

Exploring Protected Nature Through Multimodal Navigation of Multimedia Contents

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Abstract. We present a framework useful to explore naturalistic environments in a multimodal way. The multimedia information related to the different natural scenarios can be explored by the user in his home desktop through virtual tours from a web based interface, as well as from a dedicated mobile app during an on site tour of the considered natural reserves. A wearable station useful to a guide to broadcast multimedia content to the users' smartphones and tablet to better explain the naturalistic places has been developed as part of the framework. As pilot study, the framework has been employed in three different naturalistic reserves covering epigeal, hypogeum, and marine ecosystems.

[AQ1](#)

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1 Introduction

Current technologies enable users visiting a site of interest to enrich their experience thanks to an interactive access to different type of contents (text, audio, images, videos, 3D models, etc.). Recent computer vision based technologies enable generation, reconstruction and navigation of areas of interest, enabling also an augmented fruition experience. These technologies can be exploited to build virtual tours of sites which may be not physically accessible to the users (e.g. because remote, difficult to be accessed such as caves, or not accessible due to physical disabilities of the user).

Despite the multimodal fruition is already employed for cultural environments [1–7], it is not yet fully exploited for the navigation of naturalistic sites.

In this paper we propose a framework for the navigation of multimedia information related to a naturalistic environment which is composed by three main multimodal fruition components:

- an application for smartphones and tablets to allow the users of getting additional information about the natural environment.
- a web based navigation interface to allow users in retrieving multimedia information (e.g., text, audio, images, video) related to a naturalistic environment.
- a portable wearable station to allow a guide to broadcast multimedia contents to the users smartphones and tablets during a guided tour.

The overall framework gives the user the possibility to know about historical, naturalistic and cultural information of the natural sites to be explored. It allows persons with disabilities to have access to visual information related to the naturalistic places (e.g., a person with limited mobility can explore a cave with the web based virtual tour), as well as to multimedia enhanced contents (e.g., through subtitles for hearing impaired, or audio for visually impaired).

We selected three ecosystems with different peculiarities related to protected areas in Sicily (Fig. 1) as case studies for the exploitation of the proposed framework:

Terrestrial: the land of nature reserve “Complesso speleologico Villasmundo - S. Alfio” [8] has been considered (Fig. 1(a));

Cave: we chosen the nature reserve “Grotta Monello” [9] as hypogean site (Fig. 1(b));

Marine: for this ecosystem we selected the marine protected area “Isole Cicopi” [10] (Fig. 1(c)).

The paper is organised as following. In Section 2 the proposed framework is detailed. Section 3 concludes the paper providing hints for future works.

2 Proposed Fruition Framework

In this section we describe the proposed framework for the multimodal fruition of multimedia information related to natural sites. As previously mentioned, the framework is composed by three main components: a mobile app, a web based navigation system, and a wearable station. These three components allow a user to explore autonomously the site of interest from home (through virtual tour navigation) or onsite (with the help of the mobile app). The framework also allows to a guide to broadcast multimedia information directly on the smartphones or tablets of the user during a walking tour (through the wearable station) to better highlight peculiarity of the naturalistic site under exploration (e.g., broadcasting a thermal videos to better explain stalactite and stalagmite formation in a cave).



(a) *Complesso speleologico Villasmundo - S. Alfio*



(b) *Grotta Monello*



(c) *Area Marina Protetta Isole Ciclopi*

Fig. 1. Panoramas related to the considered ecosystems: (a) terrestrial, (b) cave and (c) marine.

2.1 Fruition Through Mobile Application

The mobile application is a key element of the fruition Kit associated to each ecosystem considered in this project. It has been designed in such a way that it can be easily pre-installed into a mobile device (i.e., smartphones and tablets) that will be provided to visitors at the naturalistic site entrance. It can also be downloaded and installed on personal visitors' devices. To this aim, specific



Fig. 2. Info discovery at each POI through Mobile App.

instructions will be provided to visitors at the entrance. Thanks to this application, the visitors can follow the naturalistic itinerary, by getting in each Point of Interest (POI) the related information (Fig. 2). The visitors can receive three kinds of downloadable contents in each POI:

- Historical and cultural information included inside the application as built-in information (as text, pictures and, where available, a short video).
- Extra contents. Typically videos recorded during previous visits, downloadable through a Site Information Totem located at the naturalistic site entrance.
- Additional Info provided through the Augmented Reality (AR) technology. This will include textual contents, multimedia (audio, pictures), 3D models with animations, enriching the visitors' experience with a more realistic representation of particular elements/landscape related to the current POI.

In order to get access to AR info, visitor must be close to the POI panel, since AR activation requires the identification of a specific marker to start and show the related content. Vice-versa, simple multi-media and video contents will be built-in the application so to be available for the visitors also while walking from a POI to another. Access to AR info will be available again when they will be in front of the next Tag.

