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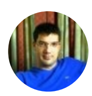

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***Abstract*—The implementation of a virtual environment is challenging when the area to be covered is of large scale with existing objects such as historical buildings, castles, city neighbors, traditional villages etc. The desire for high fidelity is compromised by the computer machine limitations thus imposing a certain trade-off between fidelity and performance being thoroughly investigated in this work. In particular, although fidelity has to be reduced to achieve better performance, there are certain limits as its reduction is totally perceived and negatively judged by the users in case of close observation. Furthermore, immersion of a user is one of the essential elements for efficiently experiencing the cultural aspects of the implemented virtual environment. In this paper, the various phases (requirements, design and implementation) for constructing a large scale virtual environment that highlights cultural heritage aspects are presented and the results are being evaluated by user tests. To enable the expansion of the virtual environment over an extended area, the integration of GIS mechanisms is also proposed to guide users and enhance their experience. Segmentation of the virtual environment is also proposed to make development manageable and improve performance.**

I. Introduction

Three dimensional (3D) virtual environments, also called 3D virtual worlds, increasingly become a suitable solution for modern applications in the area of visual representation. Having many characteristics such as intuitiveness, easy of use, interactivity and immediacy, virtual environments are also applicable in promotion and preservation of cultural heritage as deduced by the numerous examples, e.g., [1], [2], [3].

A virtual environment is proposed here for promotion and preservation of the cultural heritage, focusing on architectural heritage of the Ionian Islands (Greece). The Ionian Islands is an island complex located at the boundaries between the Adriatic and Ionian Sea, at north-west of Greece. It consists of numerous islands, inhabited since the ancient ages and hosting, through the centuries, numerous civilizations due to consequent conquests (Greeks, Romans, Venetians, French, British). The osmosis with these civilizations has left a unique footprint on these islands seen today in the culture of everyday life and most characteristically on the architectural monuments. Under this light, the proposed virtual environment aims at representing the large scale anthropogenic environment of the Ionian Islands, i.e., cities, towns and villages, including the exterior and the interior of a number of selected architectural objects.

Such large scale environments impose certain problems with respect to computational power and memory requirements by the computer machines that need both to support and display them. These problems are inflated by the fact that virtual environment's *elements*, used to represent cultural heritage objects have to resemble the real ones and represent them in real time, high *fidelity* and realism, demanding increased computer *performance* and virtual environment's *responsiveness*. The term fidelity refers to the degree of resemblance between the virtual environment's and the real world's objects, performance refers to the workload that a computer machine carries out in a defined time period and responsiveness express the particular time needed for the computer machine to respond to users' actions. The virtual environment under consideration takes into account the described challenging problems and provides cultural heritage promotion, preservation and even virtual restoration by providing users an alternative way to explore and observe cultural heritage objects and access supplementary information resources.

In this paper, the focus is on the development of a large scale virtual environment suitable for efficient and realistic digitized cultural heritage representation. Its main characteristics are the following: (i) it is efficient as it maintains critical functionality factors as performance and responsiveness; (ii) selected cultural heritage objects are realistically, in high quality and fidelity represented by elements of a virtual environment; (iii) it uses *immersion* (the feeling of being and acting in a virtual environment) [4] to provide users comprehensive and holistic view of the represented cultural heritage objects; (iv) it supports coverage of large areas and of many *points of interest* using *Geographical Information System (GIS)* to provide maps of the covered area, (v) large scale functionality constraints are overridden by using *segmentation* of the covered area; and (vi) *usability* is enhanced by use of well-known *Human Computer Interaction (HCI) metaphors* [5].

The contribution of this paper is twofold. First, a framework regarding to development and functionality issues set by the large scale is presented. Second, a novel experiment is conducted to evaluate the virtual elements' fidelity along with the system performance providing a useful dataset and valuable results.

The proposed virtual environment is accessible through the web overriding any distance restraints and therefore, allowing for international promotion while further uses are also possible, e.g., becoming an educative platform [6] since places or objects of special interest carry memories about other places, persons, objects or even events of the past and this information can be made available to interested communities. The points of interest are categorized to enable advanced search and spotted on the map with a marker. Appropriate software components and user interfaces provide useful information in text or multimedia and a link targeting to the 3D virtual representation of the selected location.

