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A Dynamic Interactive Virtual Museum for Enhancing Students Engagement

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Abstract

Responding to the growing demand of museum visitors for a personalized digital tour experience, especially in the midst of the recent Covid-2019 pandemic, this research work aims to develop a platform for offering virtual guidance and education services at the Museum of Paleontology and Geology that is hosted at the National Kapodistrian University of Athens. The platform is developed based on innovative information and communication technologies (ICT) such as personalized recommenders, gamification techniques and gaming engines, conversational agents and 3D scanning. An overview of the platform is presented, highlighting its most significant services. The solution, apart from the user-friendly access to the museum exhibits via the 360 tours, provides a set of educational programs and games that aim to attract young people's attention and interest in learning.

Keywords: virtual museum, virtual educational programs, educational games, conversational agent, palaeontology and geology learning

Introduction

In the modern digital age, people should discover new ways of educating the new generation. Young people very easily lose their interest for learning when only traditional and/or conventional methods are used. Regarding museums and cultural heritage places, teenagers show less interest across time and visit them less than ever before. The work presented in this manuscript aims to support the transformation of museums in the digital age, making them more attractive and accessible to the society and a mean of education for young people. In our research, we focus on the Museum of Paleontology and Geology that is hosted at the National Kapodistrian University of Athens. However, the proposed solution can be adapted and used by any museum or cultural space. Even though the solution is focused on providing virtual navigation services, it is also applicable in case of physical access to the museum, contributing to the upgrade of the offered traditional services.

This paper details a platform – called from now on as v-Palm - for offering virtual guidance and educational services in museums. v-Palm is based on innovative information and communication technologies (ICT) including conversational agents, machine learning, personalized recommenders, gamification techniques, serious games and content digitalization using 3D scanning devices (Konstantakis, 2023).

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The main service offered by v-Palm is the 360 Virtual Tour that enables students and generally museum visitors to have an online tour in all the thematic areas of the museum, explore the exhibits and gain scientific information about them in a pleasant way.

Apart from the 360 virtual tours, users can take advantage of the educational and entertainment services, such as the Educational Programs and Games. The Educational Programs are dynamic and interactive programs that aim to offer enhanced information to the visitors, by simulating a guided museum tour. They include not only scientific text, but also images, sounds, games, quizzes, 3D visualizations of the exhibits and therefore make the tour more interesting, pleasant and engaging. The educational programs are designed in a very structured and well-defined way to engage students who are the most demanding group of visitors.

One of the key novelties of the proposed v-Palm platform is the Conversational Agent. The Conversational Agent has the role of a personal assistant for the students and is provided in the form of a chatbot. It presents all the available services of the system, the student selects one of them and then he/she is being transferred on the application of his/her choice. The chatbot also makes recommendations about exhibits based on the student's interests and past visitors' selections. Consequently, the chatbot helps the visitors during their museum tour but most importantly makes the visit a fascinating cultural experience.

The main contribution of the presented work is the provision of an integrated solution for i) the digital transformation of the museum that leads to the increase of the museum visibility, ii) the strengthening of the educational role of the museum for all levels of education, iii) the easy access for people who cannot visit the museum physically, iv) the support of museum sustainability and v) the wide dissemination of the museum collections.

Related work and motivation

Various solutions have been made available the last years that focus on the digitalization of the content offered by museums and the provision of various online offerings (e.g., online tour in the museum exhibits (Ahmed, 2020), serious games (Doukianou, 2020)). Such solutions have further emerged in the period of the SARS-CoV-2 pandemic (Gutowski, 2020; Burke, 2020), providing ways to improve the sustainability of the services offered by the museums and to attract online and physical visitors (Ahmed, 2020).

The usage of chatbots to assist navigation in the museum content based on the preferences of the users (Schaffer, 2023), as well as the exploitation of the wealth of information available in online web sources have provided novel ways of interaction with the end users (Gaia, 2019; Varitimiadis, 2021). In many cases, focus is given on the educational perspective of the navigation to the museum content. The usage of online services constitutes a toolkit of teachers that facilitates them to introduce novel and interactive ways of teaching and engagement of the students (Pavlou, 2022; Tserklevych, 2021).

