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THE 'SYNTHESIS' VIRTUAL MUSEUM

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ABSTRACT

Open linked data technologies pave the way towards the semantic Web of the future by a) exploiting the abundance in data availability, b) enhancing the continuing application developments in the Web and computer technologies, c) increasing the availability of game engines towards an expansion of techniques and d) bridging culture and education with gaming. In this context, we introduce an innovative and content-dynamic web-based virtual museum, which relies and exploits the rich content of distributed web cultural resources and supports the creation of custom painting virtual exhibitions for cultural and educational purposes based on gaming technologies.

KEYWORDS: Virtual museum, virtual exhibition, gamification, interactive cultural exhibition, open link data.

1. INTRODUCTION

The continuous development of web services and computer infrastructures complemented by the increasing availability of game development software engines, contribute to an on-going expansion in the release of serious games (SG) in diverse areas, ranging from entertainment, cultural heritage (CH), education, artificial intelligence (AI), sociology, military to health systems (Breuer & Bente 2010). In this sense SGs can be thought of as bridging culture and education with gaming. By utilizing contemporary visualization and simulation technologies SGs are able to enhance the user experience in realistic environments with enhanced interaction (Van Eck 2006). This form of stimulation is considered to be one of the basic factors for the successful user activation, being the force that promotes focusing in the activity process and encourages users to continue. Stimulation may be considered as a targeted mechanism to achieve the desired results, and is greatly supported by using SGs (Rogers 1996).The notion of virtual museums and exhibitions has been introduced as a means to overcome the limitations of the physical space and to provide a vivid experience to remote visitors (Tsichritzis & Gibbs 1991). An overview of virtual museum technologies is presented in (Sylaiou et al. 2009).

2. RELATED WORKS

Numerous works utilize various technologies to support cultural heritage purposes, such as historical teaching and learning, or to enhance museum visits. In (Pavlidis et al. 2006), a management system of 3D digital models and a dynamic virtual exhibition showroom was introduced as a dynamic web-based virtual museum framework. In addition, in (Pavlidis et al. 2008) a more realistic framework for digital museums has been presented with the creation of a non-realistic digital replica of a museum that presents its educational activities and not its exhibits, aiming at producing more actual museum visits. In (Djaouti et al. 2009) interactive SGs for the promotion of a prehistoric heritage site of the Gargas caves (French Pyrenees) were presented. In (Anderson et al. 2010) a state-of-the-art review was presented for the existing theories, methods and technologies utilized by SGs as cultural heritage promotion tools, showing several case studies representing those technologies. Taking a step further, works like (Bellotti et al. 2012) focus on a generalization of the task-based learning theory with great advantages of smartphone support. In addition, the researchers in (Koutsoudis & Pavlidis 2011) proposed a new approach in navigating within complex cultural scenes by exploiting content-based descriptions. Scaling down to the smaller scale, the researchers in (Koutsoudis, Makarona & Pavlidis 2012) propose a content-based navigation framework for a virtual museum, based on metadata that describe the exhibits, thus providing semantic-similarity-based navigation. In a recent work (Bonis et al. 2013) a multi-user virtual exhibitions framework has been proposed that adapts to the visitors' preferences. In (Doulamis et al. 2012) an SG is proposed based on a cultural heritage scenario, and tries to enhance knowledge of cultural heritage by spreading a mystery in the ancient world.

3. GAMEFICATION AND GAME ENGINES

Nowadays gaming for education purposes, is a significant area for investigation and applications (Bowman et al. 2005) (Nicholson 2011), (Pavlidis 2015). This has taken either the form of game-based learning or serious gaming. Generally, gamification is the result of serious games based on learning, the content and game design. According to (Brown & Vaughan 2010), playing is an archetypical activity that arises from primordial biological structures existing before the conscience or the capacity for speech; it is not something a person decides to do According to Nicholson (2011), gamification is nothing more than the use of specific game design approaches and techniques in various environments, in order to attract people in problem solving and to enhance their contribution.

As gaming is one of the most important parts of the gamification the Game engines are strictly necessary for building applications. Game engines are powerful software packages that efficiently use rendering pipelines, special data-structures and speed-up techniques for visualising texture mapped 3D objects, scenes and 3D worlds in real-time with incredible graphics and interaction capacities (Harrison 2003).

