Serious Games at the Service of Cultural Heritage and Tourism

Andreas Georgopoulos, Georgia Kontogianni, Christos Koutsaftis and Margarita Skamantzari

Abstract Recent advances in contemporary technologies have greatly affected everyday life. In the field of cultural heritage, ICT (Information Communication Technologies) have enabled applications for the thorough multi-dimensional geometric documentation and consequently for the realistic visualization of monuments and artifacts. At the same time the driving force of technology is the game industry. Games and especially Serious Games can be put at the service of cultural heritage, education and tourism exploiting the aforementioned advances and especially the textured three dimensional models. They constitute an attractive platform enabling people to get acquainted with the heritage treasures and get motivated to visit the place and admire the treasures live. In this paper this technological merger is explained and three interconnected applications are presented in order to prove the concept through these implementations. They concern the development of Serious Games for an archaeological site, which aim at the trivial or more specialized information dissemination about that site, while familiarizing the prospect visitor with the environment and the monuments of the site offering the possibility of virtually visiting them. Moreover the development of a virtual museum within a game development environment is presented, which provides the possibility to learn about each exhibit, but also it offers the opportunity to the user to closely examine the exhibits through rotating their three dimensional models. All these examples use realistic models produced for documentation purposes, which convey the real impression of the monuments visualized to the user.

Keywords Serious games · Cultural heritage · Virtual museums

JEL Classification Q55 · O33

A. Georgopoulos (✉) · G. Kontogianni · C. Koutsaftis · M. Skamantzari
Laboratory of Photogrammetry, School of Rural & Surveying Engineering,
National Technical University of Athens, Athens, Greece
e-mail: drag@central.ntua.gr

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1 Introduction

During the last decades there have been numerous efforts concerning the 3D digitization of cultural heritage and the development of virtual museums, digital libraries and serious games. The realistic result has always been the main concern and a really challenging task when it comes to 3D modelling of monuments, artifacts and especially sculptures. The 3D virtual spaces and modern technology are more and more used especially in the development of applications in e-learning and edutainment by cultural organisations and museums (Moldoveanu et al. 2003).

For some decades now the Laboratory of [Photogrammetry] of [NTUA] is active in the geometric recording of cultural heritage objects, small or large, movable or immovable. During these years technology has rapidly evolved to enable the swift and easy production of realistic 3D models, able to serve many purposes such as simple visualization or metric information extraction. In this paper a further use of these models is demonstrated. Namely they are exploited to add realism to edutainment products, like Serious Games and Virtual Visits.

For that purpose three applications are described. The first one is about the developments of a Serious Game for the Ancient Agora of Athens, which aims to convey the trivial information about the site, while at the same time familiarizes the visitor with the environment and the monuments of the site offering the possibility of virtual visiting them. The second application is about the development of a Virtual museum for the Stoa of Attalos which provides the possibility to learn about each exhibit on one hand and on the other it offers the opportunity to the user to closely examine the exhibits. The third application presented is about a Serious Game for the Stoa of Attalos in particular, which aims at the dissemination of conservation notions and values to more advanced visitors. All the applications were developed in Unity 3D personal edition software.

2 Ancient Agora of Athens Serious Game

2.1 Serious Games in Cultural Heritage

Serious Games for Cultural Heritage applications can significantly help people who are note oriented or specialized in this field, such as tourists, museum visitors, students etc., to gain experience and expand their knowledge. This kind of games can be interactive through the use of virtual tour facilities, posing questions about heritage objects and the monuments and many other similar activities.

Many applications for Cultural Heritage have been developed in the past. The *Ancient Pompeii* application (Maim et al. 2007) has as main goal the simulation of a crowd of Virtual Romans that exhibit realistic behavior in a specific district in Pompeii. The *Parthenon project* aims to create a virtual version of the Parthenon and its separated sculptural elements so that they could be reunited in a virtual

