PetroAdvisor: A Volunteer-based Information System for Collecting and Rating Petroglyph Data

Vincenzo Deufemia, Luca Paolino, Giuseppe Polese
DISTRA MIT
University of Salerno
84084 Fisciano (SA), Italy
{deufemia,lpaolino,gpolese}@unisa.it

Viviana Mascardi
DIBRIS
University of Genoa
16146 Genova, Italy
mascardi@unige.it

Henry de Lumley
Laboratoire Départemental de Préhistoire du Lazaret
Parc de la villa La Côte, 33 Bis Boulevard Franck-Pilatte
06300 Nice, France
lazaret@lazaret.unice.fr

Abstract

In this paper we exploit a volunteer-based information paradigm for archaeological aims. In particular, we present PetroAdvisor, a system supporting several fundamental activities to digitally preserve petroglyph sites. The system also uses a rewarding strategy in order to stimulate people participation to the project, so that those entering useful information gain free archaeological data, tips on excursions and tours, opinions and rating from previous tourists, and so forth. User provided information typically consists of petroglyph pictures, descriptions, and several useful metadata, such as geo-referenced information, petroglyph contours, and so forth, empowering the work of the archaeologists, and enabling them to tackle technology shortfalls.

1. Introduction

In the last years, the World Wide Web has been used as a means to stimulate knowledge sharing and collaborative work, also letting people launch new models for developing services. This paradigm is generally referred to as "crowd" followed by a term identifying the aim of the service, e.g., crowdsourcing and crowdfunding. Moreover, a crowd service permits to gain information, money, or other services by leveraging the strength of the participating web community.

The World Wide Web has become one of the most powerful medium to start collaborations and to tackle problems that would otherwise be simply unmanageable. Nowadays, there are already meaningful examples of services provided by means of people combining their resources on the Web. These include the world's largest knowledge base Wikipedia[1], several complementary services for GPS-assisted navigation, such as Waze[2], and the emergency coordination platform Ushahidi-Haiti, which has been used to coordinate disaster response after the 2010 Haiti earthquake [14]. This new way of providing services is commonly referred to as *crowdsourcing* [9, 16], and it may be adapted to gather information while solving real problems in several application domains. One of the problems that may arise in crowdsourcing is due to possible conflicts among the data provided by the crowd. Moreover, there are contexts in which few people have the knowledge necessary to provide reliable data. As an example, this happens in the context of geographic information, where the process of gathering information from users is known as *volunteered geographic information* (VGI) [12].

The aim of this work is to exploit the volunteered geographic information paradigm for several archaeology activities. In particular, we address issues related to the exploration of archaeological sites, in order to derive a complete map of carvings, and digitally capture their images. Indeed, rock carvings represent an invaluable cultural and natural heritage, since they are often located in wonderful natural sites and represent an irreplaceable resource for understanding our history [6, 11]. Unfortunately, they are constantly exposed to weathering and vandalism, and it is up to hu-

[1] https://www.wikipedia.org
[2] https://www.waze.com

manity to preserve them for future generations [2]. Moreover, site exploration and carving cataloguing is a complex and expensive work, which cannot always be completely supported only by domain experts, such as the archaeologists. For this reason, VGI appears to be a promising road to explore [1]. In fact, the growing will of people to participate in this kind of projects, together with the capillarity of smartphones, tablets, and wireless connections promises to increase the possibility of having fully mapped sites [10].

In this paper, we present PetroAdvisor, a system supporting archaeologists in the digital preservation of petroglyph sites. In particular, the user provided information gathered by PetroAdvisor consists of petroglyph pictures, their contours, descriptions, comments, ratings, geo-referenced information, and so on. This way of collecting data not only reduces the necessity of man power, but it also allows archaeologists to tackle several technology shortfalls, such as the automatic segmentation and identification of petroglyphs within pictures [27].

However, in order for a VGI-based strategy to be successful, it is necessary to stimulate the participation of people in the data collection process. To this end, we use a rewarding strategy based on a "do ut des": users entering useful information gain free tourist services, e.g., archaeological data, tips on excursions and tours, opinions and rating from previous tourists.