The choice of game engines for building dynamic realistic virtual environments was guided by the numerous possibilities and advantages offered by nowadays game engines (Kiourt et al. 2015). There is a wide selection of 3D game engines available for potential use. We explore the basics of the most well-known contemporary game engines that are available to developers. According to the (Patel et al. 2003; Craighead, Burke & Murphy 2008; Sillaurren & Aguirrezabal 2012; Unity3d 2015; Crytek 2015; Unreal 2005; Kiourt et al. 2015), we have collected some major descriptions regarding these game engines discussed here.

1) Unity: Unity (Unity3d 2015; Patel et al. 2003) game engine is 3D and 2D game engine, which offers a large variety of features and very user friendly interface. Unity, lacks of real modelling or building features outside of a few primitive shapes, and consequently every 3D model needs to be created in a third party 3D application. However, it boasts a large asset library where a wide variety of assets can be downloaded or purchased. The Unity engine supports a number of features, such as many toolsets, animation mechanism, particle effects and editor system, real-time editor, real-rime graphics, AI Systems, cross-platform development, dynamic lights, water effects, 2D game engine, network systems, integrated physics system, terrain generation system, image effects, shaders, shadow support, multiplayer systems, music systems, C-sharp or JavaScript or Boo programming languages and many other components

2) CryEngine: The CryEngine (Crytek 2015; Craighead, Burke & Murphy 2008) was created by software developers Crytek Studios and was used in the game Far Cry first released in 2004 by Ubisoft Montreal. The CryEngine supports a number of features that are useful for creating realistic games and virtual environments, such as many toolsets, real-time editor, real-rime graphics, AI Systems, multi-platform exportation, dynamic lights, 2D game engine, network systems, integrated physics system, roads and river tools, particle effects and editor system, shaders, terrain generation system, solid designer tool, shadow support, multiplayer systems, C++ or LUA programming, dynamic music systems and many other components.

3) Unreal Engine: The Unreal engine (Unreal 2005; Craighead, Burke & Murphy 2008)is developed by Epic Games, with a core code being written in C++. The engine supports high performance rendering, advanced animation features and high-quality dynamic lighting, environmental effects, particle system, blueprint visual scripting, C++ scripting, Virtual Reality, AI avatar system, terrain builder, physically-based rendering, UI, level building, animation, visual effects, physics, networking, and cross-platform development. An important benefit of this game engine is the new particle system, which can handle up to a million particles in a scene at a time.

At this point it should be highlighted that the choice of game engines for building dynamic realistic virtual environments was guided by the numerous possibilities and advantages offered by nowadays game engines and by the needs of the developers.

4. SYSTEM ARCHITECTURE-STRUCTURE

This section provides the technical information about the development of the system.

4.1. Interconnectivity of the virtual museum

Differentiating from previous works, we present a novel content-dynamic web-based SG system primarily focused on creating virtual exhibitions (the 'Synthesis' virtual museum (SVM)), which relies and exploits the rich content of both internal and external web cultural resources to empower users to generate their own exhibitions through the usage of cross-platform gaming technologies. The 'Synthesis' virtual museum is not like any other virtual museum in that it is not the stakeholder of the exhibits; it is just the host virtual environment. It is built upon the Open Linked Data concept, thus supporting the creation of virtual exhibitions for cultural and educational purposes by maintaining purely persistent URIs and URLs. The 'Synthesis' virtual museum offers:

- VR-like, non-immersive 3D visualization, navigation and interaction
- Cross-platform functionality
- Purely user-driven dynamic exhibitions
- Interconnection with external resources based on data interoperability

Figure 1 presents an overview of the functionalities supported by the system. The current implementation of 'Synthesis' Virtual Museum supports interactive exhibitions in the form of 2D images mapped onto flat surfaces, like painting frames. Both exhibition visits and exhibition administration are provided through the same, unified, Graphical User Interface (GUI), thus making administration much easier and more intuitively coupled with the end-user experience.

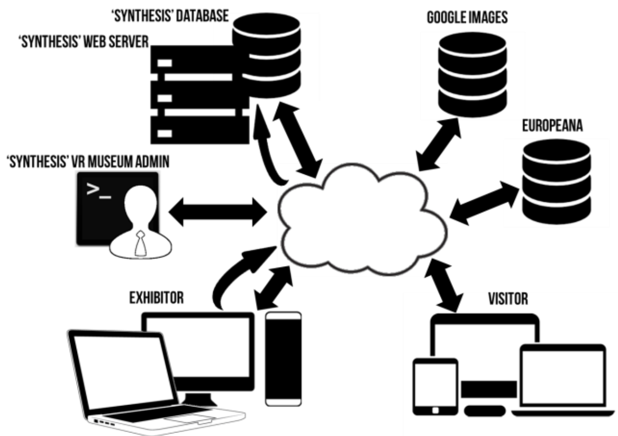

Figure 1. Abstract functionality diagram of the system.