However, even if various innovative and mature solutions are made available for the provision of digital services in museum environments, a set of challenges have appeared to properly attract end users (Choi, 2021). The provision of content accompanied by a pool of services that can be used by different type of end users is required. In this process, a significant part regards the ability to produce educational material and provide attractive interfaces to teachers and students (Noble, 2021) to consume the provided services and increase their knowledge and interest for the museum's content (Balhara, 2022).

Towards this direction, in the proposed approach in v-Palm, we focus on the development of an integrated environment that offers navigation and learning services over the available resources (e.g., text, multimedia, serious games, educational workflows). This environment

includes mechanisms for both managing the storage and production of content (e.g., information per exhibit, educational program). Openness, interoperability and modularity are basic characteristics of the produced platform to enable the development of educational content targeted to the needs of various learning groups (e.g., different age groups).

V-Palm Platform Architecture and Services

The development of the v-Palm platform is based on innovative ICT technologies, including technologies of content digitization and 3D scanning, conversational agents, personalized recommendations and gamification techniques.

An overview of the platform architecture is presented in Fig. 1. All the necessary information for the v-Palm application such as the 360 photo shoots of the museum space, the scientific texts, the multimedia content (e.g., images, videos, audio files) and the exhibits' 3D scans were digitized and inserted into the system. Also, the educational games and programs were designed and developed in a digital format. The v-Palm platform constitutes the umbrella of the supported subsystems which are: the 360-virtual representation of the museum, the educational games, the educational programs, the conversational agent, the Content Management System (CMS) where all the necessary information is stored and the Content Creation Mechanism which is used for the creation of the 360 virtual tours, the games and the educational programs. The platform supports multilingualism, however in its initial form is only available in Greek

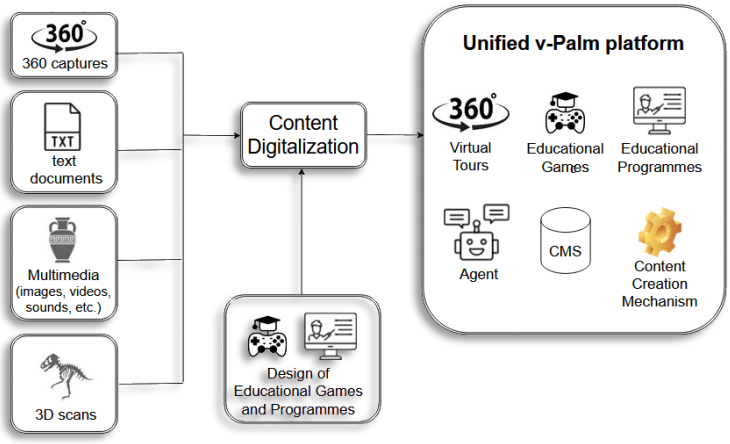

Figure 5. v-Palm Platform Overview

The above subsystems are easily accessed by users via a web application (Fig. 2) and are presented in detail below.

Figure 2. v-Palm Web Application

360 Virtual tours

Students through the 360 virtual tour application are able to navigate throughout the museum and obtain useful scientific information about the exhibits. On the 360 image, there are special symbols on the exhibits that, when selected, information about the exhibits is displayed (Fig. 3). This information is a scientific text with details regarding the exhibit, often accompanied by one or more images, a video, an audio file and the 3D visualization of the exhibit. In addition, educational games are available within some 360 views.

The 360 application is integrated with the conversational agent that supports student navigation in the virtual museum and makes the tour not only easier but also more interesting, interactive and enjoyable. More information about the agent is presented in the relevant section below.

Figure 3. 360 Virtual Tour

Educational games

Since games consist a powerful tool for learning purposes that enforce participation and increase student engagement and motivation, the proposed solution includes gamification techniques and supports a set of games. In v-Palm, the selection and design of the games are aligned with the educational character of the museum. They are designed to accomplish a specific learning objective and are integrated into the system in a way that enhances and not distracts the learning experience. Their functionality and plot are relatively simple to engage the students in a totally entertaining manner. The users receive immediate feedback on their performance, both positive and negative, so that they can adjust their selections and improve their results. A key feature of the games in the proposed solution is the existence of a goal and a reward for achieving it.