In Section II, related past work is presented and Section III describes the main objectives of the presented virtual environment as well as the challenges set by the aforementioned objectives. In Section IV, a short description of the followed development process is provided. The virtual environment's and the supporting system's architecture is given in Section V. Section VI is dedicated to one of the objectives-challenges and describes the fidelity-performance and responsiveness issues of the virtual environment as well as the evaluation tests and results. Section VII both summarizes this work and draws the lines for future ones.

II. Related work

There are numerous works or projects aiming at virtual cultural heritage. However to the best of the authors' knowledge, it is the first time that a virtual environment is designed to include an island complex of such extent. The most well-known application corresponds to the development of virtual museums [7]. Museums and artefacts have certain constraints such as the required space, travelling distance between a potential visitor, passive artefacts etc. [7]. In [8], [9] the authors propose the use of game engines in the creation of virtual museums. Game engines offer the functionality needed for a virtual environment avoiding its time-cost development from scratch.

In [10], [11] a web-application has been developed to represent the Basilica of Saint Silvestro at the Catacombs of Priscilla. In this work Unity3D [12] game engine is used to enable the virtual environment. In [13] Autodesks Image-Modeller [14] software has been used to design the interior of the museum and a desktop 3D laser scanner to scan the artefacts and create accurate 3D models of these. Thereafter, the 3D models are imported in Unity3D to construct the virtual museum. Although not related to virtual reality in [15] a novel system is proposed, combining multimedia with traditional GIS to improve the provided services for recommendations of spatial located places (Geosites) and having a feature of special interest as it is able to personalize its interaction to each individual user.

III. A Virtual Environment for Efficient Cultural Heritage Representation

The development of the particular virtual environment is challenging due to the fact that (i) it has to accurately and realistically represent the selected cultural heritage objects preserving and promoting their uniqueness; (ii) it covers a large area; (iii) it has to be immersive enough for providing users an interactive experience of the represented cultural heritage objects; (iv) at the same time to be efficient and (v) overall enhance system's usability. An example of realistic representation of large scale objects is seen in Fig. 1

Fig. 1. The proposed virtual environment enhances the realistic representation of large scale objects (view of Spianada square and Ionian Academy in Corfu town).

Realistic Representation and Uniqueness of the Represented Cultural Heritage Objects: It is important to preserve the uniqueness of the represented region of the Ionian Islands, to enhance the user's experience and be close to reality. As a result, places and specific objects related to the uniqueness of the region are specially treated. In particular, these specific objects are identified, creating a collection for reusability purposes, taking care not to introduce any negative impact on uniqueness. To improve realistic representation 3D models have to look like as if there are made of the same material as the real ones. Suitable *textures* are extracted from photos taken on site and used as materials that cover the 3D models. Additional to textures appropriate *illumination* and shadows are applied to improve *photorealism*.

Large Scale: Virtual environments, especially of large scale, are quite demanding about computer resources, mainly computational power, memory – *Random Access Memory (RAM)* – and network bandwidth. Virtual environment's segmentation as well as balancing the represented objects' fidelity with the performance are proposed as a solution to the increased demand on computer resources. Segmentation has the advantage of reducing the downloading time of the virtual environment's data, abridging the user's device memory occupation and accelerating the representation of the 3D models. Development issues set by the, due to the scale, increased workload, are resolved through a well defined process described on Section IV which includes segmentation and *iterative development* of the described virtual environment. An additional issue is users' guidance in the virtual environment (e.g., not get lost, avoid unwanted and purposeless roaming), use of map in combination with segmentation is proposed as a solution as users can be immediately directed to selected points of interest.

Immersion: The user through immersion (the *sense of presence* or simply *presence*) acts as in a real environment (e.g, thoughts and feelings are able to distract him/her from reality). To enhance immersion, in this paper authors propose high fidelity along with photo-realistic representation of the selected points and objects of interest to enhance the vision experience that is the main sense of perceiving the world. Additional to vision, usage of appropriate sounds is considered as an important factor of users' immersion.