The system requires that all users be registered. Each registered user is able to either browse and visit exhibitions, or become an exhibitor and administrator of his/her exhibitions. All exhibitions are viewable by all registered users. Currently, as shown Figure 1,the main image data resources are Google Images, Europeana and the 'Synthesis' database (developed for project 'Synthesis' that funded this work). Exhibition management by the users (creation and editing of exhibitions) is screened by a system super-administration (SA) responsible for activating exhibitions after a typical content verification.

4.2. *Technologies of the virtual museum*

The exchange of data between the core of the system and the external web-based resources is being done using JSON. The overall graph of requests and data exchange is illustrated Figure 2. For each repository a structured query subsystem was built according to the corresponding requirements, which handles the results of the queries with specific string DA ta structures. In addition, the Virtual Museum Server (VMS) handles the communication between the 3D virtual environment and the repositories. The VMS provides several dynamic services depending on the needs of the framework and the users; most of them are autonomous PHP services - that are applicable to any dynamic environment and platform - since the primary communication functionality breaks down to string parsing. Text parsing is applied in this system not only as a means for communication between the framework and the repositories, but also as the linked data system for building dynamic interactive 3D paintings. Simply put, any request by the users made through the GUI of the framework or any automated request activates specific C# scripts that POST string queries to PHP services of the VMS; the VMS processes and responds with specific structured string data that are being parsed by the services of the framework.

