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Abstract

The paper presents an interdisciplinary approach for constructing Virtual Reality exhibitions by studying the case of a Virtual Reality exhibit developed for the Philatelic and Postal Museum of Greece. The paper focuses on the tasks required for the construction of the virtual exhibition while covering the project development issues. The focus is on the design of the exhibition space, the placement of the exhibits, the organization of the content in an appropriate content architecture, the supplementary approaches, and tools for enhancing content communications as well as their accessibility. The goal is to provide a technological solution that is easy to adopt in similar projects for providing both technological solutions and a walkthrough for the various stages of collaboration with cultural heritage institutions.

Keywords

museums, cultural heritage institutions, virtual reality exhibitions, project development

1. Introduction

The paper presents an interdisciplinary approach for constructing Virtual Reality exhibitions by studying the case of a Virtual Reality exhibition developed for the Philatelic and Postal Museum of Greece [1]. Despite the fact that virtual museums are an active topic with a constantly increasing number of projects and publications [1, 2], it appears that the scientific literature does not cover a significant portion of the work and the process needed to implement a virtual museum adequately.

In this work, we present an interdisciplinary perspective by examining various issues that commonly occur within the developmental stage of such projects, namely: (i) the copyright and privacy issues of the displayed items, (ii) the content organization and the necessary transformations for its inclusion in a web Virtual Reality application [3, 4], (iii) the design of the virtual architectural space that will host the exhibition, (iv) the design and development of the Virtual Reality application that realizes the exhibition [4], and (v) supplementary content communication approaches that enhance the use of conventional informational content (text and still images) [5].

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[1]URL: https://ft-museum.gr/

1.1. Objectives

The main objective of this paper is to provide a framework for developing Virtual Reality exhibitions which comprises a set of purpose-oriented methodologies for the individuals tasks to be completed. The framework establishes a high-level interdisciplinary approach covering all the aspects of the project development and provides the foundations for task-specific methods in each phase of the project development. Furthermore it provides a detailed list of questions which allow developers to comprehensively address the developmental issues that may arise, particularly when the recipients of such systems are not technologically competent. Specifically, the construction of a Virtual Reality exhibition for the Philatelic and Postal Museum of Greece is presented as a case study.

1.2. Method

The method employed is focused primarily on the objectives of the project and includes: (i) the investigation process that is carried out primarily so that both the designer and the recipient of the Virtual Reality exhibition share a common understanding of the project, (ii) the requirements analysis based on the results of the investigative process and the examination of the informational material to be included in the exhibition, (iii) the copyright clearance of the creative material to be used in the exhibition, (iv) the design and development stage, (v) the testing and evaluation of the developed application and (vi) the handover of the system and the recipient's training on its use. Supplementary methods also employed as parts of the aforementioned tasks and stages are: the literature review, the research for the available technologies and approaches, the collection of the content including the creation/digitization and organization, the prototype design, and testing.

2. Related Work

Despite the fact that virtual museums are an active topic with a constantly increasing number of projects and publications [1, 2] it appears that a significant portion of the work and the process needed to be followed in order to implement a virtual museum is not covered sufficiently by scientific literature. In [6] is used a different approach on exhibition space by displaying only one painting at a time in a room that its dimensions are adapted to the requested painting. In this work, Unity3D was used along with a collection of scripts and tools called VRTK (Virtual Reality Toolkit). In [7] authors present the design and development of a virtual museum application for HMD and discusses usability issues related to specific equipment with respect to the final users. They also present VR games in the museum, a questionnaire with negative and positive user opinions, and use the virtual reality sickness questionnaire. The virtual museum is implemented with Unity 3D. In [8] a system called VIRTUE is presented. VIRTUE allows curators to set up virtual museum exhibitions with 2D and 3D artifacts. It consists of two parts, namely: the back-end used by curators to build a virtual exhibition; and the front-end which is developed with Unity along with the SteamVR plugin to provide an application compatible with the HTC Vive HMD.