Finally, the main objectives of PetroAdvisor are (i) to map, collect, and analyze carving data for digitally preserving petroglyphs, also yielding new research opportunities, (ii) to collect user provided information useful for automating petroglyph recognition, and (iii) to reward tourists with information guiding them during their visits to petroglyph sites.

The remainder of the paper is organized as follows. Section 2 introduces background information on rock art archaeology and provides motivations of this research. Successively, Section 3 shows some details about PetroAdvisor system design and architecture, with particular emphasis on the actors and their functionalities. Some examples of usage scenarios from both user and archaeologist points of view are described in Section 4. Section 5 provides a discussion of works related to the proposed system. Finally, conclusion and future works end the paper in Section 6.

2. Context and Motivations

Our work falls in the domain of rock art archaeology, where we worked with prehistorian archaeologists involved in the study of rock carving sites. In what follows we introduce basic knowledge about rock art and the motivations of this work.

2.1. Rock Art Archaeology

Rock art is a term coined in archaeology for indicating any human made markings carved on natural stones [4]. Most of the symbols concerning rock art are represented through petroglyphs, which are created by removing parts of a rock surface by incising, picking, carving, and abrading. They are among the oldest forms of art known to humans. Indeed, although early petroglyphs have traditionally been related to the appearance of modern humans in Europe, recent work has shown that they were created much earlier, that is, about 77,000 years ago in South Africa [15].

Usually the archaeologists working on a rock art site collect petroglyphs, classify them based on shape, and define dictionaries. Although it is not possible to give precise interpretations to petroglyphs, archaeologists have proposed many theories to explain their meaning, e.g., astronomical, cultural, or religious [26]. For example, Figure 1(a) and 1(b) show the pictures of two petroglyphs interpreted as a Christ [2] and the stellar cluster of Pleiades [11], respectively, while Figure depicts a digitalized relief interpreted as a priest making water spout from the water basin [6].

In order to digitally preserve, study, and interpret these artifacts, the archaeologists have created repositories containing heterogeneous information, like pictures, 3D images, textual descriptions, GPS coordinates, black and white reliefs, and so on. The exponential growth of these repositories and the high dimensionality of the stored data challenged rock art archaeologists to make deep analysis on them [8]. However, such analysis would never be complete without the contributions of volunteers, due to the amount of necessary work, and to technological limits, especially in the image processing domain. Indeed, although in the recent years several image recognition approaches have been proposed for automating the segmentation and classification of petroglyphs [7, 23, 27], their accuracy is not satisfactory.

To witness the relevance of the above mentioned problems, the European Community, together with other funding agencies, are financially supporting several research projects in this domain, such as Prehistoric Rock Art Trail[3] and 3D-Pitoti[4]. Among them, the IndianaMAS project [20], supported by Italian Minister of Education, involving our computer science research groups from Universities of Genoa and Salerno, together with archeologists from Laboratoire dpartemental de Prhistoire du Lazaret in Nice and from the Italian Superintendence of Cultural Heritage. The project aims to promote the awareness and the preservation of rock art, and to support archaeologists in their investigation activities. To this end, we are developing a platform that integrates and complements the techniques usually adopted to preserve cultural heritage sites. The plat-

[3] http://www.prehistour.eu
[4] http://3d-pitoti.eu/

form exploits ontologies to provide a shared and human-readable representation of the application domain [13], intelligent software agents to analyze the digital objects analysis and to perform reasoning and comparison activities on them [17], together with standard tools and technologies for Digital Libraries to manage and share digital objects. IndianaMAS provides the means to organize and structure petroglyph data in a standard way, supplying domain experts with facilities for issuing complex queries on the data repositories, making assumptions about the lifestyle of ancient people.

2.2. Motivations

Archaeologists and interested tourists frequently visit prehistoric rock art sites. By exploiting the advances in digital photography they can examine and investigate the petroglyphs without traveling, e.g., by highlighting the petroglyphs in the image and analyzing their locations, sizes, and orientations.

