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Measure for participatory valorization of Cultural Heritage

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***Abstract* – The Italian territory is characterized by an extremely high number of Cultural goods. Knowledge and measurement of many of these Cultural Heritage is extremely difficult in relation to the complexity of surveys through traditional methodologies. The contribution proposes an original approach to the knowledge and measurement of Cultural Heritage based on a *social approach*, transforming the user as an actor of the procedures for the acquisition of raw data. The Heritage Go (HeGo) project is the platform for data acquisition and processing. The contribution, in addition to a description of the project, describes the first experiments focusing on the metric quality of the models obtained with SfM methodologies from raw data acquired by users.**

I. INTRODUCTION

Our territory is characterized by the presence of an extremely considerable number of Cultural Heritage: recent sources have surveyed these realities identifying 43 UNESCO sites, about 4000 museums, 240 archaeological sites and over 500 monumental complexes [1].

Many of these monuments, artefacts, archaeological sites are widely studied and known, but many of these objects, scattered throughout the territory, are difficult to access not only for users but in some cases also for scholars due to the lack of an adequate number of resources for the study of the minor of these.

Reason for this difficulty is undoubtedly to be found of the lack of attractiveness of some Cultural Heritage compared to others of greater fame and importance, but also for the lack of valid simplified methodologies of data acquisition (metric in the first place), which is fundamental to any process of Knowledge.

In order to try to find a solution to this problem, this contribution presents the first results of what has been defined as the Heritage Go (Hego) project. The project, sponsored by the three faculties of Lazio, Cassino, Roma Sapienza, Roma Tor Vergata. constitutes a partnership between different laboratories of the University of Cassino, each for its specific discipline: the DICeM_DART Laboratory (Data Acquisition and Survey); the DAEIMI_LIT Laboratory (Database and software development); the DLeF_LaRSA Laboratory (Archaeology).

The objective of the project is to find a possible solution to the problem of basic knowledge and the diffusion of Cultural Heritage present throughout the entire national territory and in particular for those realities that, as we have just said, are less studied and known.

All this in an open scientific process that grows and evolves in a dynamic way through the interaction between scientific structures and users, allowing new forms of disclosure and knowledge not only of raw data but also of all subsequent processing and analysis.

In detail, the project proposes the construction of a platform, a database, able to receive and catalogue raw data acquired by users and that use these data for the construction of 3D models of the different sites studied. All this in a process that, although highly automated and with minimal intervention by experts, it's able to return metrically validated data, usable for the first approaches of analysis of a cultural good.

II. CITIZEN AND SOCIAL SCIENCE

The Hego project uses logics that find their reason in Citizen Science.

The term *Citizen Science* or *participatory science* defines the active and conscious involvement and participation of people of different ages, backgrounds and social backgrounds in a scientific research activity like students, simple enthusiasts and amateur scientists, not included in academic facilities. *Citizen Science* can therefore be defined as "scientific activity conducted by members of the indistinct public in collaboration with scientists or under the direction of professional scientists and scientific institutions" [2]. This is a voluntary collaboration aimed at collecting and analysing data, developing knowledge and broadening the horizons of application of science as conceived up to about a decade ago. The most revolutionary aspect of *Citizen Science* it's, however, the paradigm shift, which leads scientific research to a factor of inclusion and participation, ultimately *democratization* of knowledge for the benefit of the population.

In order to improve the knowledge of Cultural Heritage, the HeGo project is based on the belief that through a high degree of involvement it is possible to improve the level of dissemination and at the same time to acquire information about the large number of goods present on the national territory.

Hence the idea to make a *social platform* able to link the needs of different stakeholders involved in Cultural Heritage issues using a specific methodology used to create a wide involvement of users.

In identifying the most effective technique for involving users, the marketing proposes logics of interaction between goods and users that focus on the creation of an experience linked to the purchase. Among the forms of involvement, the methods with the best impact are based on forms of interaction linked to the game or what is called *Gamification*.