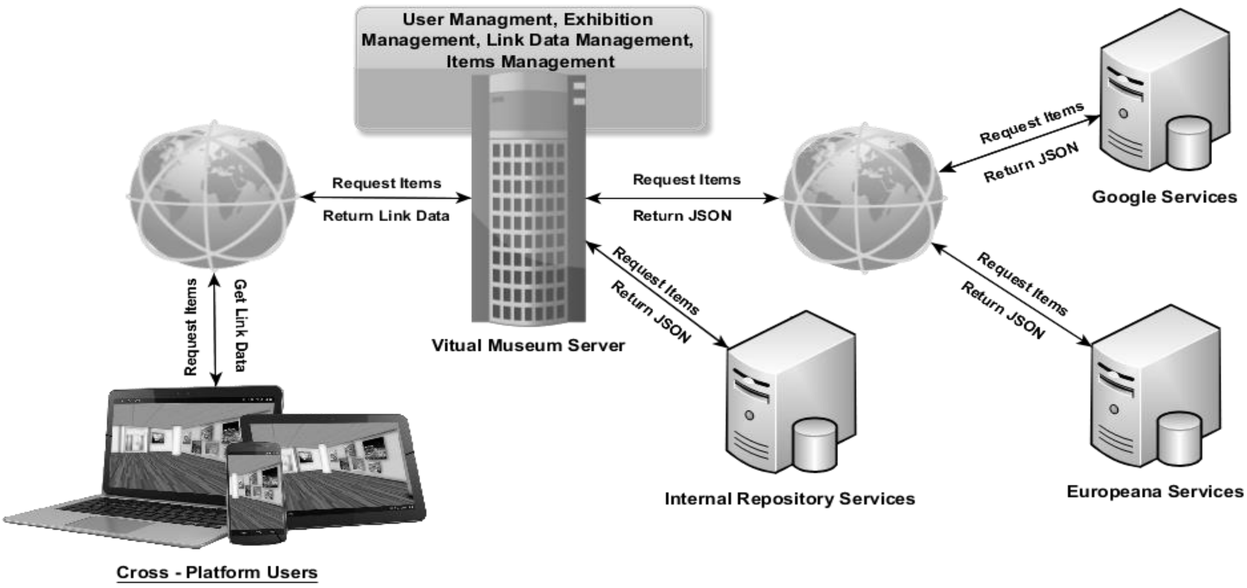

Figure 2. General technological framework of SVM

Figure 3 shows the process of the dynamic building and presenting of the interactive 3D paintings. On the left hand graph of Figure 3, the 3D painting building process is shown, beginning by providing the image's location (URL or URI) or by searching images from the available repositories. The underlying algorithm reads and analyses all the prerequisite configurations (Step 1) and starts to build in real-time the painting mesh, which is a simple box that resembles a real painting frame (Step 2). Subsequently the provided painting image from the URL or URI is mapped as a UV texture image over the object (Step 3). At the end, the user may provide any text information about the object (Step 4), based on the need of the exhibition. On the right hand graph of Figure 3, the interactivity of the 3D painting is depicted: when the user "touches" the object with a left mouse click, a pop-up window appears at the bottom of the screen with the information accompanying the exhibit.

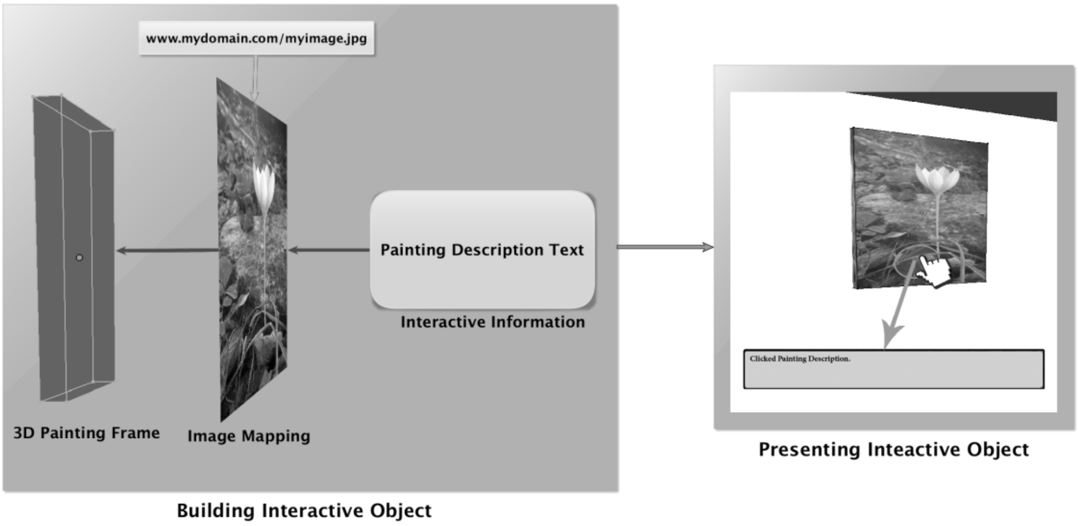

Figure 3. Workflow for reading and presenting interactive 3D paintings.