representation (Debevec 2005). The *Ancient Olympic Games* (Gaitatzes et al. 2004) is the subject of a number of gaming applications associated with Olympic Games in Ancient Greece and was developed by the Foundation of the Hellenic World. This project consists of three mini applications. The first one is the "*Olympic Pottery Puzzle*" according to which the user must re-assemble a number of ancient vases putting together pot shards. Another one is the "*Feidias Workshop"* which is an interactive virtual experience and takes place during the construction of a tall golden ivory statue of Zeus, one of the seven wonders in the world. The "*Walk through in Ancient Olympia*" is the last mini game of the Ancient Olympic Games project. In this application the user can virtually visit the site and furthermore learn about the ancient games in Olympia. Moreover the player can visit and learn more things about the ancient building of the Olympia. *Priory Undercrofts* game aims to solve a treasure hunt scenario by collecting medieval objects that used to be located in and around of the remains of the Coventry's original Benedictine monastery demolished by Henry VIII (Doulamis et al. 2012). *ICURA* is a Serious Game application in which the player learns about Japanese culture, habits and some language basics by investigating the 3D environment, collecting items, combining them and talking to persons in order to complete the game (Froschauer et al. 2010). The *MuseUs* application is carried out in museums and is running as a smartphone application. In this game the user is invited to create his own exposition and is guided by the application in doing so when he visits a museum (Coenen et al. 2013). The *Via Appia* Serious Game is an indirect augmented reality system in which 1 km of the Via Appia Antica was reconstructed in three time periods and the user can explore the notion of narrative movement and travel across space and time in a cultural heritage context, which includes a quiz game with questions related to the information provided in the virtual environment (Liestol 2014). Finally, the *Fort Ross* is mentioned, whose main goal is to explore novel ways for archiving, disseminating and teaching cultural and historical information and creating an interactive too able to educate elementary school students and park visitors about California history (Lercari et al. 2013, 2014).

2.2 Data Available

For the game development different kind of photogrammetric 3D data were used. Firstly for the terrain creation, on which the 3D models were placed, a raster DSM (Digital Surface Model) and the corresponding orthoimage from the National Cadastre and Mapping Agency S.A. were used. Furthermore different kinds of 3D textured models were used which vary as far as their source and epoch are concerned, because some of them illustrate the existing situation and some others have been historically reconstructed (Kontogianni and Georgopoulos 2015a, b). The 3D model of the Giant of the Odeon of Agrippa (Kitsakis 2011) and the south west side of the foundations of the Middle Stoa (Karageorgou et al. 2010) were created with the use of a time of flight (ToF) terrestrial laser scanner and overlapping digital

images for the texture. The model of the temple of Hephaestus was created with a ToF laser scanner which assigns colour information to the points. The southwest side of the Middle Stoa was historically reconstructed according to old drawings, images, existing literature, and experts' assumptions (Kontogianni et al. 2013). In addition, 3D models of artifacts, such as the sima, available in the relevant museum, were created with image based modelling methods. The procedure was carried out in the Autodesk 123D Catch® web service. Moreover, again with the use of image based modelling methods, the 3D texture model of the Holy Apostles church was created. In this case the 3D model was created using the Agisoft Photoscan® software. The 3D model of the Stoa of Attalos was taken from the 3D Warehouse library, from which additional 3D models of other monuments were also taken in order to complete the final result and give the opportunity to the players to learn more information about the monuments of the Athenian Agora. These monuments are: The East Building, the South Stoa II, the Temple of Ares, the Vouleftirion, the Metroon, the Aiakeion, the Tholos and the Fountain House (Kontogianni and Georgopoulos 2015a, b).

2.3 The Development of the Application

The main menu of the game has the following options: Two virtual tours, the quiz game and a help button with some instructions about the application. Two options of the virtual tours were created for the game's purpose; the first one presents the area as it is today in the 21st century and the second one as it was in the 2nd century A.D. In the virtual tours there are options in order to help the player navigate easily in the game environment. The available options give to the player the chance to return to the main menu, exit the game or continue with the other virtual tour. Furthermore a minimap helps the players navigate in the virtual environment. Also the name of each monument is annotated above or beside each monument so as to help the player see and learn which monument he/she visits (Fig. 1). The tour was realized with the use of arrow keys of the keyboard and the mouse.

When the player finishes the virtual tour he/she is able to return to the main menu in order to select the quiz game. The game begins with a message, which asks the player if he/she wants to learn more things about Ancient Greek Architecture. If the user selects "yes" he/she will be presented with information about Ancient Orders (Doric, Ionic and Corinthian) and about all the different kinds of Ancient Greek Temples. If he/she selects "no" then he/she will continue with the game (Kontogianni 2015). After this training stage the user has acquired the basic knowledge of Ancient Greek architecture, which will prove very useful during the actual visit of the site, as it will enable the visitor to understand how these buildings were in the past.