A game is an interactive, goal-oriented activity, with an active agent against whom to act, in which players can interact with other participants [3].

Gamification is defined as approaches that are based on the use of mechanics and playful dynamics within non-gaming contexts.

The literature [4] shows how the correct use of gamification can shift a user's behaviour from a point A (personal sphere of interest) to a point B (sphere of collective interest) or that through the lever of the game it is possible to ensure interaction and user participation in the process, with levels of interest much higher than the classic dynamics related to unidirectional administration.

Games are a very simple way to guarantee the interest of the public. People are intrinsically interested in the games, as shown by the statistics: 3 billion hours a week are gamed by the users. The practical and ludic approach means that a player is not obliged to understand the complicated scientific theories behind the puzzle. This fact allows to exploit the same technique for data acquisition also in highly complex disciplines such as mathematics, physics or medicine.

Fig. 1 Examples of gamification

The task of the scholar is to define a process that transforms part of the scientific problem into a game.

The game simply defines the tools that a citizen scientist can use in the play phase.

All this without the user having the knowledge to participate in a research, in a process *Win-Win*: the user wins because he plays and obtains results and a certain score; the scholar wins because he acquires useful data for the research.

III. THE HEGO PROJECT

The HeGO-HeritageGO project is aimed at the enhancement and "socialization" of Cultural Heritage and pursues an ambitious goal: to experiment with a gamification procedure that guarantees a wide use of Cultural Heritage by unqualified users in a model of social interaction, exploiting existing telecommunication infrastructures and digital tools of common use (smartphone, digital cameras, ipad etc.) through a specific App.

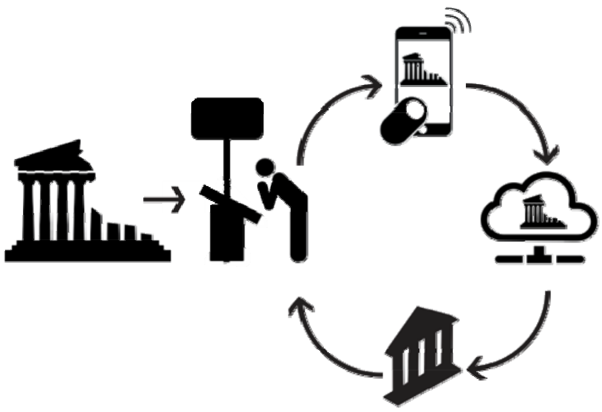

Fig. 2 The HeGo Project

HeGo sees the involvement, with specific roles and tasks of different actors: the administrations (municipalities, museums, superintendents who can make their Cultural Heritage available and who could immediately see the presence of users increase); scholars (archaeologists, historians, architects, restorers who could in this way increase the level of dissemination of their research) and users (both in the role of users of Cultural Heritage, and in the role of direct actors of the data acquiring operations). All this under the guidance of the survey scholars who have the role of structuring the platform and producing the basic elaborations from the data acquired by users.

To do this, it was necessary to structure the platform that consists of a physical component (the Totem) and a digital database whose interface it's an APP.

The objective of the game is simple: the Administration that manages a Cultural Heritage enters the game by acquiring a Totem that is located near the site/monument; the system shall attribute a value to the Cultural Heritage which is inversely proportional to its reputation; the user locates the Cultural Heritage, takes pictures and sends them to the platform; digital photos and their uploads into the system involve users by assigning scores for both the number and quality of the Cultural Heritage photographed; sending photographs allows to increase the score (and therefore the achievement of goals and rewards) by putting users in competition with each other; the main involvement is the *search* on the territory of the various sites linked to the game.

Following a path, the player will encounter the Cultural Heritage, and photographing it will provide data for the realization of 3D models with SfM methods (and immediately available online and useful for knowledge and valorisation).

Users receive a score depending on the number of photos that the system accepts and uses in creating 3d models, which generates a dynamic ranking.