Unfortunately, there is no robust, automatic segmentation algorithm capable of determining the exact shapes and spatial locations of petroglyphs from rock art pictures [27]. In particular, the exact boundaries of petroglyphs are hard to identify also due to the direction of the light [23]. Therefore, rather than solely relying on developing new and better algorithms to handle such tasks, we propose to exploit volunteered-based solutions, so as to benefit from the contributions of an external community of people. In particular, with respect to petroglyph segmentation, we ask humans to trace the petroglyph contour by means of a touch-screen. This allows us to determine the exact shapes and spatial positions of petroglyphs in pictures, and to successively classify them based on their shapes, which enables retrieving similar petroglyphs from different archives.

Another limitation in the study of petroglyphs comes from the existence of many different repositories, even for a single rock art site. As an example, the Bicknells legacy collection and the ADEVREPAM database are two repositories of Mt. Bego petroglyph site. Thus, in order to support archaeologists in the study of correlations between petroglyphs, it is necessary to create a centralized repository storing all information about rock art sites. Such a repository should contain information provided by archaeologists, like interpretations and reliefs, and those provided by tourists, like pictures and comments.

Finally, in order to motivate the participation of tourists to the previous tasks, it is necessary to implement rewarding services, such as providing them with means for calculating the most appealing visiting paths.

3. PetroAdvisor System Design

In this section we present the PetroAdvisor system design. First of all, we identify the actors, namely the users interacting with the system, including their roles. Then, we present a set of system functionalities defined based on the above mentioned issues, and on archeologist suggestions. Finally, we provide details of the PetroAdvisor architecture. In particular, we show the layers and the modular parts of the system.

3.1. Actors and Functional Requirements

During the requirement analysis phase performed with the archaeologist assistance, we identified three user categories: *Generic User*, *Archaeologist*, and *Moderator*. In the following, we describe each category together with its functional requirements.

The *Generic User* represents the majority of the people who will use the system. A user adds new pictures upon finding petroglyphs during walks, looks for descriptions about already managed petroglyphs, adds comments, and generates new itineraries when planning the site visit. Moreover, s/he should be able to communicate with other users, exchanging information. As a result, we identified the following *User Functional Requirements* (UFRs):

- UFR1: inserting a new picture
- UFR2: showing petroglyph information
- UFR3: adding comments to petroglyphs
- UFR4: rating petroglyphs
- UFR5: searching petroglyphs through custom queries
- UFR6: managing itineraries.

The user's comments contain information about the experience they had during the visit of the archaeologic site, their opinions about the beauty of the photographed petroglyphs, and further details that can foster or discourage other users to visit the site. Such comments are also summarized by the user with a rate, in the range [1-5], for the quality and the beauty of the petroglyph.

The second system actor is the *Archaeologist*. S/he is in charge of verifying the quality of the user provided data, and of making them available to *Generic Users*. To this end, other than the previous UFRs, we identified the following additional requirements (AFRs):

- AFR1: creating new petroglyphs
- AFR2: updating petroglyph information
- AFR3: writing comments

(a) (b) (c)

Figure 1. The picture of a petroglyph supposed to represent a Christ (a) [2], a picture interpreted as the stellar cluster of the Pleiades (b) [11], and the relief depicting priests making water spout from the rock (c) [6]

- AFR4: identifying territories to explore.

The involvement of users in the data acquisition process requires an actor in charge for monitoring user behavior and the quality of their contributions. For this reason, we introduced the role *Moderator*, whose task is to control the provided information, and to manage user accesses. More specifically, for the moderator we identified the following requirements (MFRs):

- MFR1: managing users
- MFR2: removing comments
- MFR3: managing discussion groups
- MFR4: removing pictures.

3.2. Architecture

Figure 2 shows the web service-based PetroAdvisor architecture. It consists of some third-party software managing communication and development, a web service agent and manager handling requests and responses, an authentication module, two specific interfaces: one for generic users and another for archaeologists, several modules for managing requests, and a database storing information regarding the digital objects.