Then the player will continue with the game. Firstly he/she will see an image of the Ancient Agora with all the monuments participating in the game. The monument that the user is able to visit is designed with a button in yellow colour. The

Fig. 1 An overview of the virtual tour

other monuments are still locked to the user and their buttons are colored red. When the player finishes with a monument, its colour becomes green and the next monument is unlocked (Fig. 2).

After selecting the unlocked monument the player is introduced into the virtual environment where he/she can tour and see how the monument is today or how it used to be in the past, in case it does not exist anymore. Furthermore the player is offered a text with some historical information about the monument (Fig. 3). Furthermore in case of the virtual tours instrumental music was added for a more entertaining experience.

Fig. 2 Map of the Ancient Agora before (*left*) and after (*right*) the visit of a monument

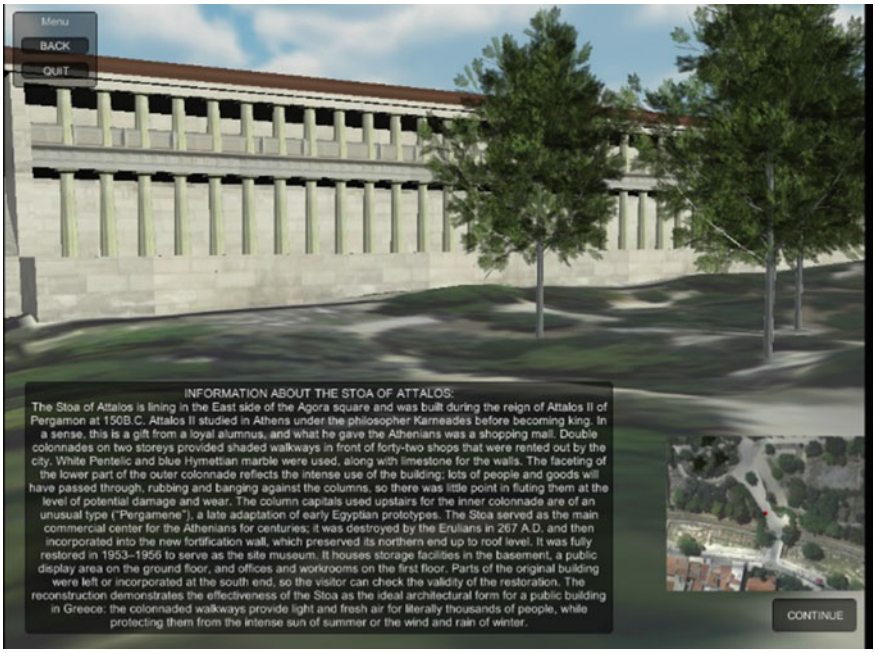

Fig. 3 Virtual tour with the information of the monument

When the player finishes the virtual tour he can continue with the quiz game which consists of five multiple choice questions for each monument (Fig. 4). These questions are based on the text that the user should have read during the virtual tour. The player can click on the answer that he knows or believes that is correct. The questions are about the history and the architecture of the monument.

In case that the choice is correct the user will continue with the next question. In this case the button of the correct answer turns green and the game automatically continues to the next question. If he/she answers wrongly, the player does not lose but a new window is loaded automatically, containing the explanation of the correct answer. In this case the relevant button is momentarily colored red (Kontogianni and Georgopoulos 2015a, b). Where necessary a drawing or an image of the monument is presented for better understanding. After completing all the questions

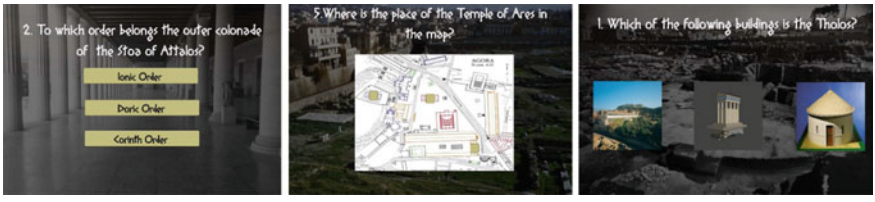

Fig. 4 Types of the questions of each monument

for each monument the player returns to the map and he/she is able to continue with the next monument which has just been unlocked. The game finishes when the player answers all the questions for all the monuments. Then he can quit from the game with the escape button of the keyboard.