IV. THE APP

All this through an App that works in mobile or desktop mode and currently in alpha version.

Fig. 3 App. Screenshot

By logging in to the App it’s possible to access to the game and send photos, view other players' uploads, see the rank of the participants in the game, get information about the Cultural Heritage and know the level of knowledge of the specific good.

All this is managed and controlled by a series of dedicated administration tools, that catalogue the picture and easily permit to make, automatically, 3D models.

V. THE SFM TECHNIQUE

With the term SfM (Structure from Motion) we mean the technique of operations carried out in a digital environment with which, starting from raster images, it’s possible to make a three-dimensional model.

SfM provides a non-invasive approach for the structure, without the direct interaction between the structure and the operator. The use is accurate as only qualitative considerations are needed. It is fast enough to respond to the monument's immediate management needs [5]. This approach exploits the computational potential of digital hardware and constitutes the natural evolution of photogrammetry, that is the “science that allows to obtain reliable information about physical objects and the surrounding environment through recording, measurement and interpretation processes of photographic and digital images formed by radiant electromagnetic energy and other physical phenomena" [6].

Photogrammetry is that discipline, falling within the scope of indirect instrumental relief, through which it is possible to reconstruct the geometric form of a territorial, urban or architectural context, through one or more photographic images. K. B. Atkinson defines it as "science, and art, to determine the size and shape of objects as a result of analysing images recorded on films or electronic media" [7].

The term SfM was born to define an automated three-dimensional modelling method based on photogrammetric and stereo-photogrammetric surveying systems performed through digital capture and processing of photographic sets. The difference between the two approaches is found in their very logical structure: the first one refers to the set of constructions and mathematical-geometric algorithms that lead from photography to measurement and then to drawing; the second one refers to the methodological process that leads from photography to the finished 3D model. Precisely because of the simplification of data acquisition and modelling operations, SfM methods are now commonly used in the knowledge of Cultural Heritage to support the traditional acquisition phases. Until now used by technicians specialized in the phases of acquisition and modelling, in this specific experimentation the project experiments the use of these methodologies starting from photographic images taken by simulating a non-skilled and qualified user, verifying the results obtained in terms of metric quality of the model returned exclusively in relation to the large number of photographs obtainable from a social process or to quantitative aspects only.

The software used in the experiment was Agisoft Photoscan. This software works by automatically recognizing homologous points in the various photographs and automatically recognized by means of specific algorithms. Through reverse perspective construction procedures, the software it’s able to proceed, first of all, aligning the photographs with each other, producing a cloud of reference points and once the entire set has been aligned, using classic stereophotogrammetry formulas, produces a cloud of dense points. From the point cloud obtained, through an interpolation operation it is possible to automatically generate 3D mesh surfaces on which the software projects the photographs, generating a textured 3D mesh model.

A typical problem of this methodology is the inability to return scaled models except for the intervention of an operator in the definition of some reference measurements.

In order to make automatic this crucial step in the metric definition of the model, and in an attempt to limit to a minimum the intervention of qualified technicians on the sites under study, the HeGo project has provided a support tool aimed at obtaining automatic scaled models.

This tool, defined as the Totem, it's equipped with targets that can be recognized by the software and it allows to measure the model without the help of additional metric references.

VI. THE TOTEM

In addition to the Informatics interface, the project provides for the existence of a physical Totem on the site included in the game.

The Totem is the scientific heart of the project and for this reason it has been the subject of a national patent.

The Totem works with a very low level of interaction with the environment (that it's essential for its inclusion in a protected context such as those typical of the Cultural Heritage) and without the help of procedures that require the presence of an expert/study for installation.

The structure consists of a base for the support of an information panel that supports a polyhedral-shaped structure (horizontal section octagonal) used for the positioning of targets.