Third-party software. Apache Tomcat is a popular application server. Its native support for the SOA architecture makes it appealing for our purposes.

Less popular is the Titanium SDK used for building the Titanium Layer[5]. In particular, Appcelerator Titanium is a platform for developing mobile applications based on the Eclipse SDK. Titanium supports the development of applications for iPhone, Android, iPad, and BlackBerry. One of the most interesting features is the ability to develop mobile applications using well-known web technologies, such as HTML and Javascript.

[5]www.appcelerator.com

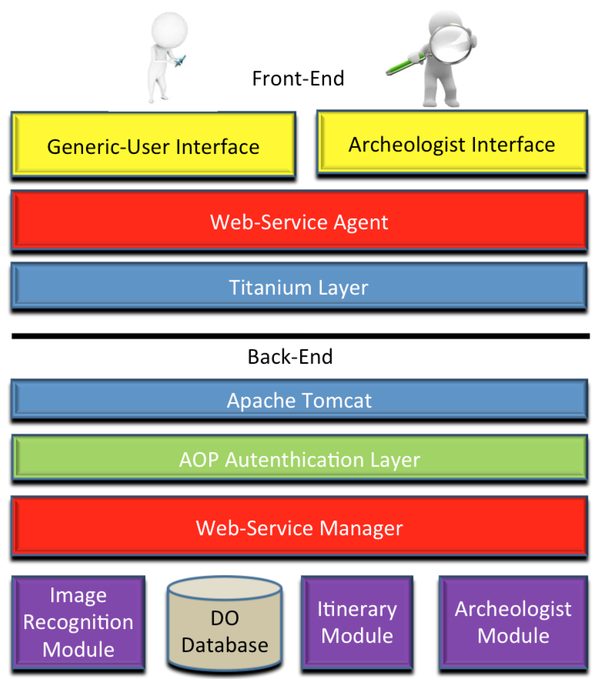


Figure 2. The PetroAdvisor architecture.

Web Service modules. Web service is a communication paradigm between electronic devices over a network. In particular, it consists of a software function provided at a web address, which is always on like in utility computing.

Web services have been particularly useful in the development of the PetroAdvisor system, since they allowed us to focus our attention on the definition and implementation of the system functionalities, relieving us from presentation issue concerns.

The combination of Web services and the Spring technology allowed us to exploit the AOP (Aspect Object Programming) for the management of security. In fact, we only needed to declare the permissions for each functionality in order to restrict their access.

Image Recognition Module. this module aims to recognize petroglyph symbols from petroglyph contours. The recognition process uses a petroglyph symbol classifier based on a flexible image matching algorithm. The idea is to measure the similarity between petroglyphs by using a distance function derived from the image deformation model (IDM) [18], which has been successfully applied to handwritten character recognition [18]. Such a distance measures the displacements of single pixels from the two compared images within a warp range, also taking into account the surrounding pixels (local context). This method is well-suited for petroglyph reliefs since it is less sensitive to local changes often occurring in the presence of symbol variability, making our method tolerant to the types of visual variations. In particular, the IDM model yields a distance measure that is tolerant with respect to local distortions. In fact, in case two images have different values for few pixels, possibly due to noise or artifacts irrelevant to classification, the distance between them is compensated by specifying a region in the matching image where it is allowed to detect a best matching pixel.

The IDM performs a pixel-by-pixel value comparison between the query and the reference images, determining the best matching pixel within a region surrounding the corresponding position in the reference image, for each pixel in the query image. The IDM has two parameters: warp range (w), and context window size (c). Figure 3 illustrates how the IDM works and the contribution of both parameters, where the warp range w constrains the set of possible mappings, whereas the $c \times c$ context window computes the difference between the horizontal and vertical gradients for each mapping.