The platform provides different types of games in order to attract a wider range of users. Indicatively some of these games are: i) search the museum and put the puzzle pieces together, ii) separate the bones from the excavation and assemble the skeleton, iii) the Geology - Paleontology crossword and iv) make your own dinosaur.

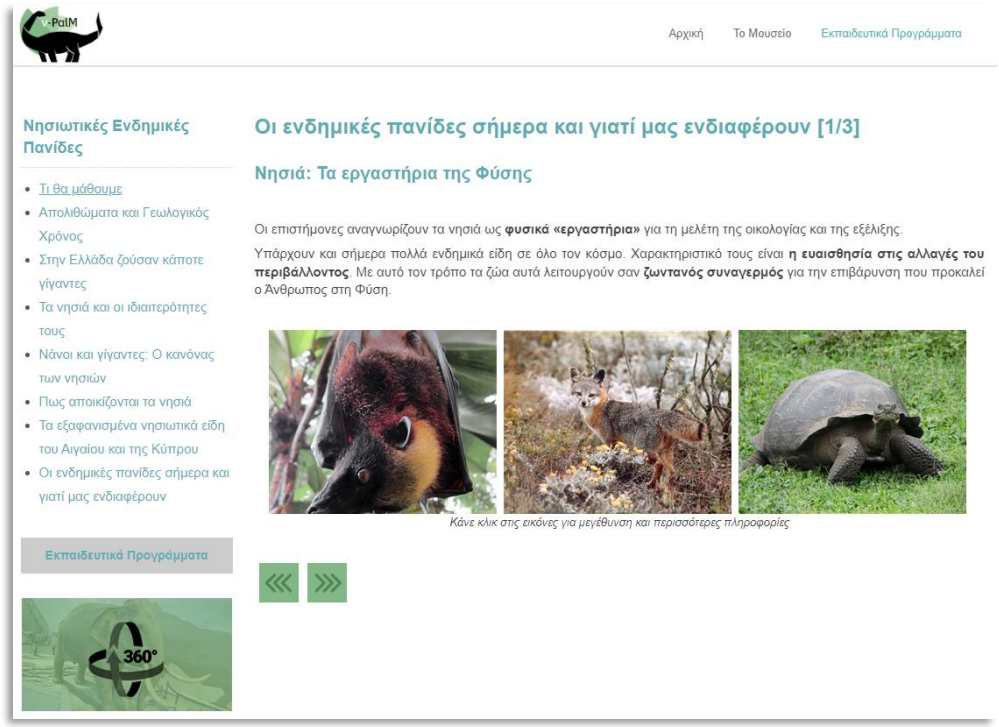

Figure 4. v-Palm Educational Program

Educational programs

The platform includes a number of Educational Programs (Fig. 4) that simulate a guided tour in the museum and intend to increase the visitor's Quality of Experience (QoE). They are designed by the scientists of the museum and are fully configurable. They are dynamic and

interactive, containing text, images, videos, games and quizzes. Each educational program introduces the students to a learning subject and has a specific educational objective and degree of difficulty. All the elements of the scenarios are broken down into steps that are clearly outlined and include points where the user is offered some degree of interactivity and freedom of navigation.

Conversational agent

The conversational agent (Fig. 5) is the key innovation of the v-Palm platform. It appears in a small window on the central 360 screen and accompanies the student while browsing in the virtual museum. The user communicates with the virtual agent either through buttons that appear in the chatbot window or through free text that the user writes inside the chatbot. The agent provides the requested information and directs the student to the selected service (e.g., a location in the virtual museum where an exhibit is located, an educational program or a game). Apart from this, the conversational agent makes personalized recommendations to the visitors. The mechanism that is used combines i) the preferences of the visitor, ii) the exhibits that have already been visited and iii) the selections of past visitors and produces a list of exhibits that have some common characteristics.