Efficiency issues: Fidelity, Performance and Responsiveness: The way 3D graphics are eventually represented is called *3D rendering*. 3D rendering is performed on users' computer machines (client-side) and is time, *Central Processing Unit* (CPU) and memory consuming, especially as the number of 3D models and their complexity increases. Despite the advancement in today's CPUs, *Graphic Processing Units* (GPUs) and 3D rendering algorithms, there are still many constraints. In order to create a lightweight virtual environment of acceptable quality, there is a trade-off between fidelity and performance. Fidelity is related to the resemblance between the real object and its virtual clone, while performance is related to the particular time that a computer machine needs to represent the virtual object. Fidelity is measured by the number of *vertices*, *edges* or *faces* that a model consists of and as these values increase, fidelity is improved. In this paper, the number of faces is used as measurement units for fidelity. Performance is measured in *frames per second* (fps) and describes how many times per second a particular computer machine terminates a 3D rendering function for a scene in a virtual environment. Obviously, large values of the number of frames per second are preferred. Even though, both performance and fidelity should be high enough to satisfy the virtual environment's users, there are certain limits such as the amount of data to be processed and the time needed to do so, set by the finite computational power. The challenge is to *balance* both fidelity and performance, given that the higher the fidelity, the more reduced the performance. Performance also affects responsiveness, i.e., the particular time needed for the computer machine to respond to users' actions. A set of tests have taken place in order to estimate the acceptable levels of fidelity, performance and responsiveness as described in Section VI.

Usability: The virtual environment under consideration has to be usable not only for computer-literate users but also for less experienced. A brief analysis of user requirements is carried on resulting that: (i) users should be provided with instructions (guidance in the virtual environment), (ii) relative information on available choices (points of interest or elements) has to be easily accessible and recommended by the system, and (iii) the above should be based on well known HCI metaphors. According to these conclusions authors propose the use of a World Wide Web *front-end* providing easy to use *views of the front-end* suitable for viewing information. In these views of the front-end, maps are incorporated to provide users intuitive interfaces with a consistent view of the points of interest accompanied by information material while markers are used as an HCI metaphor to spot the points of interest.

IV. Development process specifically aiming at cultural heritage objects

The development process followed by the development team and presented here is composed of a number of different phases producing well defined intermediate outputs that comply with the requirements (i.e. large scale, efficiency, realistic representation, immersive experience and usability) set by the key characteristics of the virtual environment under consideration and its aim is to improve both the quantity and quality of the produced result to be suitable for cultural heritage representation applications. Fig. 2 depicts the followed development process.

Preliminary phase: Initially, the cultural heritage objects to be included must be recognized and studied. In this phase research about the selected objects is carried out in order to acquire useful information and material, e.g. maps, architectural drawings, historical information, etc.

Site mapping and object recording: Each real point of interest is physically visited and adequately mapped in this phase. Every important object on site is recorded, as well as its dimensions and position using technologies such as *Global Positioning System (GPS)* and GIS. During this phase, maps and architectural drawings are sketched on the spot if they are not acquired in the preliminary phase. Additional to maps and drawings, photos and videos are necessary material in next phases of development. In this paper, maps, drawings, photos and videos are also called *raw material*.

Raw material editing: In this phase raw material acquired by previous phases is edited in order to be usable in the virtual environment's development process and it includes digitization and editing of hard copy maps and drawings as well as editing of photos acquired in site mapping phase. Any photos taken are used for textures' extraction for the materials of the 3D models in order to realistically represent the virtual environment's elements. In order to obtain appropriate textures, photo editing (e.g., correcting perspective distortions and brightness/contrast tuning) is necessary.

Architectural drawing: Architectural drawings are used as the basis of the virtual version of the real point of interest. They involve buildings' and landscape architecture as the architectural objects are inextricably connected with their surroundings. During this phase 2D architectural drawings that will guide the 3D modelling phase of the architectural elements are created/edited using e.g., the Autodesk AutoCAD (Version 2014, 2014) software [14]. Focusing on specific architectural details confers the sense of uniqueness of the objects of interest. Eventually, all details recorded during the site mapping phase are taken into consideration in this phase while their visual construction is completed in the next phase.