Fig. 4 The totem and detail of automatic target recognition

The structure for the targets is realized with a numerical control machine so that you can know with certainty the distance between the face centre and targets, this information is fundamental to the measurement of the models.

The totem is equipped with an antenna and repeater of wireless signal that guarantee a temporary connection to users registered in the game and necessary for the upload of images.

As soon as the totem becomes part of the photographs, the system automatically recognizes the targets. Given the known distance between the mutual position of the targets, automatically measuring the obtained models it's possible.

This low-impact system (in addition to providing access to the application and database through a QR-code), ensures that the well-known limit of SfM software is exceeded or that, without a known measure, it is impossible to scale the models obtained from the software.

VII. ACQUISITION DATA PROCEDURE

In order to evaluate the effectiveness of the data return procedure, some campaigns were simulated to capture photographs taken with different technologies: mobile phones, mobile phones, digital SLR cameras, action cameras, tablet.

Fig. 5 Point cloud realized by different instruments

Subject of study, the archaeological area of Cassino and, in particular, the Theatre area.

Each photo session focused on different points in the vast theatrical area, with shots taken in random and automatic mode, which simulated the operation of a user without any specific experience.

The files were individually processed to simulate the different acquisition days and then reassembled together to form a single point cloud.

Through a comparison with the point cloud acquired with 3d Laser Scanner, the level of uncertainty of the model obtained from the photographic images was evaluated. The model scaled with the help of self-recognized targets has led to a promising result, particularly in the areas where more than one photograph has been taken.

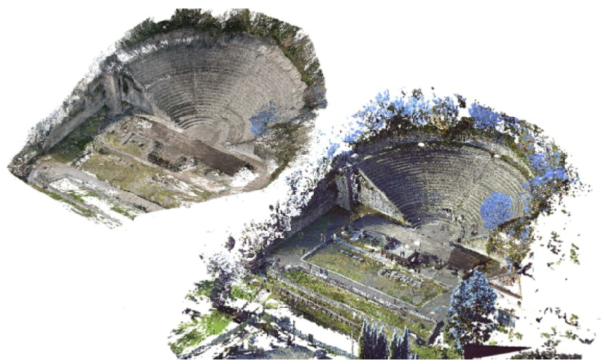

Fig. 6 Comparison of laser scanner and SfM point clouds

VIII. VALIDATION OF 3D MODELS

To verify the metric quality of the models, make from the methodology described above, some tests have been carried out.

A. Detail of a portion of the theatre

The first test was the analysis of the level of detail and quality of 3d model mapping. The object of the test is a portion of the theatre and in specific portion of the wall on the left side of the area, where it is possible to re-read various weft walls, some restoration works and a portion of frescoed.

The analysis provided a chromatic and point density result that was quite respectful, allowing a thorough rereading of all the structural elements that define the stratigraphy of the wall.

In particular, the large number of photographic images have given back a model of high detail through the reading of which it is possible to reread and measure with extreme precision the characteristics of the wall.