Since, nowadays, the most popular and used Operating Systems (OS) are Android and iOS, the mobile application targets these OS. In addition, because part of the naturalistic information is shown through the AR feature, all the technologies, able to support the AR on both these OS, have been properly investigated. As shown in Fig. 3, the AR plugin has to work on a game engine, which provides the needed development libraries in order to create the 3D environments. The game engine market offers several solutions, which could be used for the project. After a wide investigation, Unity 3D has been chosen since it is the most popular in creating 3D games, and it ensures continuous evolution and updates [11]. Unity 3D is a multi-platform Framework, which can adapt to both Android and iOS devices, thus allowing a strong reuse of 3D objects and animations. Furthermore, regarding the scripts to be created, Unity 3D supports an open-source implementation of .NET Framework called Mono Develop, which allows usage of C# language, thus allowing to easily adapt to the target OS.

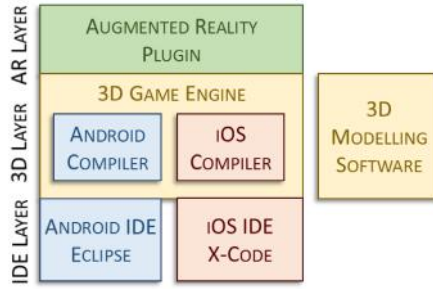


Fig. 3. Stack and relations of the development software.

This feature provides a remarkable reuse of code as well. A further strong point of Unity 3D is its full support of the physical simulation libraries (PhysX from Nvidia), which are needed to reproduce physical and mechanical events within the 3D environments (gravity, forces, collisions, and so on).

In the proposed fruition framework we have considered different 3D modeling software. The criteria used to select the most suitable one have been:

- support of 3D Rendering system, because it allows to create higher quality models.
- solutions with freeware license, because it often means a wide community of users, which suggest a continuous improvement of the solution itself.

According to those criteria, the number of possible software is reduced to eleven. Among these remaining solutions, Blender, Cinema 4D and ZModeler stand out because of their large diffusion; finally, Blender [14] has been selected because Unity 3D is capable to directly import the Blender's models from its native format, which is a strong feature because it avoids any possible compatibility issue.

In the mobile application we have considered different AR plugin. Criteria applied for selection have been:

- full compatibility of AR plugin with the chosen 3D game engine, Unity 3D;
- OS support from both Android and iOS for the AR plugin.

Based on these criteria, the final choice has been Vuforia (from Qualcomm) [15] since it is the most used by a larger community and, thanks to this, continuously updated with new features.

The implementation of the AR features requires marker creation since AR is activated by marker recognition. Attention must be paid to marker creation since the quality of the produced marker can strongly affect stability of the virtual 3D environment. The marker is an image, which contains a visual reference to the associated information which will be visualized when a mobile camera frames it. The mechanism is the following: when a mobile device detects a specific image through the applications computer-vision algorithm, it reacts by visualizing the



Fig. 4. An example of AR marker used in CET Project.

content associated to the image itself. So, in order to show the correct content, and to maintain a stable simulation of the 3D environment (avoiding lagging and blinking/unstable animations), the following criteria have to be applied while designing Tags related to the POIs:

- Univocal patterns. The target image must contain chromatic variations and not symmetrical shapes, thus avoiding any mis-recognition of the picture.
- High contrast. In order to improve recognition performances, high chromatic variations are the best practice to be applied; for this reason, Anti-Aliasing algorithms have to be reduced at most.
- High resolution. This means clearly-defined objects outlines to further improve reliable identification of the target picture.

Furthermore, in order to provide the project with homogeneous and coherent layout, marker has been designed as a “frame” target. This methodology uses the external border of the image to encrypt the information about the content to be shown. In addition, by using this approach, the central part of the image is available and even a static picture (e.g. the project Logo) can be positioned in this space, thus allowing representation of the project logo in each single Tag. This results into a homogeneous pretty graphical look for the overall solution. An example of the markers created for the CET project is shown in Fig. 4. It can be recognized the project logo in the central section and the characteristics of the external frame containing the encrypted ID information. In the example, the Frame is composed by few missing sections (blank spaces) and by many sections with different colors: both these characteristics allow a correct identification of the Tag, strongly reducing the mismatching probability.