From the above, is concluded that Unity is a powerful game engine to be used for the construction of virtual museums but the available literature does not yet cover the interdisciplinary issues of understanding cultural heritage organizations, extracting their knowledge, and incorporating it into the software development process of developing a virtual reality exhibition.

3. Project Management Methodology

This section not only describes the process followed to manage the development of the virtual reality exhibition but covers also the whole process, including the creation of the project team, the selection process for the project team members, the communication with the museum, the selection of the content and its integration into the final virtual exhibition.

3.1. Project Objectives

The project objectives are the following:

1. To highlight specific thematic categories of exhibits and selected exhibits of the Philatelic and Postal Museum of Greece by using virtual reality technology and applications.
2. To raise public awareness regarding the collections of the Museum and to focus on a specific thematic activity which is dedicated to the celebration of the 200 years of the beginning of the Greek revolution against the Ottoman empire.
3. To provide consulting services about the intellectual property issues related with the museum exhibits that will be hosted in the virtual reality exhibition.

The project was best considered to be organized in three (3) deliverables, namely:

1. The Virtual Reality Exhibition delivered in digital form and ready to be used accompanied by instructions for its installation on the servers and its use by final users.
2. The content of the Virtual Reality Exhibition delivered as a set of all the files (images, text, audio and video) comprising the informational material integrated in the exhibition.
3. Study on the intellectual property rights and its management for the selected exhibits and their use on the virtual reality exhibition and other related activities, e.g., scientific publications relevant to this project.

4. Content Preparation and Integration

The virtual reality exhibition of selected museum objects, of the Philatelic and Postal Museum (PPM) for the anniversary of 1821, is dealing not only with the presentation of the events and personalities that played an important role during the specific time period, but it consists also of a parallel presentation of the particular political, social and economic conditions of the Greek State during their issuance. This parallel and at the same time, dual approach could not be based on any existing methodological approach, so a new methodology had to be structured in order to cover the above requirements. More specifically, the special requirements and needs that led to the creation of a new methodology regarding the organization of information, were:

- The nature of the exhibits, as they are stamps and works of art at the same time
- The subject of the periodical exhibition which presents a dual character:

On the one hand, the narration of the historical events of the three historical periods had to be realized having as a reference point the representations of personalities, monuments or events on the stamps. On the other hand, the public-visitors of the virtual exhibition had to realize what the Greek State was perceiving and aiming for, through the presentation of the subjects of the stamps as well as how the State saw or imagined its relationship with the Revolution.

4.1. Structure of the Periodical Exhibition

The virtual space of the exhibition was structured in four different sections: the first three sections were selected by the scientific staff of the PPM, while the fourth intended to highlight the human being / the artist behind the art of creating the stamp.

1. The first section concerns the Pre-Revolutionary Period and the preparation of the Revolution, based on the available topics.
2. the second section deals with the Struggle for Independence and the personalities who started and carried out the Revolution of 1821.
3. the third section concerns the National Integration with the creation of the newborn Greek State.
4. the fourth section presents, in video form, the elements that inspired the artists to create their pieces of art (stamps / exhibits).

4.2. Placing the projects in the virtual space

The 1st Section - Virtual Room is called ”The Pre-Revolutionary Period” and consists of 14 stamps. It concerns the preparation of the Revolution, based on the available subjects such as Constantine Palaiologos, the Greek community of Venice, the representatives of the neo-Greek enlightenment, Rigas Feraios, the Filiki Eteria (in Greek: Φιλικὴ Ἑταιρεία) or the Society of Friends etc. The 2nd Section - Virtual Room is called ”Revolution” and the selections of the 17 stamps mainly concern the narrative of the events and the symbolism attributed to the subjects of the stamps by the Greek State The 3rd Section - Virtual Room is called ”National Integration” and is represented by 16 stamps, dealing with the period from the creation of the Greek State to the time of Otto, the first King of the newborn Greek State Section 4th presents, in the form of a video, the elements that inspired the artists to create their exhibits and concerns the utilization of the empiric approach of the engraver/artist himself, when called upon to implement a project, i.e. showing off his / her expertise by carving a model for a stamp.