3 The Virtual Museum of the Stoa of Attalos

3.1 The Advantages of Virtual Museums

Developing and displaying a museum in a virtual environment has some advantages especially concerning the preservation and promotion of cultural heritage but also the development of tourism and the promotion of the touristic product. Virtual museums are important to both the visitors and the museums themselves and their curators. The majority of the museums only exhibit a small part of their collection due to the lack of space and of course due to the fact that some objects are extremely valuable or fragile (Lepouras et al. 2004). In a virtual and interactive environment the visitor is able to interact with the digitised exhibits and learn all the essential, historical information about them. Moreover, in a virtual environment the visitor can view a virtual reconstruction of important objects, buildings and archaeological sites that may no longer exist are damaged or access to them is not permitted. Moreover collections may also be displayed made of objects that are spread in various museums around the world.

Furthermore, the digitisation of cultural heritage helps to preserve it, store, renew, retrieve and make it accessible for a wider audience in a more appealing and contemporary way, especially to people with special abilities or people that may never have the chance to visit the real museum (Sylaiou et al. 2009). The wide use of internet, social media and websites can make the digitised content of a museum more accessible and transport it to everyone all around the world. It is important to mention the result of the Colorado's University research according to which 70% of a total of 223 million people who visit a museum website would subsequently be more likely to go and also visit the real museum (Griffiths and King 2007). This means that the virtual museum functions in a complementary manner to the real museum. Moreover, it has been proven that the visitors tend to remember more information when they are having a digital or recorded tour in a museum rather than when they are just reading the panels of the exhibits in the museum (Schwarzer 2001). Finally, in virtual museum exhibitions the visitor is able to fully control the navigation as well as to freely explore, move around, manipulate the exhibits and create his/her own, unique virtual experience or collection of 3D digital exhibits even from different museums. It is obvious that every effort and innovation that concerns the digitisation of cultural heritage and the development of virtual museums and applications is a complicated, difficult, controversial task with many advantages and can only benefit and offer both the museums and the visitors.

Especially in Greece, 65% of the tourists make an online search of their destination and 45% of them are interested in cultural heritage, monuments, museums and archaeological sites. It is rather important to make cultural heritage appealing and accessible to all in order to promote it and attract more people.

The Virtual Museum of the Stoa of Attalos is an application where the visitor is able to make a tour in the museum on his own, explore it, interact with the exhibits, rotate them and learn all the necessary information about them (Skamantzari 2015). The development of this application took into consideration various aspects such as the requirements' analysis, the architectural design, the planning of the exhibits' presentation, the user interaction, the programming process and the evaluation of the final product (Lepouras et al. 2004).

3.2 Data Available

As far as the Virtual Museum of the Stoa of Attalos is concerned, the virtual environment hosts some of the exhibits which can be found on the ground floor of the Stoa of Attalos, in the Ancient Agora of Athens. For this project, only 16 of the exhibits were chosen from the south part of the colonnade of the museum and the most important concern was to produce accurate, realistic and appealing 3D models that can be used in virtual applications, especially in a short period of time. That is why photogrammetric methods and 3D surveys were used for the mass production of the exhibits' 3D models and the development of the virtual museum. In order to process the data and build the accurate, textured 3D models of the exhibits PhotoScan Professional® v.1.1 software by Agisoft was used (www.agisoft.gr).

3.3 The Development of the Virtual Museum

The application is available in two languages, Greek and English. In the beginning of the virtual tour the visitor has the chance to read the instructions that are available in order to freely navigate in the environment and understand the options and opportunities he/she has in the virtual museum (Fig. 5). Particular attention was given to the formation and design of this panel with the instructions so as to make the virtual tour simple and understanding. The parameters that concern the movement, speed, rotation, height vision and behaviour of the visitor were extremely important in order to make the navigation friendly and easy for the visitor, as the majority of them may not have any previous experience with this kind of applications or even with the use of computers. This is the main reason why the instructions appear in the beginning of the application. During the navigation the visitor listens to the music that is used as a sound effect so as to have a more appealing, pleasant, entertaining and interesting navigation.

