POINT CLOUD SEGMENTATION AND FILTERING TO VERIFY THE GEOMETRIC GENESIS OF SIMPLE AND COMPOSED VAULTS.

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ABSTRACT:

This research work proposes a methodology to statistically determine the geometric configuration of a masonry cross vault. Within Cultural Heritage it is possible to find architectural elements with absent or scarce historical sources about design approach or construction techniques. The cross vault case study belongs to a partially destroyed vaulted system distributed along the aisles of ancient Assunta's Cathedral which is part of the Aragonese Castle on Ischia island, near Naples (Italy). Using photogrammetrical data acquisition, standard geometric analysis, numerical processes, computing and statistics this paper shows a method to objectively determine the geometric shape which best fits one of the existing Cathedral vault according to critical interpretation about stylistic and cultural contents linked to specific geographical and temporal contexts. This paper provides explanations, methods and objective calculation algorithms to find the best-fitting shape for a generic given point cloud and it is aimed at demonstrating the complementarity between descriptive geometry and algorithmic mathematical approaches. The final product of this multidisciplinary workflow is a 3D model deriving from the comparison between an ideal automatic model built thanks to the translation of traditional geometric rules in visual scripting language and an automatic model deriving from the mathematical analysis of survey data, curves and surface, of the architectural element. This experimentation generates 3D models to perform in-depth multidisciplinary tests and AR and VR applications to promote the communication of destroyed or inaccessible cultural heritage.

1. INTRODUCTION

Knowledge, preservation, communication and fruition are the main steps for Cultural Heritage valorisation. These steps require an interrelated analysis of different information thanks to integrated approaches. 3D surveys represent one of the main inputs for multidisciplinary analysis.

Documentation and conservation of Cultural Heritage is experiencing a strong innovation in linked primarily to the digitisation of information. (Bitelli, 2018)

Survey activity is the main tool to reconstruct the basic geometric structure of the design and construction process according to a Scan to HBIM approach.

However, objective data of an architectural work will always correspond to a series of subjective information linked to the human interpretation of the element. (Cianciani, 2015)

This contribution analyzes the geometric structure of a cross vault belonging to the partially destroyed original side aisle of the ancient Assunta's Cathedral on Ischia island. (Fig. 1 - 2)

A rigorous survey activity supports the comparison between an ideal geometric model and numerical model of a point cloud. The main goal of this work is to achieve a digital product aimed at conservation, enhancement and dissemination of this cultural heritage through VR and AR applications.

The absence of graphic and textual sources, diagnostic activity (thermography, coring works, etc.) and the presence of geometric inconsistencies probably caused by possible resetting interventions or possible structure deformations over the time, requires hypotheses about the constructive rules of this architectural element. Another goal is also to investigate unknown construction techniques. Therefore, numerous cross and longitudinal profiles have been extracted from the point cloud to understand the specific geometry of the selected vault. The goal is the correct interpretation and modeling of the arches

and surfaces that compose the vaults system of the original Cathedral's aisle. (Fig. 2)

Arches and surfaces have been used in many ways and applied to different composition styles over time in architectural heritage buildings. Sometimes their geometric and constructive layout has been recorded on historical treatises or sketches allowing to know the construction process.

However, in other cases there are no documents to objectively determine the geometry of historic buildings, opening a subjective and intuitive debate in order to define a coherent geometric configuration of a specific case study. (Samper et al., 2016)

Therefore, the goal of this contribution is to validate the interpretative hypothesis of the Cathedral's semi-destroyed vaulted system through mathematical best fit of the hypothesized surfaces that compose the element reducing as much as possible the operator arbitrariness.

However, in some cases, profile and section curves analysis involved in the genesis of a specific kind of vault is not sufficient and to create an accurate digital model it is necessary to know masonry structure, webbings, intrados and extrados single or double curvature or to have information about used materials.

These deficiencies complicate the recognition and interpretation of a simple vault or composed vault about its portions and spheroidal or cylindrical lunettes.

Structural analysis and conservative approaches require accurate models about the specific curvature of an architectural element.

In the field of cultural heritage communication, VR or AR applications need accurate models: sometimes it is necessary to project textures of frescoes and paintings or design artistic installations on curved surfaces.

Furthermore, the correct nature of a curved surface facilitates the element genesis and simplifies its 3D modeling according to

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