3D Modeling: All 3D models used in the described virtual environment are created by the development team using two different methods depending on the case, (i) manual editing of 2D architectural drawings for architectural objects and the broader anthropogenic environment; and (ii) automatic image based for smaller objects of complicated geometry, i.e. sculptures, small size monuments and artefacts. The software used for this purpose is Autodesk 3ds Max (Version 2014, 2014) [14] for the manual 3D modeling and 123D Catch [16] for the automatic image based 3D modeling. Once the 3D models are designed they are overlayed by the material made of, using the corresponding photo-extracted textures to look like the real objects.

Constructing the virtual environment's points of interest: A virtual environment is not a static view of objects but it gives users the ability to move in it and interact with the designed scene as in reality. To create the virtual environment a game engine is used, i.e., Unity3D [12] (Version 4.3, 2014) software. The effort for realistic representation is carried on and during this phase (the virtual environment's settings affect the appearance of it's elements) and the resulted representation is improved by applying illumination and shadow models.

Unifying the virtual points of interest: One of the challenges of the considered virtual environment is its size as it spans over ten islands covering an area of about 2307km^2 and having many points of interest. A special designed map based on a public available GIS (Google maps [17]) is used to represent the whole area covered by the virtual environment and markers on it to spot points of interest.

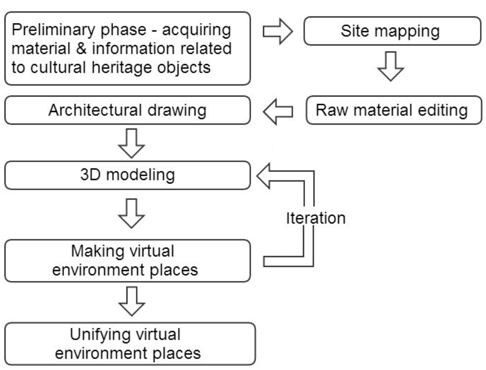

Fig. 2. The development process.

V. System's architecture

The proposed system's architecture is based on *client-server* architecture, as shown in Fig. 3, and aims to efficient functionality of the virtual environment taking into consideration the large scale factor, the support of high fidelity and realistic representation and it complies with extensibility requirements. It is also developed to provide users with worldwide access to the virtual environment and any other related information material and to support multiple platforms using user-friendly interfaces. In the proposed architecture each service is installed on a separate, dedicated to it, computer machine for increased performance. Nevertheless the whole system, including the client, could be installed on a single computer machine reducing the cost but sacrificing the performance.

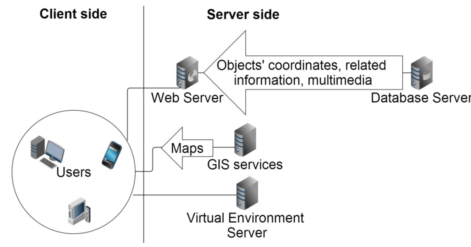

Fig. 3. Architecture of the considered virtual environment.

With the term client the computer machine, or any other device capable of processing data, used by users in order to access the virtual environment is meant. Web server handles the requests send by clients and serves views of the front-end depending on the parameters (e.g., points of interest, categories of points of interest, etc.) of the request. Use of the publicly available GIS simplifies the system's architecture, reduces the cost and may minimize malfunction incidents. The database server is required as the system makes use of different types of information that have to be permanently stored and instantly served to users. An increased computational power computer machine is used as virtual environment server. The use of a computer server, with sufficient processing power and memory, having high bandwidth network connection, dedicated to this purpose is set by the efficiency requirements as virtual environment elements have to be delivered to computer clients with as short as possible delays. The proposed architecture so far deals with the one user case. The multiple user case, left for future work, imposes numerous challenges [19], [20].