The algorithm requires each pixel in the query image to be mapped to a pixel within the reference image not more distant than w pixels from the place it would take in a linear matching. Over all these possible mappings, the best matching pixel is determined using the $c \times c$ local gradient context window, by minimizing the difference with respect to the test image pixel. In particular, the IDM distance D between two symbols S_1 (the query input) and S_2 (the template) is defined as:

$$D^2 = \sum_{x,y} \min_{d_x,d_y} ||S_1(x + d_x, y + d_y) - S_2(x, y)||^2$$

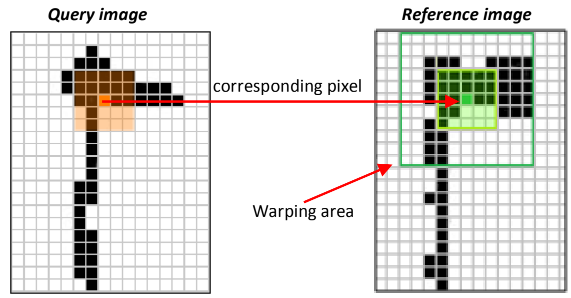


Figure 3. Example of areas affected by the comparison of pixels with IDM, where $w = 3$ and $c = 2$. The query pixel context (indicated by the orange area in the query image) is compared with each equal-sized rectangle within the warping area (dark-green rectangle of the reference image).

where d_x and d_y represent pixel shifts and $S_i(x, y)$ represents the feature values in S_i from the patch centered at x, y.

Itinerary module. This module generates personalized tourist route on the basis of several requirements, which can be either of the user or the archaeologist. Basically, users parameters may be alphanumeric or geographical. As an example, one parameter is the available time to walk through the path. The calculated path also depends on the users trekking ability, which can be customized through the interface. Instead, the geographical parameters correspond to the places that the user wants to mandatorily visit. The latter might also be set by the archaeologists, which in some cases need to explore new regions, and/or want to invoke volunteers assistance.

The algorithm used to calculate personalized tourist route is an extension of the single optimal route computation algorithm for transit networks [22]. In particular, the extension concerns the generation of multiple routes for a given departure and arrival point [24]. The generation process consists of three steps. First, the system creates a list of recommended Points of Interest (POIs) by combining the tourist information with the user prole. Then, the routing algorithm combines this information with users constraints (available time, starting POI, trekking ability, and so on), POI data, and itinerary properties (slope degree, kind of track, and so on) to generate personalized routes. Finally, users have the opportunity to customize the proposed route to better fit their needs.

Archaeologist Module. The aim of this module is twofold: (i) manage petroglyphs, their information, descriptions, keywords, dating, and so on; (ii) analyze the user provided information. The latter is very important for the research phase. Basically, PetroAdvisor aims to support archaeologists in the exploration of wide portions of territory by leveraging the volunteers community. In this sense, the module is the final phase of this exploration, when experts analyze the collected data and, in some way, make them available to tourists.

4. Usage Scenario

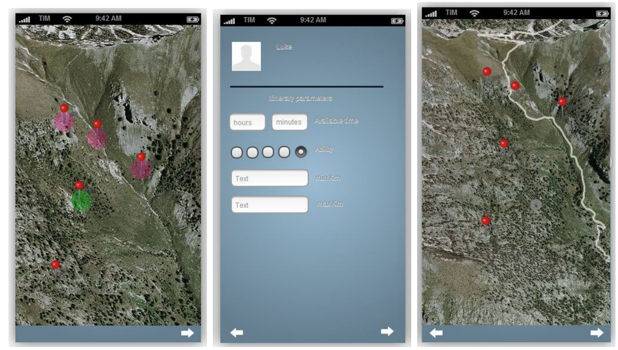
In this section, we propose three user scenarios, aiming to show the main functionalities of the PetroAdvisor system. Basically, they are described by following a hypothetical mental action road, which starts from the itinerary selection, expects the insertion of a petroglyph, and ends with its check and validation.

This meta scenario is particularly significant for two reasons: it has been proposed by some archaeologists, meaning that the scenario satisfies the specific requirements in terms of data collection quantity and quality. In terms of quantity, because the system takes advantage of the tourists for exploring large parts of a territory in a short time, and in terms of quality, because every information must be checked and validated by an archaeologist.