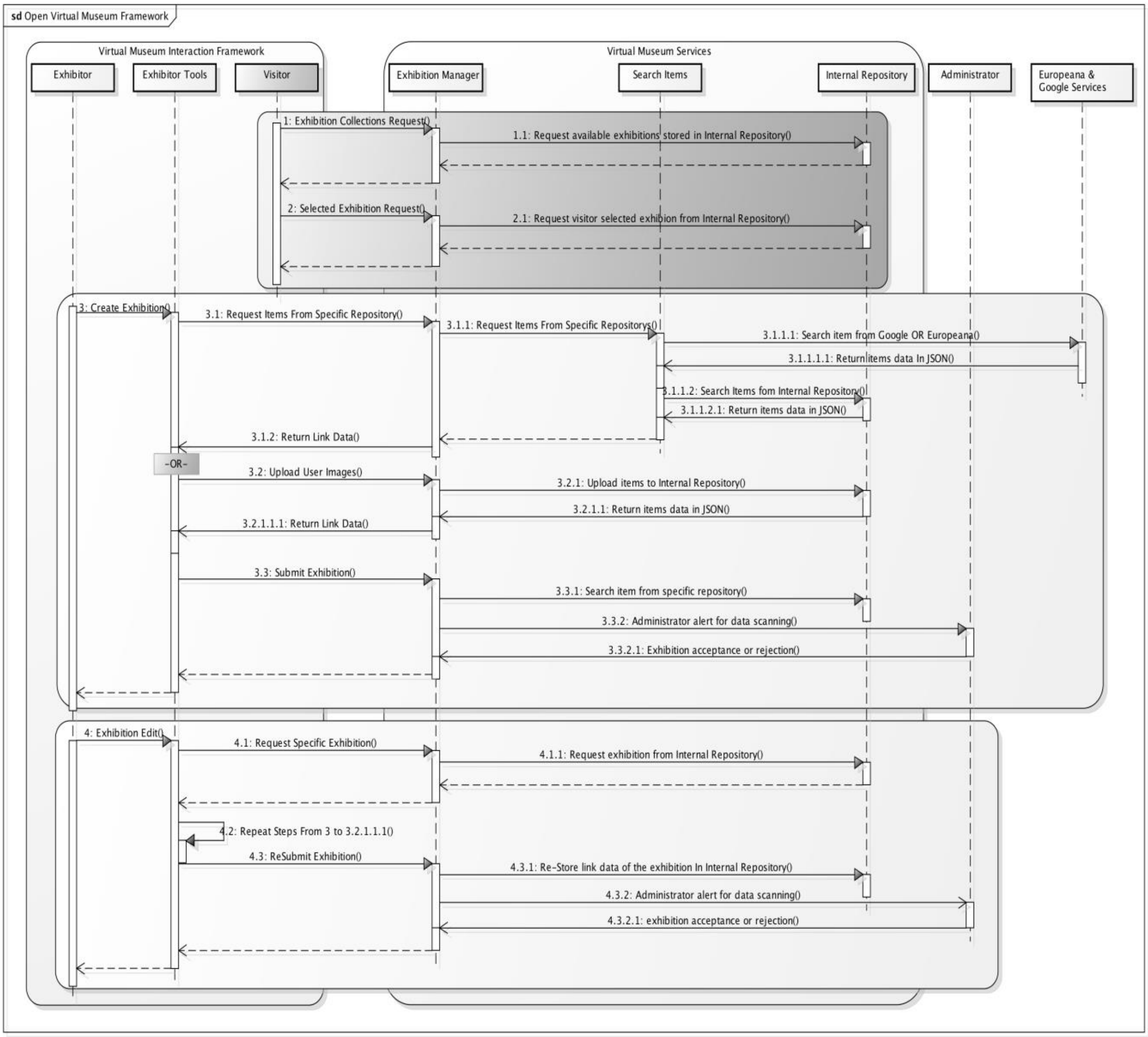

Figure 4. Sequential diagram of the activities in the SVM.

The overall graph of requests, data exchange and system usage is illustrated in detail as a typical sequence diagram in Figure 4. The visitors' perspective is depicted with a dark gray rectangle, on the sequences presented, whereas the exhibitors' perspective is marked with light gray rectangles.

4.3. *Synthesis Virtual Museum's dynamic user interface*

Visitors can basically browse through the available exhibitions and request an exhibition for viewing. Exhibitors can either create a new exhibition or edit one of their previously created exhibitions. Exhibition management is, at a top level, controlled by a system super administration, responsible for activating exhibitions after a typical content verification and appropriate content screening.

Basically, the entire user systems are built over the GUI (a 2D layer in front of the 3D scene), with dynamic components driven by a relational database. Specifically, every user interaction with a component of the GUI, is a database query which response with dynamically building components based on the query results. As an example, Figure 5 shows, the entire system for exhibition selection, which is divided into three parts. A user selects an exhibitor from a pop-up window with all the available exhibitors stored in the database. Then another pop-up window appears in the middle of the screen, providing all the available exhibitions of the selected exhibitor. Subsequently, by selecting an exhibition a short description of the exhibition provided by the exhibitor appears at another pop-up window on the right. At the end the user loads the exhibition with the "Load Exhibition" option.

