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HeritageGO (HeGO): A Social Media Based Project for Cultural Heritage Valorization

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ABSTRACT

In this digital era, one of the main challenge faced by cultural heritage is digitization. This challenge is particularly hard in countries like Italy, characterized by an extremely high number of Cultural goods. Data acquisition for many of these Cultural Heritage is extremely difficult, because of the complexity of surveys through traditional methodologies. In this paper, we propose a novel approach to the knowledge and data acquisition Cultural Heritage based on social media. The proposed approach, named "HeritageGo" (HeGo), transforms the user as an actor of the procedures for the acquisition of raw data. The paper also describes the first experiments focusing on the metric quality of the models obtained with SfM methodologies from raw data acquired by users.

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1 INTRODUCTION

Italy is characterized by the presence of a considerable Cultural Heritage: recent sources have surveyed these realities identifying 43 UNESCO sites, about 4000 museums, 240 archaeological sites and over 500 monumental complexes [11]. Many of these monuments, artefacts and 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 adequate resources for studying even the less famous among them. Most probably, the reason for this difficulty is 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). In order to try to solve this problem, this contribution presents the first results of the HeritageGo (HeGo) project. The project constitutes a partnership by different Italian and Spanish Universities: University of Cassino and Southern Latium, Sapienza University of Rome, "Federico II" University of Naples, Marche Polytechnic University, University of Alcalá.

The project aims to enhance the dissemination of Cultural Heritage throughout the entire Italian territory and in particular for those realities that, as we have just said, are less studied and known. This objective is achieved by fostering a scientific process that grows and evolves in a dynamic way through the interaction between scientific structures and users. This process allows new forms of disclosure and knowledge not only of raw data but also of all subsequent processing and analysis phases. In detail, the project proposes the construction of a platform able to receive and catalogue raw data acquired by users. The acquired data are then used for the construction of 3D models of the different sites studied. It is worth noting that although highly automated and with minimal intervention by experts, this process returns metrically validated data, that can be used for the first analysis of any cultural good.

Finally, since, currently Artificial Intelligence (AI) and Pattern Recognition (PR) technologies are already employed in the field of cultural heritage [2, 4–6], a further objective of the project will be to acquire data (images) for the training of deep neural networks,

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that although have proved to very effective, typically need massive training data.

2 CITIZENS AND SOCIAL SCIENCE

The HeGo project is based on the concept of 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 status in a scientific research activity like students, simple enthusiasts and amateur scientists, not included in academic facilities. Citizen Science can, therefore, be defined as "a scientific activity conducted by members of the indistinct public in collaboration with scientists or under the direction of professional scientists and scientific institutions" [7]. This is a voluntary collaboration aimed at collecting and analyzing 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 is, 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 a large number of goods present on the national territory. Thus, the rationale of the project is to build a *social platform* able to link the needs of different Cultural Heritage stakeholders, by using an approach that allows a wide involvement of users. In marketing science, the most effective techniques for involving users are based on the interaction between the good to sell and the users, focused on experiences related to the purchase of the good. Among these forms of involvement, the most effective ones are those based on some forms of 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]. As for the gamification, it denotes those approaches based on the use of mechanics and playful dynamics within non-gaming contexts. The literature [8, 10] shows how the correct use of gamification can shift a user's behavior from a point A (personal sphere of interest) to a point B (sphere of collective interest) or that by using a game it is possible to ensure interaction and user participation in a given process, with levels of interest much higher than the classic dynamics related too unidirectional administration.

Games represent a very simple and effective way to attract the attention of a wide public. People are intrinsically interested in the games, as shown by the statistics: 3 billion hours a week are gamed by the users. This approach implies that a player is not obliged to understand the complicated scientific theories behind the puzzle. This fact allows the same technique for data acquisition to be exploited also in highly complex disciplines such as mathematics, physics or medicine. In this framework, 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. All this without the user being aware to participate in a research activity, in a Win-Win process: the user wins because he plays and obtains some results and a score; the scholar wins because he acquires useful data for its research.

Figure 1: Examples of gamification.

3 THE HEGO PROJECT

The HeGO - HeritageGO project is aimed at the enhancement and "socialization" of Cultural Heritage by using a gamification-based approach. This approach will allow a wide audience of unqualified users(citizens) to have a better experience with Cultural Heritage, in a model of social interaction, exploiting existing telecommunication infrastructures and digital tools of common use (smartphone, digital cameras, iPad etc.) by using an app specifically devised. HeGo involves different actors with specific roles and tasks: the

Figure 2: The HeGo Project

administrations (municipalities, museums, superintendents which can make their Cultural Heritage available and which 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 processing the data acquired by the involved users. The implemented platform consists of two main components: a physical one component (the Totem) and a digital database whose interface is an app.

The objective of the game is simple: the manager of a given monument enters the game by acquiring a Totem that is located near the monument; the system attributes a value to a given Cultural Heritage site which is inversely proportional to its reputation; the user locates the monument, takes pictures and sends them to the platform; the number and quality of photos sent to the platform determines the score assigned to the user; then users will compete with each other to increase their scores (and therefore the achievement of goals and rewards), by searching for the best sites involved in the game, i.e. those with less reputation, that as mentioned above, guarantees higher scores. In this way, along a given path, the player will encounter the sites involved in the game Cultural Heritage, and photographing them he will provide data for the realization of 3D models with SfM methods, that will be immediately available online and useful for a better knowledge and valorisation of the involved sites, especially for the last famous ones. 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.

