EUROGRAPHICS Workshop on Graphics and Cultural Heritage (2023)
A. Bucciero, B. Fanini, H. Graf, S. Pescarin, and S. Rizvic (Editors)

Poster

Project “Wall facing Automatic Image Identification Laboratory” – W.A.L.(L)

F. Buscemi[1], G. Gallo[2], M.Figuera[1], Y. Gholizade Atani[2], A. Lo Duca[3]

[1]CNR, Institute of Heritage Sciences, Catania, Italy
[2]Dipartimento di Matematica e Informatica, Università di Catania, Italy
[3]CNR, Istituto di Informatica e Telematica, Pisa, Italy

Abstract

The advantages of digitalization of cultural heritage artifacts go beyond the basic documentation of the archeological findings contexts and offer a tool to gain new scientific insights. W.A.L.(L) is an on-going project whose results show that the interdisciplinary collaboration between archeologists, data and computer scientists, carried on with rigorous methods of data collection, processing, organization and analysis may offer great opportunities for archeological data sharing and understanding.

CCS Concepts

• ***Applied computing*** $\rightarrow$ ***Computers in other domains;*** • ***Computing methodologies*** $\rightarrow$ ***Machine learning;***

1. Ancient architecture and the potential of quantitative analysis

The “Wall facing Automatic image identification Laboratory” - W.A.L.(L) project is a CNR funded Archaeological International Joint Laboratory. It is inspired by the topographical and surveying activity of the Archaeological Mission in Phaistos (Crete) of the University of Catania., in charge of the CNR-ISPC. The project is in line with recent interdisciplinary projects ([CM21], [Gro16], [Iov11]) demonstrating that digital methods are valuable tools for the archeological research well beyond their relevance for documentation. In particular, the W.A.L.(L) project is aimed at applying quantitative analysis and Machine Learning methods to ancient architecture and at creating a dedicated research infrastructure, based on open-source technology, according to the principles of Open Science.

Building materials have a great potential as an information tool of a historical, social and cultural nature. The challenge of the project is to extract archaeologically relevant features from three-dimensional digital data (digital models of wall facing stones of Pre-historical and Proto-historical period) and to make them searchable. Interdisciplinary collaboration among computer scientists and archeologists has identified significant quantitative characteristics of the models that can be evaluated with standard geometrical processing tools [MHWS19].

Some of the goals of the study are to: identify on a statistical basis building practices (methods of working and placing the stones); evaluate phenomena of continuity/change of building behavior, attributable to tradition, group identity, chronology; contribute to the definition of an intra-site relative chronology of the masonries; identify restoration patterns.

A dedicated web database allows the end user to query the walls through a user-friendly interface based on the Django framework [DJA]. Data will be open accessible at the conclusion of the project and may be, at this time, accessed upon credential request to the authors.

The elaboration of the logical model of the database has required an important effort on the conceptualization and semantic classification of data. The absence of databases specifically addressed to ancient architectural data has entailed a careful work on vocabularies. This is fundamental for communication between archaeologists in Crete, coming from different parts of the world.

2. Data, methods and results

2.1. Project scope and data sources

The results of the 2015-2018 excavation campaigns in Phaistos, with the identification of an entire phase of reoccupation of the Palace in the Sub-Minoan-Geometric period (11th-8th century BC), suggested to use some walls of this period as sample structures. Until recently these structures have been little investigated because the sumptuous Minoan phase (II Millennium) had, in preference, attracted the attention of scholars.

The research team, starting from 3D photogrammetric models, has created a training dataset of about 1,300 digital models of the facing part of stones. They belong to twelve walls dating from the Late Minoan IIIC (1200-1050 BC) to the entire Geometric period (8th century BC), and located in four Cretan archaeological

DOI: 10.2312/gch.20231181

sites (Phaistos, Aya Triada, Sissi, Anavlochos). See Fig.1 for an overview of the walls that have been considered in this study.

2.2. Feature extraction and automatic classific

The extraction of quantitative features from the 1.300 samples of virtual stones identified as significant by the archaeologist has been carried out with a suitable Python script [MHWS19]. The extracted information has been stored in csv format for processing with classification algorithms. The computed features are also integrated into the dedicated web database mentioned above. Quantitative estimate of stone features (dimensions, arrangement, orientation, position inside the wall, typology, degree of workmanship) has allowed the begin of some studies on ancient architectures through Machine Learning.