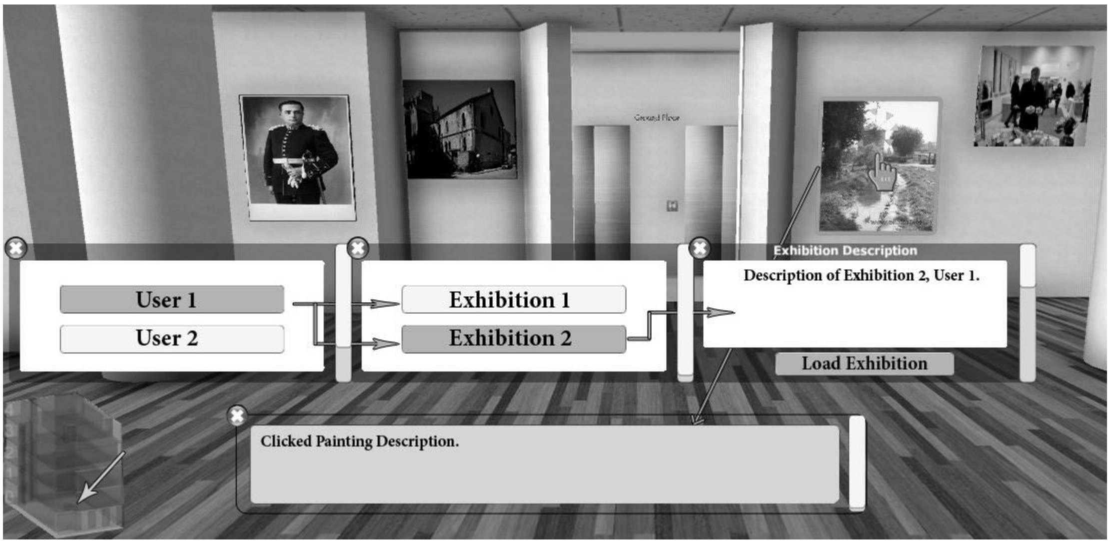

Figure 5. Exhibition selection and exhibit interaction systems.

Figure 6 shows the entire process of exhibition creation by using the corresponding tool of the SVM. First of all, an exhibition title and description should be added (panel A). The user has three options on how to add paintings in the environment: first, by searching with keywords in the available repositories (panel B); second, by uploading own images (panels Bb-1→Bb-2); third, by directly providing an image URL or URI in the input field (C2). Using the two first options, the system directly produces thumbnail previews (panel C1) from which the user may select images for the exhibition. Placed exhibits may be re-configured, shifted (moved) scaled or rotated from the last panel (E), where the final submission of the exhibition is being made. It should be emphasized that the numbering of the Figure 6 panels, is done according to the exhibition creation process.