The first scenario, also described in Figure 4, concerns with the itinerary selection. As previously stated in the functional requirements, the system should be able to propose new itineraries on the basis of information provided by the user and/or the archaeologists. The user can specify the trekking ability or the time available for walking through the itinerary. Instead, the archaeologist can specify the regions of interest like for example those not explored yet, or those that do not require further effort to be explored. S/he can also assign a score for indicating which petroglyphs should be visited. Such a score is mediated through the scores assigned by the users who visited them.

In what follows, we describe the scenario in Figure 4, which represents the user point of view. The first frame (Figure 4(a)) shows the map of the site indicating the petroglyph locations and the region of interest. Notice that petroglyphs are differently colored based on the score they achieved. Here, the user may see comments, descriptions, and any other information related to the petroglyphs. Based on such information, users may choose those to mandatorily see, those to optionally see, and those to absolutely avoid. The next step allows users to set own parameters (Figure 4(b)). Finally, the itinerary will be generated and submitted to the user, who can either accept or request the generation of a new one.

Figure 5 shows the second scenario, which corresponds to the main task a generic user should perform. After selecting an itinerary, like the one highlighted in the previous scenario, the user walk can start. During the excursion the user can see his/her position on the map, as shown in Figure



(a) (b) (c)

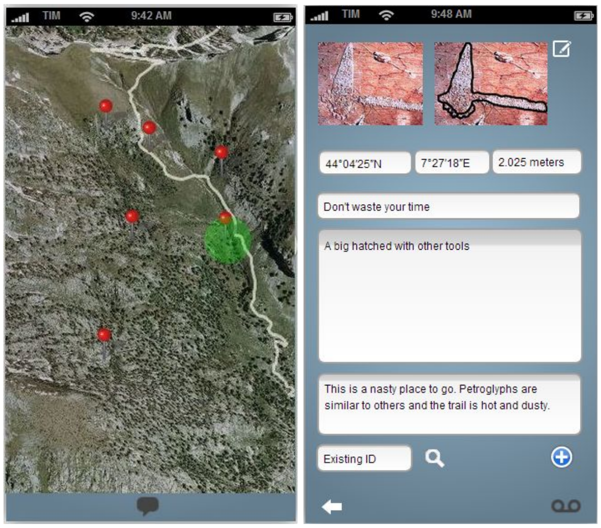
Figure 4. The itinerary selection scenario. (a) petroglyph locations and the region of interest, (b) itinerary parameter settings, and (c) the generated itinerary (white colored line).

5(a), and tap the screen to see information about the reached petroglyphs. In case the user identifies a new petroglyph, or if s/he wants to add a description or comment to an existing one, s/he can access its properties. A workflow guides the user during the accomplishment of this task, where the first step is to add a new picture of the identified petroglyph (see Figure 5(b)), which can be accepted or rejected. Once completed this step, the user is enabled to insert the information: descriptions, comments, scores, and so on (Figure 5(c)), and the petroglyph contour (Figure 5(d)). After depicted the latter, the user can also search for similar petroglyphs, and look for ones elsewhere (Figure 5(e)). Finally, s/he can submit the form and the data to complete the task.

The final scenario is shown in Figure 6. It does not involve *Generic Users*, but *Archaeologists*. The latter can check and validate the user provided information. Initially, the archaeologist sees a map where the validated petroglyph and those to be validated are highlighted by using different colors. By clicking on each of them, the archaeologist accesses the mask where s/he can modify the submitted information, associate it to an existing petroglyph, or create a new one.

5. Related Work

In the recent years, several systems involving human participation have been developed in the context of cultural heritage. CAPTCHA-ROCK is a system for helping archaeologists to extract data from petroglyph images [27]. In particular, it is a CAPTCHA system where users have to trace petroglyph images with the mouse pointer for access control purposes. The collected contours are exploited by a data mining algorithm for classifying petroglyphs. PetroAdvisor



(a) (b)

Figure 6. Petroglyph check and validation scenario. (a) map of petroglyph location highlighting those to be validated by archaeologists, (b) form through which the archaeologists can view and modify tourist provided information.

provides a similar contour collection feature, but with an increased usability, since it is conceived for mobile devices, hence it provides touchscreen based interaction modality.