VI. Evaluating Fidelity, Performance and Responsiveness

Fidelity, performance and responsiveness are addressed here by conducting a set of experiments including users' evaluation. Computer-literate users have to accomplish an objective while moving, by controlling an avatar, among objects of diverse fidelity, as seen in Fig. 4. Diverse fidelity is employed to create realistic conditions that will cause changes on performance that will be recorded and studied later in combination with the users' evaluation.

A. Description of the experiment

In the conducted experiment eleven scenarios are tested parameterized according to the represented 3D models' fidelity. Users have to accomplish a certain objective in order to record performance and responsiveness against fidelity for each case. Reduced performance tends to put a negative effect on responsiveness, making motion and controlling a user's avatar difficult. Performance of the virtual environment in fps and all users' actions (i.e., avatar's movements required to accomplish the objective of each case) are recorded. It is observed that the less responsive the virtual environment, the more the user's actions required. Finally, a questionnaire is filled in by the users to evaluate both fidelity and the corresponding responsiveness.

Before the experiment, all users have time to familiarize with the virtual environment and the objective. The experiment is conducted with five users given that five users is a generally acceptable number of testers [21]. There are eleven scenarios that each user has to test, their sequence being randomly selected for every user to avoid overtraining effects and fatigue that could affect the results. Tests are running on a common computer having the Intel i5-3230M CPU @ 2.6 GHz, 4.00 GB RAM installed, 2GB graphics memory and 64-bit operating system.

Fig. 4. The particular sculpture's model used as a reference model in the experiments as seen in 100%, 50% and 1% fidelity.

B. Measurements

In the conducted experiments the particular fidelity of the represented objects, the virtual environment's performance and the users' actions are recorded, while users evaluate both fidelity and responsiveness. All these parameters are normalized into percentages for comparison reasons. Initially, fidelity is measured by the number of faces consisting the 3D models. The more precise model has 511080 faces and it is acquired by an automatic image-based modeling process provided by Autodesk 123D Catch software [16]. This model is the prototype and is referred to as the 100% fidelity model. Fidelity is then reduced (e.g., using ProOptimizer modifier in 3D S Max [22]), thus creating experimentation scenarios of 90%, 80%, 70%, 60%, 50%, 40%, 30%, 20%, 10% and 1% fidelity. Performance is initially measured in fps, the maximum recorded value is used to represent the 100% performance and the mean value for every case is presented. For every user, the scenario case that requires the largest number of actions is selected as the reference one corresponding to 100% of the particular user's actions. After the accomplishment of a category's objective, users evaluate the fidelity of the objects seen and the responsiveness within a grade ranging from 0 to 100.

C. Results

The rise of performance as fidelity is reduced is observed in the results presented in Fig. 5. The average performance recorded in 100% fidelity category is 14.06% with 28.65 fps on average. The maximum performance, 45.83% and 60.87 average fps, is recorded in the case of fidelity 1%.

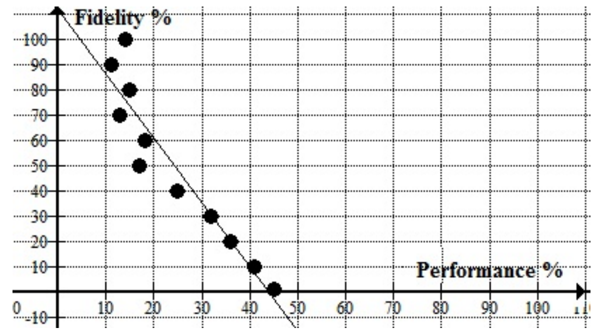

Fig. 5. Comparison of fidelity vs. performance.

When performance is increased the number of a user's actions required to accomplish the task is reduced, as seen in Fig. 6. The average number of actions needed in 100% fidelity is 75, while in 1% fidelity it is 49. Note that the reduction of user's actions improves user experience.