Fig. 5 The virtual environment of the museum in the beginning of the navigation with the available instructions to the visitor

Moreover, the ambience and the depth of field were properly adjusted in order to have a more clear and realistic view of the exhibits, which is also important to the visitor and his/her virtual experience in the museum. Then, the visitor has the chance to learn and find out more information about the exhibits that attract and interest him/her simply by clicking at them (Fig. 6). Moreover, the visitor is able to rotate the exhibits while the panel with the information appears on the right part of

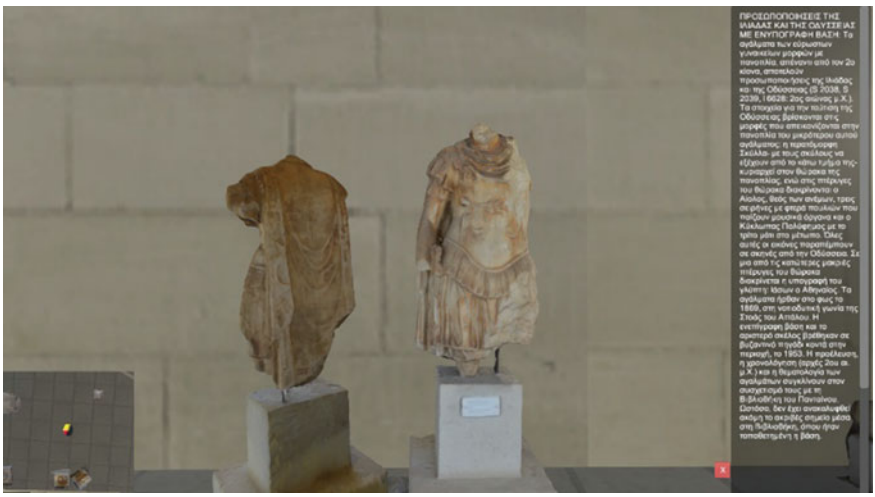

Fig. 6 The virtual museum with all the necessary elements that includes

the screen. In that way the visitor is able to manipulate, examine closely and observe the details of every exhibit and at the same time learn not only the available information of the small panel that exists in the real museum, but also further information about it. The curator of the museum has the opportunity to choose the information that will be available to visitor and this is one of the advantages of this kind of applications. The visitor is free to exit the virtual museum by pressing the Esc key whenever he/she chooses to do so. Finally, the last element that was added in the virtual environment was a mini-map to help the visitor move around and navigate in the environment without feeling disorientated, simply by offering him/her a view of the virtual museum from the top.

4 Discovering the Stoa of Attalos

The "Discovering of Stoa of Attalos" game aims at helping the player to understand the fact that the Stoa of Attalos is the result of a controversial reconstruction campaign, carried out by the ASCSA in the years 1953–56 only partially presented in the current interpretation strategies of the building (Koutsaftis 2016) as well as basic information about the project: rationale, techniques, materials used etc., without neglecting core historical facts about the original use of the building: who built it, its original use and how it was destroyed. More specifically, the player is expected to comprehend the fact that a small percentage of the building material is the original and to be able to distinguish between old and new in the context of the Stoa of Attalos. On a broader educative level, the application aims at extending the visitor's perception of the restoration of antiquity monuments. This attempted by introducing anastylosis (Hueber 2002) and reconstruction (Stanley-Price 2009) as two distinct scientific methods of conservation, by comparing them and ultimately by prompting the visitor-player to apply the knowledge acquired by recognising them in other cases of antiquity monuments (Koutsaftis and Georgopoulos 2015).

Since the gaming concept is dependent on the fidelity of the virtual representation of the Stoa of Attalos, the selected method for the generation of the 3D model of the virtual space was the image-based modelling technique and the 3D model of the Stoa was created in Agisoft Photoscan® software such as the exhibits in the case of the Virtual Museum.

4.1 The Development Of the "Discovering the Stoa of Attalos"

The game is structured in four parts, which include the introduction, the main game in 3D space, a transitionary section and a second quiz. A title menu and a closing credits scene are also part of the game (Fig. 7).