The Wicklow Rock Art Project[6] aims to explore the potential of photogrammetry in rock art recording, and to examine ways of protecting and promoting prehistoric open-air rock art in a sustainable fashion. Moreover, the project has the goal of creating a public engagement and interaction environment based on the crowdsourcing model. The latter should encourage people to identify with the rock art in their area, and cultivate a sense of guardianship and protection of such a fragile resource.

Heritage Crowd[7] is a project providing participants with tools for defining the cultural heritage of their place by using sms messages, voicemail, and other channels. In particular, through the use of a number of technologies, contributors have the possibility of creating a database of local history knowledge, which are accessible through a public website.

MicroPasts[8] is a community platform for conducting, designing, and funding research on human past [3]. In particular, it aims to provide an online space, where mixed groups of archaeologists and other volunteers collaborate to produce innovative open datasets, develop new research projects on archaeology, history and heritage, and micro-fund those new collaborative projects via crowdfunding.

Ancient Lives[9] is a system that helps researchers transcribe Greco-Roman texts recovered from fragments of papyrus found in Egypt to better understand the periods culture. This is accomplished by involving people in transcribing items from the Oxyrhynchus Papyri and determining if they are parts of already known texts or if they are new texts. After transcriptions have been digitally collected, the system combines human and computer intelligence to identify known texts and documents. Similarly, the Transcribe Bushman[10] project aims at preserving the extinct $|xam$ and endangered $!kun$ languages of the Bushman people. People can contribute to the project by transcribing some pages of materials, which include rock art painting, drawings, and notebooks.

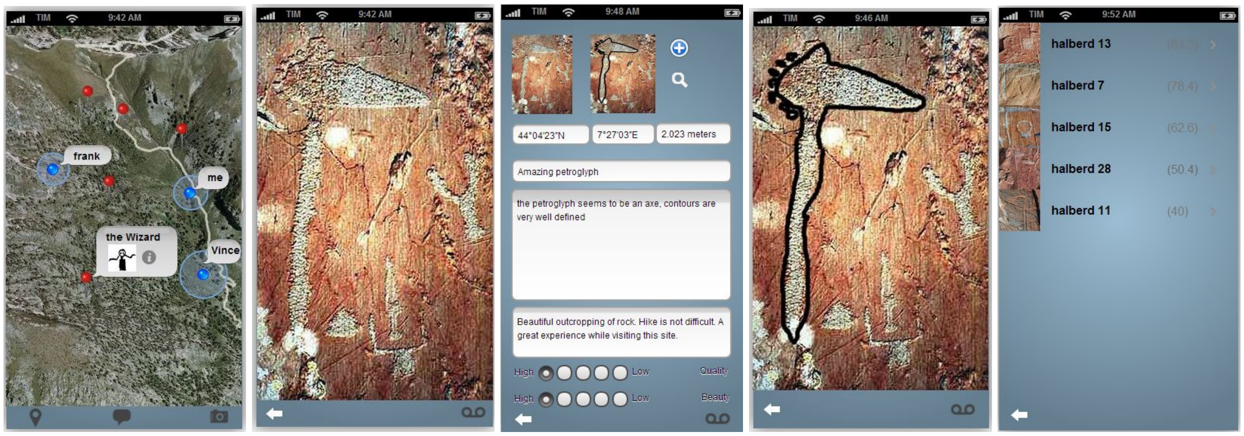
The Portable Antiquity Scheme[11] is a project to encourage volunteers in recording archaeological objects found in England and Wales. Every year many thousands of objects are discovered, many of which through metal-detectors, but also by people whilst out walking, gardening, or going about their daily work. As a consequence, the project has also the aim of stimulating public involvement and promoting best practice.

The Valley of the Khans[12] project aims to identify the site of Genghis Khans Tomb using noninvasive technologies ranging from aerial and satellite imaging, human computation, and non-invasive geophysical surveying. Users can join the research team by examining the satellite images and searching for clues guiding in the discovery of the lost tomb of Genghis Khan. Within a year, the participants created more than two million notes in about 6.000 km^2, which include lakes, rivers, and potential archaeological sites.