4.3. Phases of organizing the content

The content and the selection of the stamps were implemented exclusively by the team of the scientific staff of the PPM. Our team was evaluating the quality of the given content and asked for additional resources or corrections if those were needed.

4.3.1. First stage: getting the initial content

The content management and organization team initially received a file of almost all the stamps relating to the creation of the Periodical Exhibition of 1821, as well as three single texts relating to each section separately.

4.3.2. Second stage: content evaluation and selection of exhibits

During which there was done an evaluation of the stamp file and a first division into the files that would create the exhibition. In constant communication and research with the relevant PPM team, they were excluded stamp files that presented the phases of creating the final form of the stamp. For example, for a given stamp (Fig. 1), the selection was made among numerous candidates.

However, it was agreed that the Exhibition would be more interesting if not only images of the final stamps were used, but if a variety of formats were used, in addition to the final stamps, sheets of stamps, printing essays with comments-corrections, printing proofs and envelopes of the first day of circulation (examples in Fig. 1, 2, 3, 4,).

4.3.3. Third Stage: organizing the informational material

The team of the scientific staff of the PPM organized and sent the information about the stamps, in the form of files that related to each Section separately. So that the content management and organization team received the following: A) A file with a single text of historical content that related to the description of each stamp, and to the particular political, social and economic conditions that prevailed at the time of the stamp's circulation. B) A file with information of philatelic nature, such as: the identity of the engraver, the original work on which it was based, the date of publication, the edition, the value, etc. C) A file of specific information, such as biographical information about the subject depicted on each stamp. D) A file that contained special comments regarding the illustration of each stamp.

4.3.4. Fourth Stage: organizing the exhibition space and the information architecture within the exhibition

The information management and organization team, after thoroughly studying all the files of the information material, transferred the main axes of the material to the project implementation team. Initially, the four-part division of the space was confirmed, so that each section can be viewed separately. Afterwards, a three-level information and functionality architecture of the virtual reality exhibition was designed in order to deal with the variety of informational content as well as the specific user requirements for interacting with it. This architecture, which is discussed in 5.4 was proposed during the knowledge exchange and design meetings and finally was agreed by the scientific team of the PPM.

4.3.5. Fifth Stage

Then, as part of setting up the report and organizing the information levels, the information management and organization team undertook to separate the source material for all three

Figure 1: Various phases of a stamp's design. Working drafts and the printing essay selected for exhibition.

modules into three levels as described above. Thus, it was created from a separate file for each of the 47 total stamps containing the corresponding information: the stamp in high resolution (1st level of information), the historical content (2nd level of information) and the philatelic information with comments and biographies or thematic texts (3rd level of information). The new material created was sent to the relevant scientific team of the PPM to be reviewed and approved as final posting material.

4.3.6. Sixth Stage

For the process of translation the material, the information management and organization team collected the checked material of each section into three single files and gradually sent it to the

Figure 2: Image 1, stamp: Section A, "200 years since the establishment of Filiki Eteria". Image 2, sheet of stamps: Section B, "The battle of Athens".