Fig. 5 shows some screen shots of the mobile app interface for the Main Menu, the Circuits Selection Menu and POI Information. After selecting the ecosystem to visit, full list of possible associated POIs is shown on the left side of the screen, whilst cultural information are presented on the right. Further contents can be visualized thanks to three buttons at the end of the POI description:

- Play the video, to start a short video describing the POI;
- Augmented reality, to launch the AR;

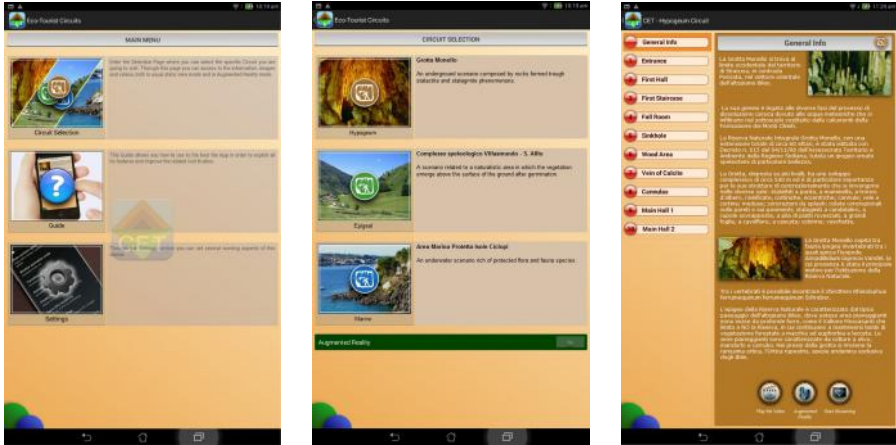


Fig. 5. Mobile Application: Main menu (left), Circuit Selection menu (middle) and POI information (right).

- Start streaming, to activate the video-streaming coming from the handheld camera operated by the visit guide.

The AR feature can also be started by selecting a proper option into the Circuit Selection menu. Thanks to Vuforia AR enhanced libraries, the mobile application gives the possibility to touch and even to move 3D objects. Thus, allowing the visitors to easily interact with the simulated environment, the result is that the visitor can access a 3D menu, where options' selection is performed by touching the associated objects, behaving like 3D buttons.

This menu offers four different options to the visitors to get info about the POI:

- Text: this option opens a pop-up including all text information regarding the POI.
- 3D: in case of POI where a specific 3D model has been created, this option shows a 3D model and its animation.
- Pictures: this 3D button makes visible all the pictures related to the POI.
- Video: this option allows the visitor to watch a recorded video about the POI.

Thanks to this 3D menu, visitor can easily customize the visit experience according to his/her preference. Adults may be interested mainly in reading the information, or in seeing an audio-commented video. Young visitors might be interested in using the interaction offered by AR. In all these different fruition modalities, the developed mobile application supports the visitor by providing an interactive naturalistic experience.

2.2 Web Based Fruition

A classic and key fruition modality to promote protected natural sites is to make related information about their existence and peculiarities available on request. Almost all national parks worldwide have their own navigable website where images and videos are becoming more and more important to better capture the interests of the potential visitors. Despite the navigation of a website can be optimized to allow the users a better discovering of the multimedia information (e.g., thanks to the design of the web based user interface and considering advanced techniques for data search), this kind of remote fruition of natural places results very different from the experience that can be done by visitors during a walking tour in the protected natural site of interested.

To fill the gap between the web visit and the natural fruition experience we have included virtual tours as fruition modality. For each POI of the a certain ecosystem we have built a spherical panorama using Autopano [12] which have been then connected in a virtual tour through the use of Panotour [13]. Three examples of spherical panoramas obtained from the acquisition campaign of the terrestrial ecosystem are shown in Fig. 6. The navigable virtual tours have been enhanced by including a description and other multimedia information (images, videos, 3D Models) related to important details to be emphasised in the panoramas (e.g. images of important flowers' species which grow during the year in the terrestrial site have been included in the panoramas by considering their usual positions in the environment, images of protected fishes have been included for the underwater virtual tour of the protected marine area, videos have been included in panoramas of the hypogeuum virtual tour reflecting where the fauna, e.g., bats, usually live). To open a multimedia content during the virtual tour, a web visitor can click on an icon which pops up when a specific detail is present in a certain view of the spherical panorama under exploration. Aerial videos of the terrestrial and marine ecosystems acquired with drones (i.e., quadricopters) have been also included as contents in the virtual tours.

The built virtual tours can be explored by simply opening a web browser. We have included them as contents of the mobile application discussed in Section 2.1. Because the panorama are georeferenced and associated to the predefined POIs available into the mobile app, the user can also use the panoramas during an onsite visit to explore a specific point of interest. In particular, considering that the built panoramas have been created taking into account of the gyroscope information, during a walking tour the users can activate the gyroscope fruition modality by pointing the mobile and associate a particular detail shown in the virtual panorama with the real visited environment.

The aforementioned virtual tours are embedded in the websites of the projects where the selected protected areas are available for the exploration. The developed web fruition modality allows also the advanced search among all the multimedia contents (images, videos, texts) related to the specific ecosystems by exploiting their metadata (e.g, acquisition time, geolocalization of images, data of videos related to recorded tours), tags and descriptions.