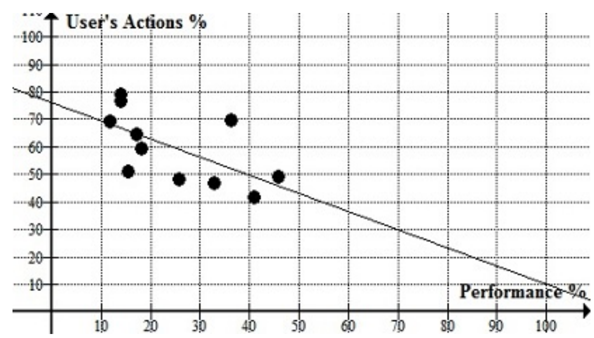

Fig. 6. Comparison of performance vs. number of users' actions.

Variations on fidelity are perceived by the users as shown in Fig. 7. There is an absolute correlation (1.0 under the Pearson Product Moment Correlation[23] test) between the existing fidelity and the evaluated one. Note that fidelity reduction in geometrical complex objects as the sculpture of the tests below 50% is unacceptable by the users for close observation cases. Beside that, it is observed that in distant observation scenarios 30% fidelity offers satisfying user experience as the details are not seen due to distance, and the average performance is kept in relatively high level, 32.92%, while the average maximum performance recorded in the case of 1% fidelity is 45.83%.

Fig. 8 depicts a comparison among performance and responsiveness as perceived by users. Responsiveness is improved as performance is increased. The less responsive category, according to users' evaluation, corresponds the case for 100% fidelity and 44% evaluated responsiveness and the most responsive category for 1% fidelity and 94% evaluated responsiveness.

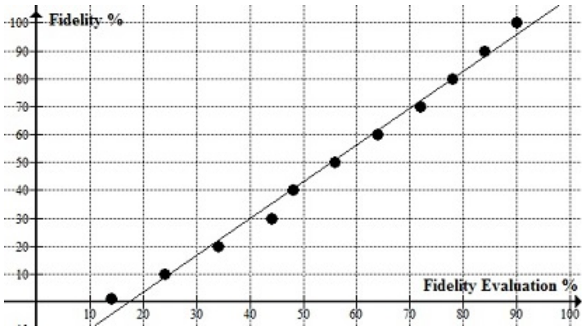

Fig. 7. Comparison of fidelity vs. users' evaluation.

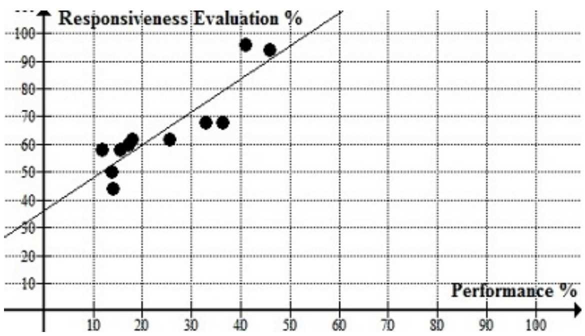

Fig. 8. Comparison of performance vs. responsiveness evaluation.

VII. Conclusions

In the present paper, a virtual environment architecture and methodology is proposed for the development and functionality of large scale virtual environments serving as a media for promoting cultural heritage. The corresponding requirements have been considered throughout the proposed phases. To enable the expansion of the virtual environment over an extended area, authors propose the integration of GIS mechanisms to guide users while offering them extra information through a user friendly GUI that consistently connects the virtual places. Segmentation of the virtual environment proposed here enables the aforementioned expansion as it makes development manageable and improves the execution by users' devices. Special attention is given on fidelity of the artefacts and the related aspects of performance and responsiveness. A set of outcomes has been extracted from the conducted tests showing that although fidelity has to be reduced to achieve better performance and responsiveness, there are strict limits as the reduced fidelity is totally perceived and negatively judged by the users in case of close observation. In future work, tests will be expanded for more users and more cases of close and distant observation for various different categories of artefacts having different requirements on fidelity.

VIII. Acknowledgements

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References

[1] Addison, Alonzo C. "Emerging trends in virtual heritage." *MultiMedia, IEEE* 7.2 (2000): 22-25.

[2] Wojciechowski, Rafal, et al. "Building virtual and augmented reality museum exhibitions." *Proceedings of the ninth international conference on 3D Web technology*. ACM, 2004.