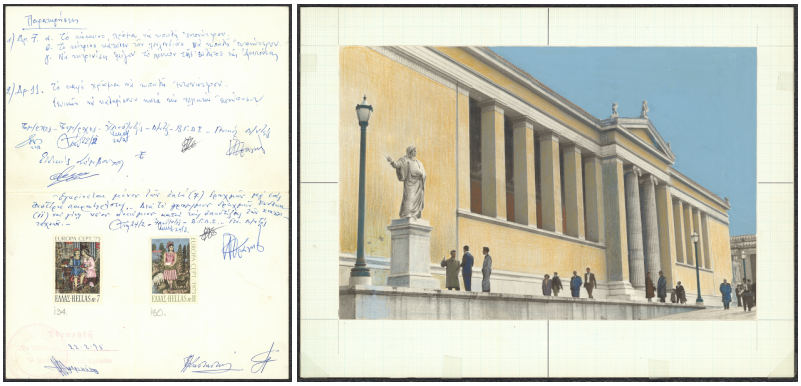

Figure 3: Image 1, printing essays with comments-corrections: Section A, "a. Erotokritos and Aretousa b. The Girl in the Hat". Image 2, draft drawing: Section 3, "University of Athens".

Figure 4: Section 3, "Performances from the Theater of Shadows" (free composition), envelope of first day of circulation.

translator. Each translated section was sent to the relevant scientific team of the PPM in order to be reviewed and approved and finally to be posted in English language as well.

The exhibits that were selected by the museum staff for the virtual reality exhibition were

postage stamps. Most of the selected stamps were already digitized and provided to the development team. A small number of stamps that were not initially provided were digitized in a second phase of collecting the assets.

4.4. Exhibit classes-categories

The following classes of stamp-related exhibits are identified:

- Stamp
- Sheet of stamps
- First day of issue cover
- Printing proof - Detail from a printing proof
- Detail from a printing essay - final printing essay
- Engraving
- Draft Drawing

4.5. Image content

Postage stamps as well as the other exhibit classes are 2D representations that can be represented by image files. High quality scanned images of postage stamps are provided by the Museum. Image editing tasks, e.g. cropping, resizing, rotation etc., are performed to improve their appearance and enhance uniformity. Postage stamps previews of reduced resolution are created for application's optimization purpose. High resolution images are available on demand, e.g. when users zooms in on a stamp. Images are integrated into the the VR exhibition.

4.6. Informational Text - Textual Descriptions

For each one of the selected stamps, museum staff prepared a set of textual descriptions that should accompany the stamps in the virtual reality exhibition.

All the stamps have the following textual descriptions:

1. Title of stamp series
2. Title of stamp
3. Information on stamp
4. Information on the historical and social context related to the stamp.
5. Biographies and other information relavant to the subject of the stamp.

The textual descriptions were provided in modern Greek language, the development team hired a professional translator and the translated documents were sent back to the museum staff for checks and corrections. It is noted that in many cases the Greek texts were changed-updated by the museum staff. The texts were usually sent by email and cloud-based file sharing services were often used. The content that was provided by the scientific personnel of the museum and was processed in collaboration with the historical team includes:

- Historical content: historical events of the time in which they took place along with the socio-political situation when the stamps were issued.

- Philatelic information: series, denomination, print method, watermark, perforation, print run, circulation date etc.
- Comments: original work or inspiration for the final creation of the stamp.
- More specific information: historical content such as biographies of the personalities or presentation of significant events depicted on the stamps.

The informational text is also available in audio narrated by actors or Text-to-Speech synthesis software.

4.7. Video Content

Produced in two cases: Short introductory video with footage shot in the museum areas while information is given with voice over. Also, interviews of two prominent Greek artists/academics in the field of stamps were taken. The question asked was: "How do you approach the creation of a stamp?" The interviews produced a rich amount of information and arguments on the subject that was not possible to make it in the final cut. The decisions in editing were made on the basis of making the video comprehensive within a short duration. Interviews were given in the artist's workshops making possible to show actual steps of stamp creation process while the artist talks about her/his art. The production demanded the use of specialized equipment such as strong magnification probe camera lens and high intensity focusable lighting.

4.8. Language and translation requirements

The additional information should be available in Greek and English language in text and audio. The videos provided in the 4th section are recorded in greek language but both english and greek subtitles are also available.

5. Design and Implementation of the Virtual Reality Exhibition

5.1. Project Description and Requirements Analysis

A set of meetings with the museum staff was conducted so that the design team could understand the vision of the Museum staff and that could provide an initial design proposal for discussion.