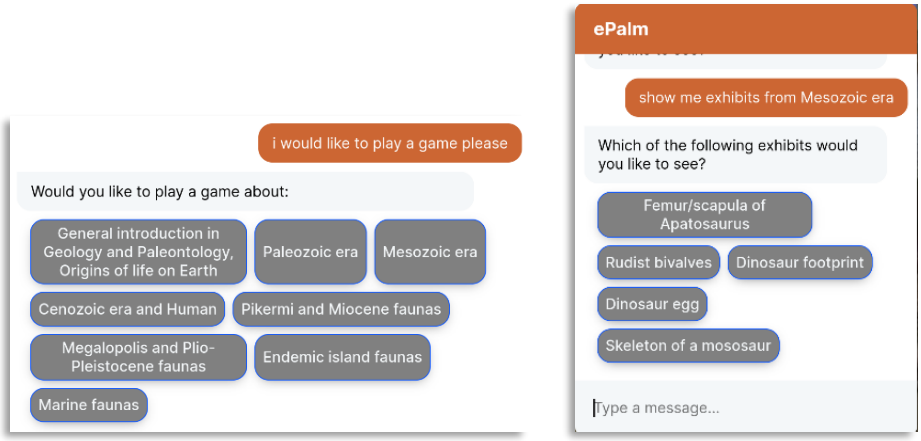

Figure 5. Conversational Agent

Content management system

The CMS is the repository where all the necessary information for the operation of the v-Palm platform is kept and maintained. In particular, the exhibits, the 360 shots, the exhibits' multimedia content (e.g., pictures, videos, audio files, 3D images), the material of the educational programs and games are stored. In order to upload or update the content of the CMS tool, a suitable User Interface is developed. People with non-technical background (e.g., museum employees) can easily access, organise and update the information of the CMS. For the development of the CMS, the .NET Microsoft framework has been used.

Content creation system

The Content Creation System is the mechanism that is used to create the 360 views of the virtual museum, the educational games and programs. The Unity framework which is a well-

known game engine is used for the development of the 360 virtual tours and games. Through a friendly user interface, the user creates the desired 360 views. The user selects a 360 image and adds the information icon (e.g., ) to the exhibits where navigation will be offered. Through the icon, links to relevant information for the exhibit is provided. A list of the stored exhibits in the CMS is presented every time the user wants to add an exhibit in a 360 view. Regarding the educational games, different templates have been created in Unity to support the different types of games provided by the platform. Similar to the CMS, the Content Creation System is really easy to use even for people with no background knowledge.

Advantages

The advantages of the proposed solution are significant and concern both the museum and the community.

Focusing on the museum perspective, the museum is being transformed from traditional to digital. All the exhibits and relative scientific material are digitalized and better organized. 3D visualizations of exhibits are produced and additional photographic material is added to the museum collection. Dissemination of the rich and rare paleontological material of the museum is provided, considering also the accumulated scientific knowledge of the palaeontologists and geologists working in it. The sustainability of the museum is supported as it will have a greater number of visitors and up-to-date content. Finally, new partnerships with other museums and organizations may emerge as the number and the importance of museum exhibits will become known to the cultural community.

Focusing on the visitor perspective, visitors can access the virtual museum at any time and regardless of their geographical location. They will become familiar with palaeontology and geology aspects and enrich their knowledge in these domains. The visitors' QoE is envisaged to be significantly improved based on the offered level of personalization, interactivity, and richness of content. At last, the museum will attract, and primarily educate and entertain the youth through the introduced technological innovations.

Conclusions

This article presents the innovative virtual museum platform, called as v-Palm. The solution has been implemented for the Paleontology and Geology Museum of the National Kapodistrian University of Athens; however, it is generic enough and can be applied to other museums. The development of the platform is based on state-of-the-art ICT technologies, thus exploiting and demonstrating the innovations, advantages and role of ICT technologies in educational excellence and effectiveness. One of main advantages of the proposed solution is the easiness to manage and configure it by non-technical personnel which contributes to its sustainability over time. The basic components of the system, the supported functionalities and the advantages of the solution for both the cultural heritage space and the visitors are presented.

Our future work includes further improvement of the agent functionalities by implementing speech-to-text conversion and including recommendations that will satisfy not only the visitors' interests but also time constraints (e.g., 30-minutes tour).

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