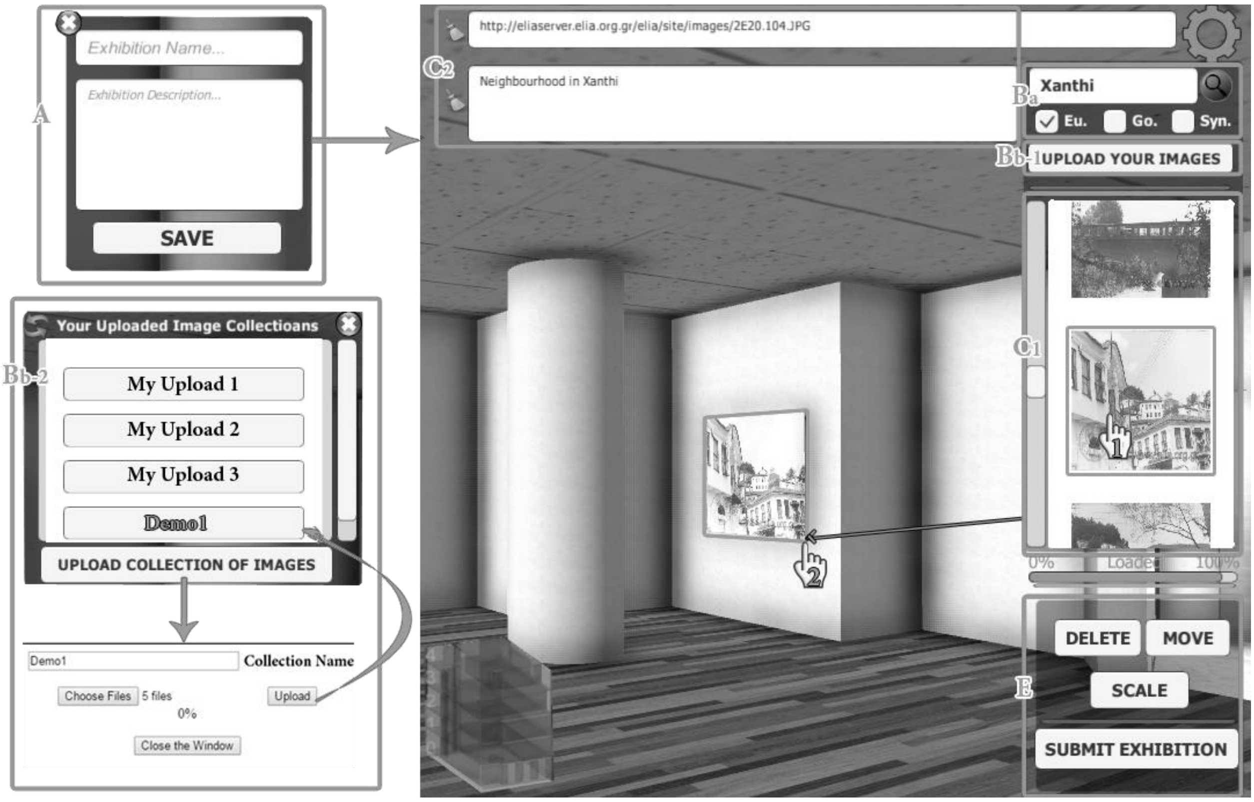

Figure 6. Exhibition development tool

4.4. Exhibitions' screening system

The SVM employs a dynamic asynchronous communication messaging system (MS). In every change of an exhibition the exhibitor and the administrator receive emails notifications. An example of the MS is the new submission notification of the administrator, in which the administrator of the SVM has to screen the content of the new submitted exhibition in order to activate it or not.

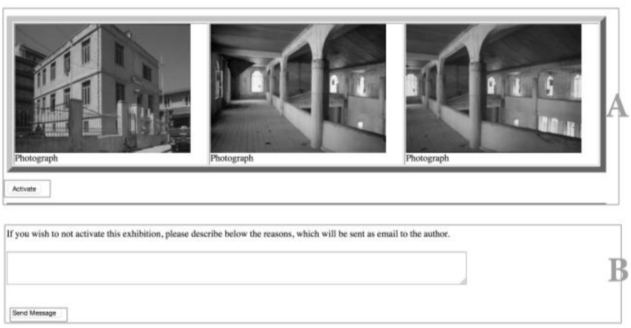

Figure 7. Exhibition screening system.

Figure 7 shows the exhibition screening tool of the SVM's administrator. All the submitted images with their descriptions are shown in a table format with two options, either to activate the exhibition or to reject it. If the administrator does not activate the exhibition, he/she has to provide the reasons, which are sent to the exhibitor. In both cases the exhibitor receives the appropriate email message.

5. CASE STUDY: THE THEOCHARAKIS VIRTUAL MUSEUM

In order to test the SVM framework presented in this paper, a case study has been conducted. The case study involved the application of the proposed technology in the development of a virtual museum for "*The B & M Theocharakis Foundation for the Fine Arts and Music*", which is located opposite the *Hellenic Parliament* in the heart of Athens, Greece. The virtual building is inspired by the original building. Figure 8 shows screenshots of the exterior and the interior of the virtual museum. The SVM technology was applied in order to provide a virtual exhibition framework that would be used in educational activities using the cultural content of the museum. To meet the needs of this case study, the SVM technology has been customized to display a virtual world that basically consists of a digital replica of the building of the *Theocharakis Foundation*.

Figure 8. Screenshot of the virtual building's exterior and of an exhibition in the ground floor.

Preliminary evaluation and testing has been conducted at the *Athens Science Festival 2015* and, a little later, at the *Thessaloniki Science Festival 2015*. At these Festivals more than 200 pupils used the system, with ages ranging between 10 to 14 (there were some younger ones also). They were very responsive and creative and, given the time and space limits, some of them developed their own exhibitions. They all thought—and were enthusiastic about it—that it could be a nice game to play at home. A long list of emails from teachers and laymen was collected in order to have them updated about the system's readiness level and availability.

6. CONCLUSIONS

By utilizing open link data on a virtual world based on the Unity3D game engine, we have developed a dynamic interactive 3D virtual museum technology that provides an open system for all users to create their painting exhibitions for cultural, educational or any other purposes. The content of the exhibitions may be provided by cultural resources and repositories, content that is distributed on the web or by the users themselves. This functionality provides a high level of open link data utilization and significant application usability from users without specific IT knowledge or programming competences. The virtual museum is built upon the serious games paradigm and provides a first or third person virtual world experience for navigation and content manipulation. The application is still being tested under several case studies, showing promising results. We are experimenting with avatars and agents to bring a diverse set of useful functionalities to the system. In particular, we plan to transform it to a multi-agent system, where virtual agents will get collective knowledge based on their social interactions with other agents and humans.

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