5.1.1. General Project Requirements

During the first meetings the following requirements were communicated by the museum staff:

1. The virtual reality exhibition will present selected exhibits of varying thematic categories of the Museum collections.
2. The exhibition is structured in four (4) thematic sections. The first three sections will host exhibits selected by the museum staff and the fourth section is aimed to highlight the importance of the designers creating the stamps.
3. Visitors will enter the exhibition from the museum's official website.
4. The exhibition should be comprehensible by both Greek and English language speakers.
5. Users of physical and cognitive disabilities should not be excluded from the exhibition.

5.1.2. VR design guidelines

The virtual reality specialist designed the application proposal which initially had the following guidelines:

1. The virtual exhibition will be a 3D interactive space in which users will be able to navigate by using their PC or tablet/smartphone.
2. The exhibition space will simulate an actual exhibition space where users have a first person experience as if they were physically present in it.
3. In addition to the previous, users will be able to navigate in the exhibition space with methods that simulate the physical movement (walking), in order to increase the realism, provide an easy to use method for flexible navigation and facilitate the close observation of the exhibits.

5.1.3. Desired User Experience Analysis

Once the basic aspects of experiencing a virtual reality space are decided, a detailed analysis is performed based on the purpose of the considered space and application. The virtual reality specialist in this phase starts with the question ”Imagining that I am in this space, what would I want to do?”. That question provides some straightforward answers which can be turned in specific requirements and guidelines. The straightforward answers were:

1. I expect to read a caption providing some basic information about the stamps, perhaps its title, date and designer. What if I would like to learn more things about? Can I have a leaflet or a guide providing that information?
2. Given that the exhibition shows stamps I would like to see the details. I imagine having a magnifier to look closer on the stamps.
3. When zooming in the stamps additional information on their design would be appreciated.

5.1.4. Functional Requirements

That straightforward answers are then transformed in more appropriate sentences providing information that is comprehensible by both the design team and the museum staff and which could be summarized to the following:

1. Every exhibit will have appropriate interaction functionality so that users will be able to observe the exhibit details and get additional information.
2. The interaction functionality should be easily accessible when users approach the exhibits.
3. The interaction functionality should allow the display of a pop-up graphical user interface with the ability to zoom-in and zoom-out an exhibit as well as providing options for access to additional information.
4. The exhibition should support two-language content and the corresponding options for users to select their language.
5. The textual content should be also available for listening in audio form.
6. Navigation assistance methods for portable devices and disabled users should be provided.

It is noted that the use of audio where text is already available has been decided to enable users with disabilities (vision impairments and cognitive disabilities).

5.2. Technical Information

The implementation of the virtual reality exhibition will be based on the capabilities of modern game engines, Unity in our case, that provide high quality 3D graphics, inherent support for user interfaces and are in overall easy to use tools. The virtual reality exhibition will be accessible through the world wide web and by browsers. Users will be able to use keyboard and pointing devices, e.g., mouse, trackball, etc., for navigation and additional, navigation and interaction through touch screens will be also supported in order to facilitate its use on mobile devices (smartphones and tablets). The virtual reality exhibition will be hosted on computational infrastructure (servers) provided by the Museum and will be integrated to the museum's website so that its visitors can easily enter the exhibition.

This work uses a newly developed system called VRM-Frame (Virtual Reality Museums Framework) [9]. VRM-Frame shares the same underlying ideas, basic mechanisms and know-how with previous works, e.g. handling content of exhibits [4], space organization [10] and interaction aspects [11] while extending them and adding new functionalities.

5.3. Design of the Exhibition Area

The exhibition is organized in 4 Sections which should be easily recognized during navigation and facilitate visitors flow. Given the aforementioned, the design team decided that an ellipsoid exhibition area would be friendly to visitors and an appropriate conformation for the sections based on the quadrants concept could be used (Fig.5).