The application of automatic analysis methods in this context is challenging because of the characteristics of ancient architecture, especially that of the Pre-historic period. The poor predictability of the masonry, i.e. the uniqueness or extreme irregularity of each building element and of the walls as a whole, requires large training datasets, and careful selection and evaluation of the relevance of the quantitative features.

Some first and promising results have been achieved. In the automatic recognition of the types of unworked building materials (wedges and rubble stones), automatic classification algorithms have been tested. The best result has been obtained through the Random Forest [Bre01] classification, with an accuracy of 83.85%. The study has been complemented with the exploration of the features that are most relevant for “black box” automatic classifier ([Mol20]). It has been observed a good convergence between the features considered relevant by the algorithm and the qualitative features considered by the human expert when faced with the same classification task [GGL*23].

A video illustrating in more details the work-flow and the results of the project is at the URL: `https://wall.ispc.cnr.it/video/`.

2.3. Open data fruition

To be useful, data must be "findable", "accessible", "searchable" and "reusable". The W.A.L.(L) Project adheres to the principles of Open Science: open knowledge, open access, open publishing.

- All the software tools used in the Project are Open of Free Source: segmentation of the 3D models of the walls into individual stone facing elements has been done in Blender 3d;
- Machine Learning processing has been carried out with free Python libraries “pandas”vers 2.0.3 [PAN] and “scikit-learn” vers.1.2 [SCI];
- the Django framework [DJA23] has been adopted to orchestrate various modules of the project: from the import of csv data into the database, to the generation of data entry modules for its manual population. The resulting web interface allows the interrogation of digital resources as well as a collaborative process of data implementation by all the partners of the W.A.L.(L) Project.

2.4. Conclusions

Digital models of cultural heritage artifacts are becoming more and more available. It is evident that the advantages of digitalization go beyond the basic and offer a tool to gain new insights and support or disprove scientific hypotheses. The W.A.L.(L) project is within this frame: its results show that the interdisciplinary collaboration between archeologists, data and computer scientists, carried on with rigorous methods of data collection, processing, organization and analysis may offer opportunities for data sharing and understanding.

References

[Bre01] BREIMAN L.: Random forests. *Machine Learning 45* (2001), 5–32. doi:10.1023/A:1010933404324. 2

[CM21] CARAVALE A., MOSCATI P.: *La Bibliografia di Informatica Archeologica nella Cultura Digitale Degli Anni Novanta (30 anni di informatica archeologica - 1)*. All’Insegna del Giglio, Firenze, Italy, 2021. 1

[DJA] URL: www.djangoproject.com. 1

[GGL*23] GALLO G., GHOLIZADE Y., LEOTTA R., STANCO F., BUSCEMI F., FIGUERA M.: Feature relevance in classification of 3d stone from ancient wall structures. *ICIAP 2023, 4th International Workshop on Pattern Recognition for Cultural Heritage, Udine, Italy* (2023). 2

[Gro16] GROSSMAN L.: Reaching the point of no return: The computational revolution in archaeology. *Annual Review of Anthropology* (November 2016). doi:10.1146/annurev-anthro-102215-095946. 1

[Iov11] IOVITA R.: Shape variation in aterian tanged tools and the origins of projectile technology: a morphometric perspective on stone tool function. *PLOS ONE 12*, 6 (2011), 1–14. doi:10.1371/journal.pone.0029029. 1

[MHWS19] MARI J., H´ETROY-WHEELER F., SUBSOL G.: *Geometric and Topological Mesh Feature Extraction for 3D Shape Analysis*. 2019. 1, 2

[Mol20] MOLNAR C.: *Interpretable Machine Learning: A Guide for Making Black Box Models Explainable*. 2020. 2

[PAN] URL: pandas.pydata.org. 2

[SCI] URL: scikit-learn.org. 2

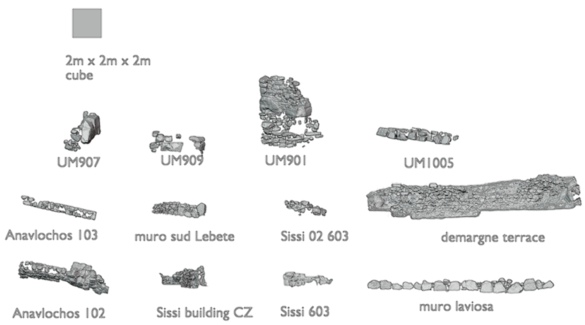

Figure 1: *Overview of the wall units that have been object of study for the W.A.L.(L) project.*

Proceedings published by Eurographics - The European Association for Computer Graphics.