Fig. 7 The structure of the "discovering the Stoa of Attalos" game

The game begins with the introduction which is a slideshow with a succession of static images and textual information. Necessary background facts about the history of the Stoa of Attalos, from antiquity until the present time are included. It is explained to the player that the Stoa of Attalos is the result of a reconstruction project and that only a small portion of the building has survived since the antiquity. The last slide introduces the game concept and locates the 3D space of in the Stoa. A diagram, clarifies the part of the Stoa's area that is occupied by the gaming environment. The player is presented with the game mission, the task that is to be fulfilled: answering correctly on the question of the originality of the specific part of the Stoa of Attalos that is included on the interaction hotspot each time.

After finishing the introduction part players are able to continue with the main game in which they are transferred to the Stoa of Attalos where they can freely navigate, using a first-person perspective and can examine closely the surfaces and some exhibits and objects. As already explained, the game area is confined in the textured modelled part of the Stoa. The interaction between player and textured model composes the core of the gameplay. Seven areas of authentic material were recognized after consultation with the site's archaeologists and were mapped on the model, on the interior façade of the stores and on the internal façade of the south wall.

When the player approaches each one of these areas, a quiz dialog is triggered. The question the player is confronted with is about the authenticity of the material in the specific area, which is highlighted in order to be clear which part is in question. A GUI (graphic user interface) provides immediate feedback for the choice (Yes/No) and occasionally additional information (text, images) connected with the specific interaction area is also displayed (Fig. 8).

Obviously, for the game play to be challenging enough, it must contain various degrees of difficulty. For that reason, it was necessary to include interaction with areas of restored material or added objects. Besides, among the learning goals, as it was previously analyzed, is the understanding of technical matters of the reconstruction project as well as the current use of the Stoa of Attalos, which can be supported by providing context-sensitive information. Both these goals are closely linked to restored parts of the monument. The areas of restored material are organized in object groups, providing identical feedback to the player's interaction.

These groups are the following three: a. *The Ionic colonnade*. Clicking on each of the columns the player is informed about the sourcing of marble and the fact that local craftsmen worked following ancient techniques, all with accompanying images. b. *The statues—exhibits*. It is clarified that all the statues and the ionic capital are added objects. The use of the Stoa as a museum is highlighted, as well as

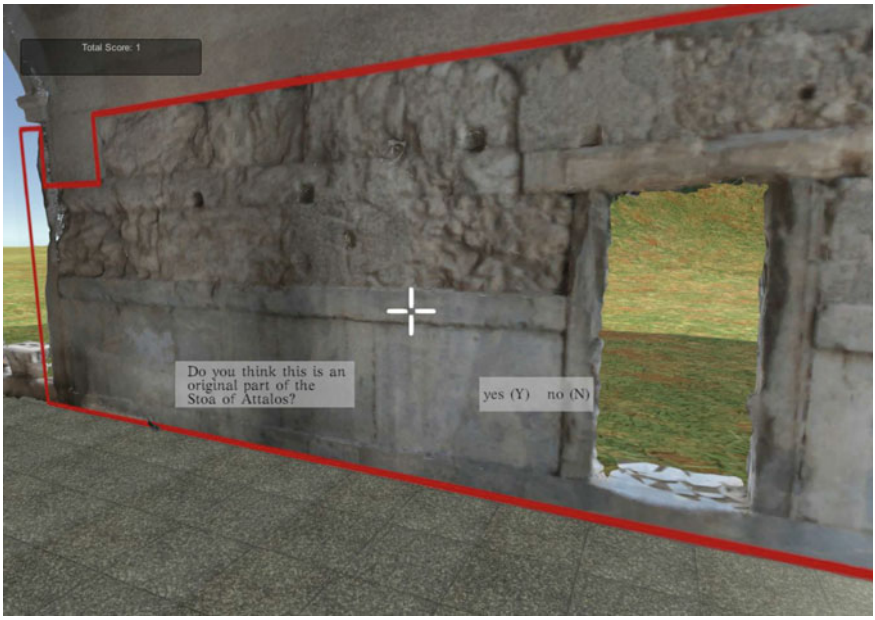

Fig. 8 Quiz dialog in one of the interaction hotspots

the wealth of the findings of the Agora excavations. And finally, c. *The wooden doors on the stores wall*. Information provided is on the current uses of the building of the Stoa as a museum, administration offices and open-air sculpture exhibition.