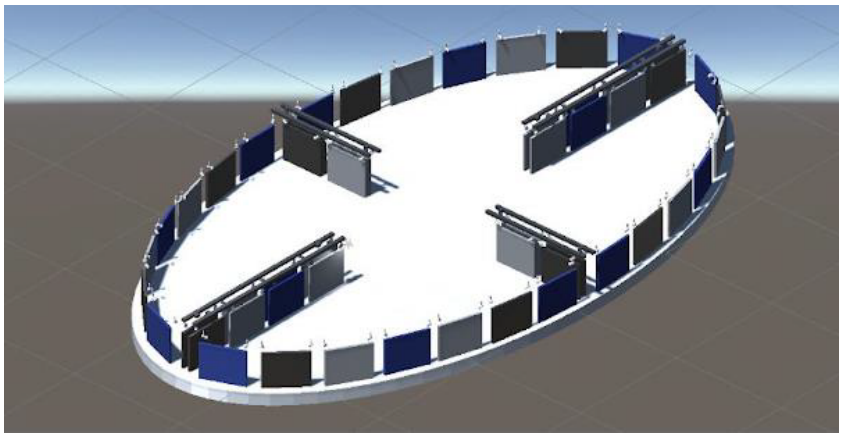

Figure 5: Exhibition area layout. An ellipsoid surface and its appropriate conformation based on the quadrants concept creates the exhibition space.

In this case, the perimeter of the ellipse can be used both as a barrier and exhibition space while the quadrants are partially visible by walls that are used both as borders between the sections and exhibition space. The initial idea to design an open space remains by breaking down the walls in smaller segments that become the canvases that will host the exhibits (Fig. 6).

During the design process of the exhibition space it was decided that we wanted to provide an interesting and innovative design that would not be limited by the certain constraints that apply on designs intended to be actually built. Our intention was to give a space with visible

Figure 6: An exhibition canvas with an exhibit.

boundaries but still open, thus a glass perimeter surrounded by pillars is designed. The same applies to the roof where we wanted to have a ceiling obstructing the infinite space resembling the sky while keeping an opening to it. In addition, regarding the feeling of being within an infinite empty space that should be avoided, the building is surrounded by trees.

Figure 7: Exhibition view.

5.4. Information and Functionality Architecture

As stated in subsection 5.1.3, there are various user needs depending on the content and the users' purposes. Moreover, the purpose of the exhibition is to provide a thorough understanding of the exhibits based on extensive informational material (4.6) which should be organized in order to avoid user's cognitive overload. Given the above, an appropriate informational and functional scheme should be designed and incorporated in the virtual reality exhibition as already mentioned in 4.3.4.

Both the functionality and the content are organized in 3 levels (Fig. 8). On the 1st level, users are able to navigate in the 3D space and view the stamps as they are exhibited in the 3D space. Users can select a stamp in order to get more information, by clicking on a stamp they enter the 2nd level which consists of the 2D user interfaces that are used to provide the information in the virtual reality exhibition. Both the 1st and 2nd level are integrated in the virtual reality exhibition. When a user wants to get additional information or to acquire access in content specific actions, such as to magnify the stamps in order to observe the details on them, then he/she enters on the 3rd level which is implemented by using world wide web technologies and it looks like a book in which further textual information and magnifying functionality are available.