(a) *POI - Laghetto (Panorama 1)*



(b) *POI - Laghetto (Panorama 2)*



(c) *POI - Torrente Belluzza*

Fig. 6. Spherical panoramas (360° horizontal and 180° vertical field of view), of three different POIs related to the virtual tour of the terrestrial ecosystem Complesso speleologico Villasmundo - S. Alfio. The panoramas are navigable in the web based fruition modality.

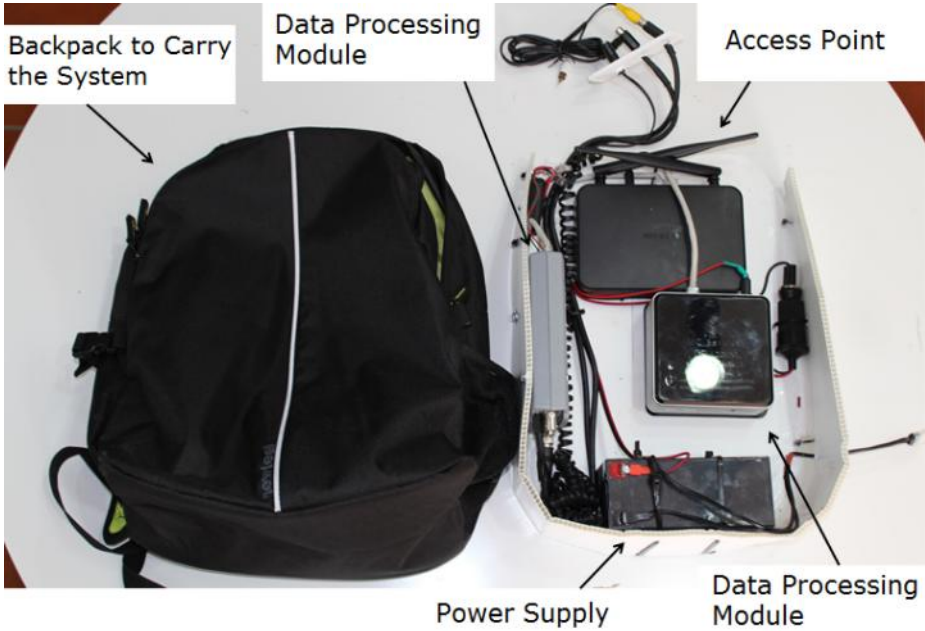


Fig. 7. The wearable system.

2.3 Wearable Station for on Site Walking Tours Fruition

A wearable station has been developed as support for the guide of a naturalistic tour (Fig. 7). Different acquisition sensors (Thermal camera, wearable video camera, underwater camera, microphones) can be connected to the developed system. A tablet is used by the guide to interact with the wearable system in order to activate the different fruition modalities and the contents broadcast. The information acquired during a guided tour can be stored for later usage (e.g., can be included as contents for the web based fruition system) or broadcasted to the mobile's users to provide additional information on specific peculiarities of a site (e.g., an underwater realtime video of the marine scenario broadcasted to the tourists' mobile during the boat tour, a thermal view of a cave scenario to observe bats behaviours, etc.). The wearable station is also able to broadcast the guided tour directly to the mobile app described in Section 2.1, on the web based fruition system as well as to a totem at the entrance of the naturalistic site. This allows remote user as well as people with disabilities to "join" the tour.

The wearable system is composed of three main modules:

Module 1: Portable acquisition system (below, backpack system), to be used by a guide. It can be connected to a thermal camera, a video camera and a microphone.

Module 2: A tablet which allows the interaction to the system in order to share the data collected on site and to acquire additional naturalistic contents during the tour. The tablet can be connected to a local network managed by the system in the backpack.

Module 3: A totem located at the entrance of the naturalistic site. The aim of the totem is to assure that people with disabilities (e.g., wheelchair’s visitors) staying next to it, can activate the mobile app and enjoy the tour broadcasted by the guide through the wearable system.

3 Conclusions and Future Works

This paper presented a framework for the multimodal fruition of multimedia contents related to naturalistic sites. The proposed framework is composed by three main component: a mobile app, a web based fruition interface and a wearable station. Three different natural ecosystems in Sicily have been considered as scenarios. Computer vision technologies have been exploited to include augmented reality into the mobile app as well as to build virtual tours of the considered ecosystems. Thermal technology has been considered for the wearable station to allow a guide to better enhance hypogeum peculiarities. The framework is able to effectively present historical, natural and cultural information to the visitor allowing also a simple interaction with contents. Future works can be devoted to extend the framework to include new wearable devices (e.g., smart glasses) to better involve the visitors into the naturalistic experience. Finally, the plan is to extend the framework to include other protected areas and reserves to allow people of enjoying more nature sites.

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