In 2008 British Library started the BL Georeferencer[13] research project for geo-referencing historical maps [21]. In particular, volunteers scanned and georeferenced maps of the 17th, 18th, and 19th century from England and Wales. The results of this work led to the digitization and distribution of more maps via Internet [19]. Similarly, the New York Public Library's MapWarper project[14] aimed at correcting historical maps through an environment enabling volunteers to browse and correct old historic maps from the collection of the New York Public Library. Another relevant and successful collaborative geo-referencing project is eHarta[15], which focuses on historical series maps of Roma-

[6] http://www.ahiddenview.com/
[7] http://www.heritagecrowd.org/
[8] http://micropasts.org/

[9] http://ancientlives.org/
[10] http://boinc.cs.uct.ac.za/transcribe_bushman/
[11] http://finds.org.uk/
[12] http://www.nationalgeographic.com/explorers/projects/valley-khans-project/
[13] http://www.bl.uk/maps/index.html
[14] http://maps.nypl.org/warper/
[15] http://earth.unibuc.ro/articole/eHarta



(a) (b) (c) (d) (e)

Figure 5. Submission of petroglyph info scenario. (a) visualization of tourist info, (b) tourist picture of a candidate petroglyph, (c) form through which tourists enter the petroglyph info, (d) petroglyph contour traced by a tourist, (e) petroglyphs with a contour similar to the one highlighted in (d).

nia [5].

MayaArch3D has the goal of creating virtual models of the Maya archaeological site of Copan in Honduras [25]. Among its research program objectives, there is the creation and visualization of three-dimensional models of cities and landscapes by volunteers provided information.

The HEIR[16] (Historic Environment Image Resource) project aims at digitalizing and keyword indexing old photos of monuments, landscapes, and environments taken across the world, and to re-photograph their modern settings. It is a crowdsourcing initiative for creating a worldwide accessible, interdisciplinary research resource, which can potentially provide a greater understanding of all aspects of the society and of the environment.

The above-mentioned projects have similar goals and objectives with respect to PetroAdvisor. In particular, all of them share the spirit of involving volunteers to raise awareness of cultural heritage, to increase identification of new archaeological information, and to bridge the gap in current technology. The originality of PetroAdvisor resides in the adoption of a rewarding strategy, which stimulates tourists to submit information to the system. In particular, the tourists are rewarded with information guiding them during their visits to petroglyph sites, such as visiting route based on user abilities.

6. Conclusion and Future Works

We have presented PetroAdvisor, a volunteer-based system supporting archaeologists in the digital preservation of petroglyph sites. In particular, PetroAdvisor provides a centralized repository containing both archeologist and tourists provided information. The system also collects user provided petroglyph contours, which are particularly useful due to the limits of the current image recognition algorithms.

To stimulate tourist involvement, PetroAdvisor rewards tourists with information useful to visit archaeological sites, such as comments from previous petroglyph visitors, the recommendation of personalized tourist route, and archaeological information.

In the future we plan to perform massive experiments to evaluate the system usability, and the quality of the services it provides. Moreover, we would like to experimentally evaluate the usefulness of the whole approach from the archeologist point of view. Another important issue that deserves to be investigated is the detection of diverging comments on the same petroglyph, as those shown in Figure 5(c) and 6(b). Currently, we rely on the archeologist to accomplish this task. However, this task might result overwhelming for the number of available experts. Thus, other than devising volunteer-based strategies, it would be interesting investigating the natural-language processing approaches to partially automate this task.

In terms of implementation, we also plan to integrate the system within the IndianaMAS software platform so as to benefit from the availability of a repository storing a broad collection of petroglyph site and, access more sophisticated functionalities for searching and classifying petroglyphs.

Finally, we would like to add social network services in order to further stimulate system usage and active participation to information provisioning.

[16]http://www.arch.ox.ac.uk/HEIR.html

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