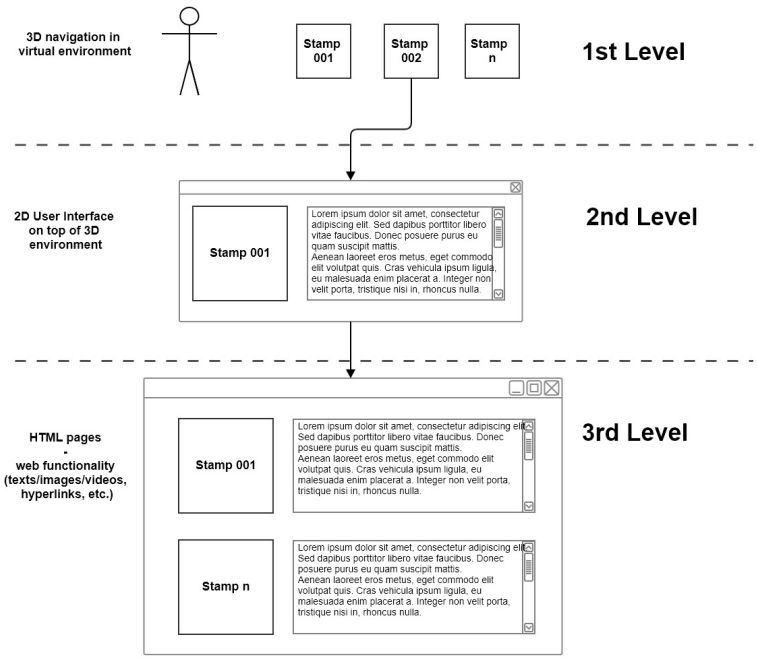

Figure 8: The three-level information architecture and the corresponding user interfaces.

6. Supplementary Content Communication Approaches: Digital Catalog

As stated in the Introduction, the Web VR application was the main objective of this project but as the project evolved the need for supplementary content communication approaches arose as rich content in the form of long texts emerged, and reading in VR [12, 13] appears to be more difficult than reading in printed media or conventional desktop applications, especially for longer texts. Due to the above, it is decided to use a conventional approach for providing these longer texts (Fig. 9) as well as for providing images in higher resolution with zooming

functionality (Fig. 10). The catalog integrates functionality for increased accessibility and use with screen readers by removing complex styling and images (Fig. 9).

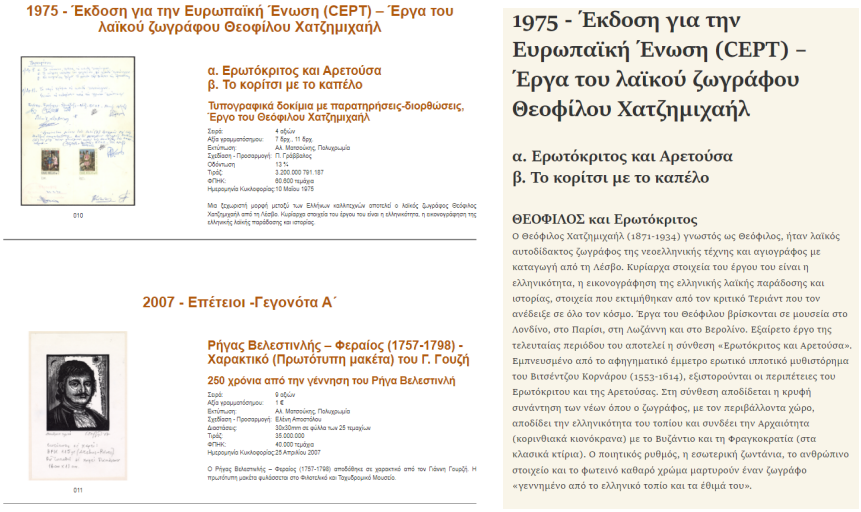

Figure 9: View of the catalog and its content: (i) in normal mode, and (ii) in accessible mode.

Figure 10: View of the catalog while zooming and panning on a stamp.

7. Conclusion

In summary, this work aims to present an approach for constructing Virtual Reality exhibitions by studying the case of a Virtual Reality exhibition developed for the Philatelic and Postal Museum of Greece. The numerous aspects of the presented approach and the employed methods are listed. Regarding the technological aspects of this work, the emphasis was given to the development of a Web Virtual Reality application, the design of the exhibition space, the placement of the exhibits, the organization of the content in an appropriate content architecture, the supplementary approaches, and tools for enhancing content communications as well as their accessibility.

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