A DYNAMIC CONTENT MANAGEMENT SYSTEM FOR THE VISUALIZATION OF CULTURAL INFORMATION; THE CASE OF THE STATE CONSERVATORY OF THESSALONIKI, GR

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ABSTRACT:

Although there are several attempts of embedding static content in events' brochures and posters, the increasing need for flexibility and versatility of the content, leads to the development of a mobile application with an in-app dynamic content management system. In this context, DigiOrch is an ongoing research program where, a Content Management System is developed to organize all the digital material and maintain the appropriate connection to the analogical markers. Furthermore, a mobile application is developed that leverages this system using in app dynamic modules, which, by utilizing the augmented reality technology, presents multimedia data such as texts, photos, videos, and 3D Models to the end-user by "superimposing" them on mobile devices screen, providing extra additional information on any valid smart-leaflet.
The overall workflow of the in-app Dynamic Content Management System (DCMS) can be described as a group of modules that managing and copying content files from a remote infrastructure such as an ftp server or a local resource if network is missing, to the mobile device's file system.
The in-app DCMS consists of 4 modules: The first module is the ***parser***, which is responsible for reading a downloaded *.json file and creating content-linked objects. The second module is the ***download*** module which is responsible for downloading the overall content by iterating the content-linked objects, created by the previous module. The third module le is the ***update*** module that, by iterating the initial content file and the local file system, suggests whether a content update is necessary. The fourth module is the ***loading*** module, which is responsible for fetching the content on runtime to fill the content-holding components, such as 3D Models and UI photo galleries, of the AR scenes on runtime.

1. INTRODUCTION

1.1 Augmented Reality as a Dynamic Content enrichment tool for Static analogical material

Smart devices have been developed rapidly over the last two decades and their capabilities are providing multiple processes such as Dynamic content, Augmented Reality targeting the digital enhancement of analogical materials. In recent years, the rapid development of Augmented Reality technology has been observed both in terms of progress and its dissemination (Angelopoulou et al. 2012). The term Augmented Reality refers to the technology which, through the appropriate hardware and software, succeeds in enriching the environment with virtual digital objects, receiving its image from a camera, and projecting the result on a screen. Augmented reality is a promising technology and has been the subject of research for more than 50 years. However, like most emerging new technologies it did not always develop at the same pace. In the earlier years of Augmented Reality technology, the equipment required to develop and deploy an Augmented Reality application made cost, time, and lack of device flexibility prohibitive factors in its development and deployment. Specifically, in literature, it is found that the first Augmented Reality device was manufactured in 1968 by Ivan Sutherland under the name "The Sword of Damocles", which consisted of a portable screen, a massive arm, and the main body of the device. Augmented reality has undergone considerable improvement in past years. Many special techniques and hardware devices were developed, but the crucial breakthrough came with the spread of intelligent mobile phones (Procházka et al., 2011). Now, the conditions at the level of hardware and software are more favorable than ever. Every year more and more powerful computing devices are available on the market, which are equipped with a set of sensors, such as gyroscopes, accelerometers, and TOF lenses supporting AR capabilities and powerful processing units in combination to fast 4G and 5G networks.
The enhanced hardware and software lead the developers to create more complex applications in terms of content management (multiple and large datasets) and "linkage" of the content to the camera's ability to recognize "markers" on static brochures and posters.
Static materials such as brochures and posters are providing artifacts as "markers" to enrich the user's analogical experience with digital content. The "markers" are well-defined to be recognizable from the camera and linked to specific content. The content is easily accessible by selecting the marker and requesting access to the linked information.
All this content is not static. Changing the content, if possible, will lead to additional development time and costs. This causes several problems that significantly limit the use of AR in Digital and Cultural heritage (Serres et al., 2023). The problem that the

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update of the content creates is since adding a new artifact in an AR mobile application must extend the AR Content and a team of developers must be involved. Furthermore, applications that do not have the content embedded should have constant internet access. (Serres et al., 2023). Based on this fact a structure to support the interconnection between content, material and "markers" should be established. For this reason these operational data should be structured for efficiency in processing and management and a central management system with a mechanism to retrieve and dynamically embed them to the mobile application should be established (Sherman et al., 2015).
In this paper, an approach to solving the dynamic update of the content and the need for a constant internet connection is described.

1.1 The DIGI-ORCH Research Project

The DIGI-ORCH project consortium consists of an Academic Organisation (Laboratory of Photogrammetry and Remote Sensing, School of Rural and Surveying Engineering, AUTH), a Cultural and Educational Foundation (State Conservatory of Thessaloniki, Greece-TSC), and two representatives from the private sector with expertise in the field of visual communication/advertising (Beetroot) and consulting (VBC).
The main objective of the DIGI-ORCH project is to develop a mobile device system that will extend the experience of concerts and the other educational programs of the Thessaloniki State Conservatory (TSC). This application will offer the end user a visually enhancing overview of the cultural activities and events of TSC, along with personalized interactive information retrieval through smart mobile devices. It will also provide an important tool to TSC for its promotional strategy implementation. The system will integrate augmented reality technologies and database infrastructure in a unified environment. (Patias et al., 2023)
In this context the project plan has two live events scheduled provide the opportunity to the end users to have direct access to the mobile application in order to evaluate the functionality, content and the User Interface and User experience. The first one "Musical Kaleidoscope" is already completed. This event was a music concert for piano, violin, and cello, organized by the TSC on December 2022. The goal of this first event was to evaluate the system under development both in Main Content Management System and the Mobile Application and the in-app DCMS.