In the transitional section which is the next step of the game, the concept of reconstruction as a specific conservation method is introduced and juxtaposed to anastylosis as the preferred alternative method nowadays. The example of the Acropolis is introduced as an anastylosis case. This section, like the introduction, has a guiding role to the player by organising the acquired knowledge in the previous part of the game, providing a summary of the completion of the level and offering a chance for reflection, while functioning also as an introduction to the next challenge and the task and its objectives.

In the last part of the game, the player is challenged to apply the knowledge acquired in the previous section by recognizing which one of the two methods (anastylosis—reconstruction) is implemented in a series of restored monuments which are presented in photographic images (Fig. 9). The feedback to the player's choice is accompanied by some basic information about the intervention in each case.

Simple quizzes have been explored as a basic and schematic game structure, but also one that involves cognitive aspects such as reflection, analysis of the question on available clues and previously learned concepts and critical reasoning. The player can easily focus on the content of such embedded quizzes, which have been proven to successfully enhance first-person exploration of virtual game spaces and

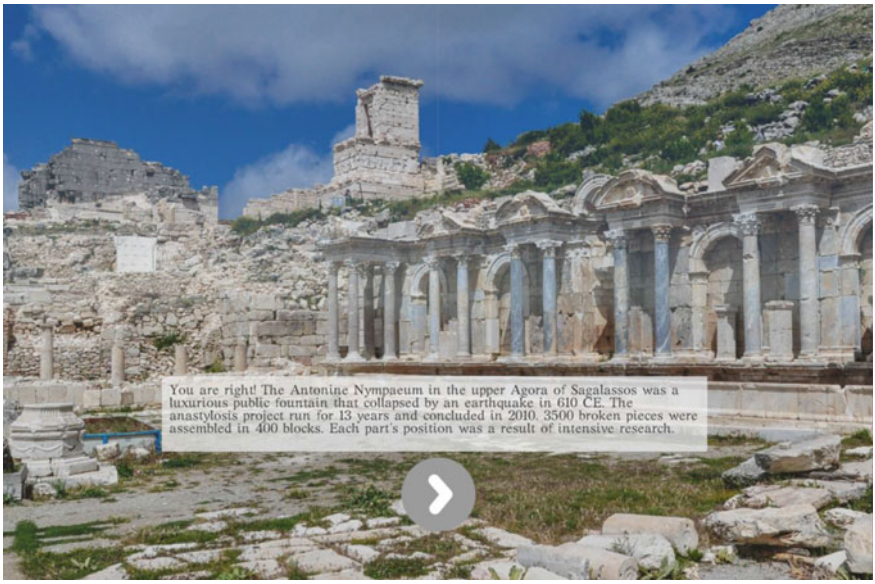

Fig. 9 Screenshot from the image quiz "anastylosis or reconstruction?"

provide the same degree of satisfaction as state-of-the-art games (Bellotti et al. 2010). In this case, a specialized technical intervention, the restoration of an archaeological monument, becomes the subject of a game and since the content can be a challenging one, the simple visual quiz structure was selected. Focus is indeed on the content and the application of previously acquired knowledge.

Moreover, this part of the game could generate a positive spillover effect by stimulating the player to learn more about the presented monuments or even inspire him/her to visit the sites in person.

5 Conclusions

Although it may sound strange, tourism and cultural heritage in general have a lot to benefit from technological advances in the field of Geomatics. The ability to produce realistic three dimensional texture models of archaeological objects, small or large, movable or immovable using contemporary computer vision and photogrammetric algorithms, has contributed a lot to the dissemination of vivid visual information about the treasures of museums and archaeological sites. Hence through these technological achievements a contemporary way is developed for attracting visitors.

The development of the virtual museum and the two games and their realization in Unity 3D® was a rather challenging and complex process that required constant

testing and control at every step of the procedure. The results, as shown, were visitor friendly environments, easy to use and understand, while maintaining the accuracy and realism of the 3D models. Information and Communication Technologies (ICT) combined with Geomatics methodology of data acquisition and processing offer many interactive possibilities. The educational character of these applications is rather obvious as the visitors/players learn through a vivid, realistic and appealing process while at the same time they have the chance to interact with the monuments and the exhibits and advance their knowledge in a pleasant manner. At the same time the touristic product is believed to be promoted in a subtle, but effective way. Many improvements can be made to these virtual museum and game applications. However it is believed that they prove the concept set as goal at the beginning of this effort.

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