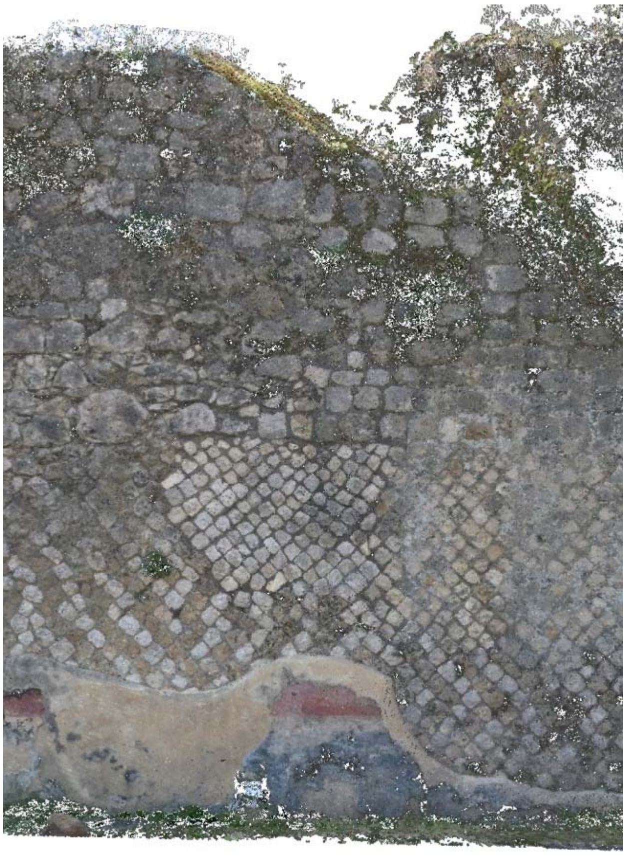

Fig. 7 Detail of the point cloud

B. Entry Scale Faculty of Engineering Faculty

In order to evaluate the metric quality of the models measured by the Totem, it’s been made a model of a geometrically complex structure present in the atrium of the Faculty of Engineering of the University of Cassino.

The object studied is a ramp staircase and curved landings made of concrete. The totem was positioned 5 meters from the staircase and for the realization of the photographs a large series of shots were taken following the natural path offered by the staircase.

The objective was to create a model capable of describing all the ramps and assessing the model's compliance with reality, previously subject to a detailed direct survey.

The result was very promising, in particular because of its ability to describe with extreme precision the individual steps (degree and subgrade) while maintaining an appropriate level of precision. In order to evaluate the system's ability not to undergo deformations with the removal of the totem from the place where it was triggered, attention was focused on some median points of the different ramps, placed at increasing distance from the totem and their correspondence to the metric survey was verified.

The result in numerical terms was certainly interesting, except for some areas that were not defined, due to reflections that affected the shooting result. In general, no significant deformations are noticeable and on the selected points it is possible to determine how the error falls in +/- 5% regardless of the distance from the totem.

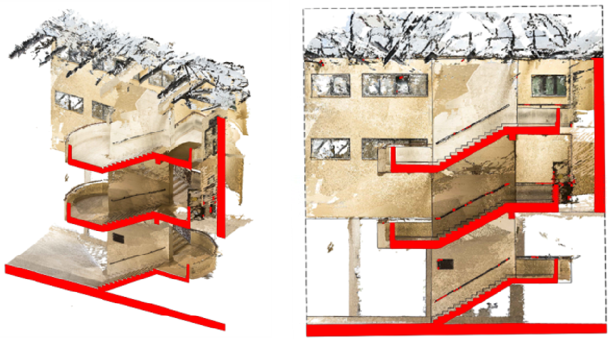

Fig. 8 Detail of the point cloud model and section of the stairs

IX. CONCLUSIONS

Science is commonly considered as an activity of an exclusive club, which takes place behind the closed doors of the laboratory. HeGo challenges this notion by opening the doors of the laboratory and inviting people from all areas of origin to contribute to the resolution of the problems related to data acquisition.

The novelty is the opportunity to structure a methodology able to produce scientific data without the help of qualified technicians, that work only on the preparatory phase.

At the same time, thanks to the inexpensiveness of the method used, the study opens new scenarios for the knowledge and research of all those realities scattered throughout the territory, so far little studied, or valued for the high costs of an analysis carried out with traditional methods.

The results of the first pilot trial validate the process and its consistency in scientific terms and give hope for possible developments. This is evident in the quality of the results obtained, compared with a traditional survey and in it's appropriate to underline that the totem is a tool with excellent potential for overcoming the limits typical of SfM methods. In fact, although experiments are still in progress to define the real potentiality and criticality, and although aware of the risk of uncertainty linked to the small distance between the targets of the totem, the result gives hope on the possible use of this element that has in its structural simplicity the main characteristic and that makes it easy to fit into protected contexts such as those typical of Cultural Heritage.

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