3.1 The app

As for the developed app, it can work both in mobile or desktop mode and is currently in an alpha version. Through the app, after a

Figure 3: App's Screenshots.

log-in procedure, it is possible to send photos, view other players' uploads, see the rank of the participants in the game, get information about the Cultural Heritage sites involved in the game in the neighborhood, and to search for a specific involved site. All this is managed and controlled by a series of dedicated administration tools, that catalogue the pictures sent by the users and allow 3D models to be easily built.

3.2 The SFM Technique

Structure from motion (SfM) is a photogrammetric range imaging technique that permit the estimation of three-di-mensional structures from a sequence of raster images. SfM provides a non-invasive approach for the structure, without the direct interaction between the structure to be modeled and the operator and its use needs only qualitative considerations. Moreover, it is fast enough to respond to the monument's immediate management needs [9]. This approach exploits the computational potential of digital hardware and represents the natural evolution of photogrammetry, which is defined as: "the science that allows obtaining 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" [12].

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, both in urban and architectural contexts, 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 the analysis of images recorded on films or electronic media" [1].

The term SfM was born to define an automated three-dimensional modeling method based on photogrammetric and stereo-photogrammetric surveying systems performed through digital capture and processing of photographic sets. The difference between the two approaches lies in their logical structure: the first one refers to the set of constructions and mathematical-geometric algorithms that lead from photography to measurement and then to the drawing; the second one refers to the methodological process that leads from photography to the final 3D model. Because of the simplification of data acquisition and modeling operations, SfM methods are now commonly used in the Cultural Heritage field to support the traditional acquisition phases. Up to date, SfM has been used by technicians specialized in the phases of acquisition and modeling, whereas in our project this methodology will be applied to images taken by non-skilled users. As for the results the achieved results, they will be evaluated taking into account the metric quality of the model returned.

The software used in the experiment was Agisoft Photoscan. This software works by automatically recognizing homologous points in the various photographs which are automatically recognized by means of specific algorithms. Through reverse perspective construction procedures, the software is 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 automatically scaled models. This tool, defined as the Totem, is equipped with targets that can be recognized by the software and that allows the model to be measured without the help of additional metric references.

3.3 The totem

As mentioned above, in addition to the software interface, the project also includes a physical a Totem, to be placed 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 (this is an essential requirement for its inclusion in a protected context such as those typical of Cultural Heritage sites) and without the help of procedures that require the presence of an expert or of a study for its 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 the targets (see Figure 4). The structure for

Figure 4: The Totem and details of the automatic target recognition.

the targets is realized with a numerical control machine so that you can know with certainty the distance between the face centre and the targets, this information is fundamental to the measurement of the models. The totem is equipped with an antenna and repeater of a wireless signal that guarantees a temporary connection to the registered game users and the upload of images. When a given a totem is part of a given photograph, the system is able to automatically recognize the related targets. Since the distance between the targets and the totem is known, it is possible to automatically measure the objects in the photograph. In such a way, it is possible to overcome the well-known limit of SfM software: without a known measure, it is impossible to scale the models obtained from the software. This low-impact system also provides access to the application and the database through a QR-code.

3.4 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, digital SLR cameras, action cameras and tablets.

The subject of our study has been the archaeological area of Cassino and, in particular, the Theater 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 to form a single point cloud.

Through a comparison with the point cloud acquired with a 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 was taken.

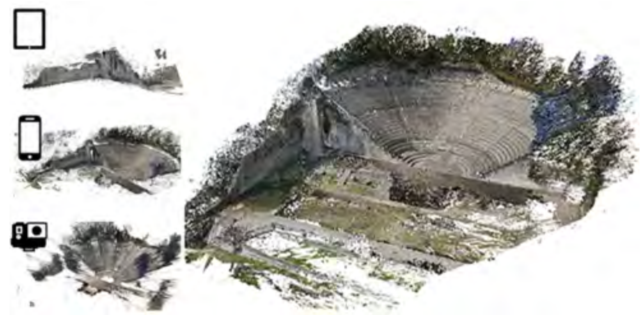

Figure 5: An example of point cloud realized by different instruments.

4 VALIDATION OF 3D MODELS

To verify the metric quality of the models, made by using the methodology described above, some tests have been carried out. These tests are detailed in the following subsections.

4.1 Detail of a portion of the theater

The first test was performed to analyze the level of detail and the quality of the 3D model mapping. The object of the test was a portion of the theater and a specific portion of the wall on the left side of the area, where it is possible to see various weft walls, some restoration works and a portion of a frescoed (see Figure 6). The analysis provided a chromatic and point density result that was satisfactory, allowing the view of all the structural elements that define the stratigraphy of the wall. In particular, the large number of photographic images have given back a very detailed model which allowed us to measure with extreme precision the characteristics of the wall.

4.2 Cassino Faculty Staircase

In order to evaluate the metric quality of the models measured by the Totem, itâĂŹs 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 (see Figure 7). 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 the real structure, 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 were noticeable and on the

Figure 6: Detail of the point cloud of the theater wall.

selected points it was possible to determine an error that falls in +/- 5% range regardless of the distance from the totem.

Figure 7: Detail of the point cloud of the stairs.

5 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 bode well for future developments. This is evident in the quality of the results obtained, compared with a traditional survey. Moreover, it is worth noting 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 we are aware of the risk of uncertainty related to the small distance between the targets of the totem, these preliminary results confirm that the effectiveness of our approach. Finally, is also worth noting that the structural simplicity of the proposed methodology makes it easy to fit into protected contexts such as those typical of Cultural Heritage sites.

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