[3] Carrozzino, Marcello, and Massimo Bergamasco. "Beyond virtual museums: Experiencing immersive virtual reality in real museums." *Journal of Cultural Heritage* 11.4 (2010): 452-458.

[4] Bowman, Doug A., and Ryan P. McMahan. "Virtual reality: how much immersion is enough?." *Computer* 40.7 (2007): 36-43.

[5] Helander, Martin G., Thomas K. Landauer, and Prasad V. Prabhu, eds. "The Role of Metaphors in User Interface Design", in *Handbook of human-computer interaction*. Elsevier, 1997, ch. 20, pp. 441- 457.

[6] Antonaci, Alessandra, Michela Ott, and Francesca Pozzi. "Virtual Museums, Cultural Heritage Education and 21st Century skills." *Learning & Teaching with Media & Technology* (2013): 185.

[7] Tsichritzis, Dennis, and Simon J. Gibbs. "Virtual Museums and Virtual Realities." *ICHIM*. 1991.

[8] Mateevitsi, Victor, et al. "A game-engine based virtual museum authoring and presentation system." *Proceedings of the 3rd international conference on Digital Interactive Media in Entertainment and Arts*. ACM, 2008.

[9] Lepouras, George, and Costas Vassilakis. "Virtual museums for all: employing game technology for edutainment." *Virtual reality* 8.2 (2004): 96-106.

[10] Pecchioli, Laura, and Barbara Mazzei. "The museum of the sculptures in the Basilica of Saint Silvestro at the Catacombs of Priscilla. A virtual visit using Isee Web-Application." *Proceedings of the Electronic Imaging & the Visual Arts*, EVA (2011).

[11] Pecchioli, Laura, et al. "Browsing in the Virtual Museum of the Sarcophagi in the Basilica of St. Silvestro at the Catacombs of Priscilla in Rome." *Virtual Systems and Multimedia (VSMM), 2012 18th International Conference on*. IEEE, 2012.

[12] Unity company web site. Retrieved February 15, 2014 from: http://unity3d.com

[13] Monaghan, David, et al. "Low-cost creation of a 3D interactive museum exhibition." *Proceedings of the 19th ACM international conference on Multimedia*. ACM, 2011.

[14] Autodesk company web site. Retrieved January 8, 2014 from http://www.autodesk.com

[15] Charou, E., Kabassi, K., Martinis, A., & Stefouli, M. "Integrating multimedia GIS technologies in a recommendation system for geotourism." *Multimedia services in intelligent environments*. Springer Berlin Heidelberg, 2010. 63-74.

[16] 123D Catch [Software]. (2014). Autodesk. Retrieved February 17, 2014 from http://www.123dapp.com/catch

[17] Google Maps JavaScript API v3. Retrieved February 22, 2014 from https://developers.google.com/maps/documentation/javascript/

[18] Wordpress [Software]. Wordpress GNU Public License. Retrieved from http://wordpress.org

[19] Smed, Jouni, Timo Kaukoranta, and Harri Hakonen. "Aspects of networking in multiplayer computer games." *Electronic Library*, The 20.2 (2002): 87-97.

[20] Bhola, Sumeer Kumar, Guruduth S. Banavar, and Mustaque Ahamad. "Responsiveness and consistency tradeoffs in interactive groupware." (1998).

[21] Nielsen, J. (2000, March). Why you only need to test with 5 users: Alertbox. Retrieved January 15, 2014 from http://www.useit.com/alertbox/20000319.html.

[22] ProOptimizer modifier, 3ds Max (Version 2014) [Software]. Autodesk. Retrieved January 15, 2014 from http://docs.autodesk.com/3DSMAX/16/ENU/3ds-Max-Help/index.html?url=files/GUID-109C880F-181B-4067-91F0-B4EF79639FB3.htm,topicNumber=d30e250634

[23] Stanton, Jeffrey M. "Galton, Pearson, and the peas: A brief history of linear regression for statistics instructors." *Journal of Statistics Education* 9.3 (2001).