphic interpretation to provide a historically and archaeologically precise restitution.

Dr. Emanuela Patriarca

Processing of Planet satellite images to identify Bark Beetle Damage: The Case of Forests around Brunico

internship at Eurac Research (Bolzano)

In recent years, the red fir forests in Trentino-Alto Adige and Veneto regions have suffered severe damage due to the unprecedented spread of the bark beetle, which has proliferated due to the abundant presence of trees felled during the Vaia storm in 2018. This insect, by burrowing galleries into the bark of the firs, takes the tree through various stages, from water stress to death. Monitoring activities to counter the spread of the bark beetle and mitigate its effects represent a burdensome effort for foresters in terms of both time and money. The use of remote sensing tools can help to reduce these costs by providing frequent and spatially continuous data on vegetation conditions. In recent years, there has been a significant increase of commercial satellite data from companies such as Planet, Maxar, and Airbus. These data offer increasingly higher spatial resolutions and rapid update frequencies, allowing detailed and timely monitoring of ground conditions. In this study, we aimed to test images acquired by the PlanetScope satellite constellation, with a spatial resolution of 3 m, in detecting the different stages of bark beetle infestation in the forests around Brunico, in Alto Adige. Due to the impossibility of collecting ground truths, the results produced by a hyperspectral study in 2022 were used as reference data. Using the Random Forest algorithm, a Planet image closest to the flight date of the mentioned study on October 7, 2022, was classified. Two classifications were conducted: one using only the October Planet image and various indices calculated from it, and a second classifying a time series of multiple images with their respective indices. The classes used refer to the different stages of infestation and they are as follows: healthy (1), green stage (2), which is the very first stage of infestation when the canopy does not change color but the tree is already in a state of stress, red stage (3), during which the canopy changes color, and finally gray stage (4), when the tree has reached the end of its life cycle. The accuracy of the obtained results varies depending on the class, with not very satisfactory performance for the green class and better results for the red and gray stages when the damage becomes more evident. Between the two classifications performed, the one that included more dates proved to be the best. Additionally, a comparison between the obtained classification and the results derived from the processing of images acquired by the well-known and widely used Sentinel-2 satellite highlighted the potential advantages and disadvantages of these increasingly prevalent commercial data.

Dr. Giulio Perda

Products of aerial photogrammetry for sustainable land management

internship at Fondazione Bruno Kessler (Trento)

Within the European project USAGE, digital methodologies are explored to represent the urban territory and provide a description that can be useful for local administrations in making decisions impacting environmental sustainability. Using nadiral and oblique aerial photographs of the Austrian city of Graz, a project partner, the urban environment is reconstructed in 3D, leveraging additional perspectives from oblique images to reconstruct building facades in narrow streets. The reconstructed point cloud is classified using the RF4PCC and PointTransformer artificial intelligence algorithms. The two methods are compared, and PointTransformer yields better classification, ensuring the extraction of roofs and building facades in the study area using a minimal training set. Roofs and facades are used to estimate solar irradiance through PV2.5D and VOSTOK, two-dimensional and three-dimensional methods, respectively. Both methods provide similar results for roofs throughout the year 2022. Additionally, data on the increase in irradiance due to facades is provided to assess the installation of panels on them. The result is supported by validation with data from the meteorological station at the University of Graz, located in the study area.

To provide a simplified and intuitive representation of the urban environment supporting the decision-making processes of local administrations, building models are automatically generated at two different levels of detail, LOD1.2 and LOD2.0, based on their ground footprints and the terrain elevation model. Future developments will enrich this representation with estimated irradiance data.