2. DEVELOPING THE DIGI-ORCH SYSTEM

2.1 Conceptualization

The initial conceptualization of the system is focusing on the data that is expected to be included in the application and can refer to the concert itself and other educational material, or online resources. It can take the form of video, audio, text, animation, and 360 or 3D data as well. The implementation of the application includes the development of a content management system that will include functionalities for data storage, management, and serving dynamic information.
In addition, smart communication materials/documents have been developed that along with a mobile application provide the user with the ability to project, and superimpose 3D objects on the printed documents, visualize additional content in a user-friendly interface, and promote the events on social media.
The paper focuses on a part of the overall System development and specifically the In-App Dynamic Content Management System. The In-App DCMS is developed in a way to Dynamically update the User Interface components based on the input content of each event.

2.2 Overall system design

The above-described Concept is based on a general architecture that needs specific functional units (Figure 1), which consist of technologies that were identified and analyzed.

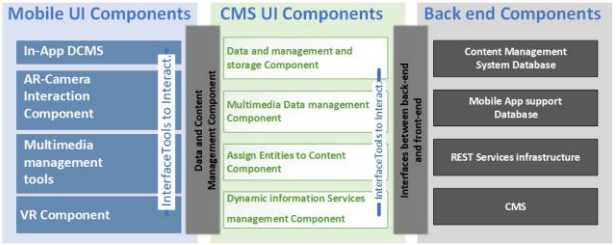


Figure 1. DIGI-ORCH System's functional Units

The first functional unit concerns the support infrastructure of the content management system. To implement the front-end content management User Interface (UI) according to the requirements of the project in terms of functionality and security, the design and implementation of a back-end infrastructure are needed.
The second functional unit concerns front-end content management UI. To support the workflows required to prepare the content and organize it in a way that it can be accessed by the mobile application, additional interfaces have been implemented. For this reason, forms have been created to manage and organize the content in a way that the mobile application needs. In this context, several component interfaces have been designed and implemented.
The third functional unit concerns the mobile application for the promotion and display of analog printed material with augmented reality functions and other services. The mobile application consists of functionalities to manage a set of content, which, as described above, have been organized to feed dynamically or not the mobile UI. The mobile application will be updated by the in-app DCMS on what material is available per form and event and will load it for display to the end user.
For the detailed Design, the above-mentioned interfaces have been defined as well as the interconnection between them (Figure 2). Therefore, to support the Content Management System, it is necessary to create the back-end infrastructures that will serve the indexes of the content as well as the content itself. At the same time, REST API (Prayogi et al., 2020) infrastructures have been created to access CRUD procedures for its organization. A user management infrastructure is needed to secure the content and provide multilevel access to the user.
The main component on the part of the presentation tier (mobile application) is the mechanism to access and organize the content from the central management system to the mobile application. In this context three main subsystems where designed and created to support this process. The component to manage the initialization of the application and the in-app DCMS, the DCMS process component and the AR mechanism to support the "markers" intercontection with the content are the main part of the application development. These components communicate with the central conten management system on the initialization using REST APIs gathering the necessary information and content to build the application. Files and information stored locally on the device and there is no need of further internet connection since the first initialization. All these tools to connect, download and gather the content from the mobile application, were designed and

implemented with the aim of making in-app the necessary links to successfully build the user interface of the app.
Finally, the end-user interface for the mobile devices was designed and Implemented.

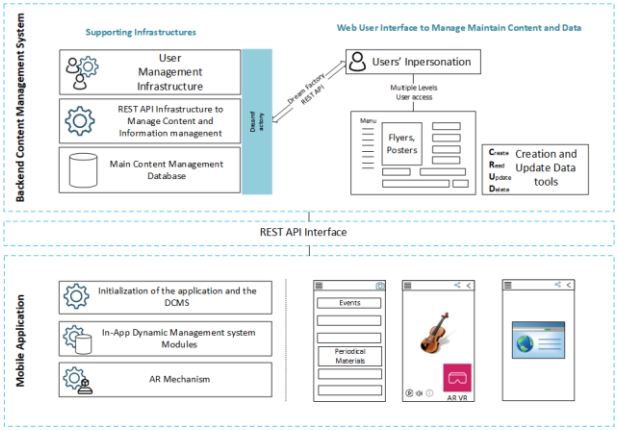


Figure 2. DIGI-ORCH Components System Design

2.3 Brief Description of the Central Content Management System

The two important functional units of the system are the Central Content Management System and the Mobile Application. The first one is regarding the content management infrastructure and the second regards the development of the mobile application. The content management system is implemented through a web interface that allows users with administrative privileges, to create new events, upload information and files that are to be included and served through the mobile application and connect this data to each communication material (Figure 3).

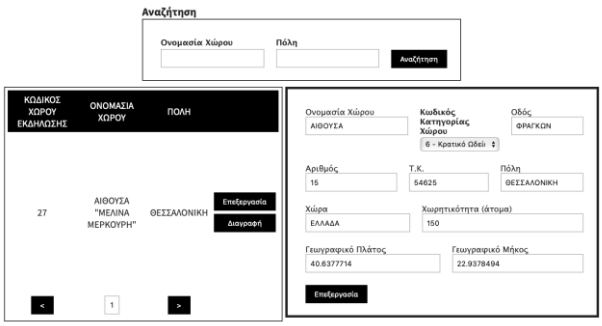


Figure 3. Web interface for recording the event's content in a central DB uploading data to the Main content management system (CMS).

All the structured information that the Central Content Management system maintains is intended to be loaded on the Mobile Application.

2.4 Detailed Description of the Mobile Application Design

The design of the mobile application interface except for taking into account the needs for data storage and management, is based on the analysis and user requirements gathering. In this context, the application consists of the modules used to organize the ongoing events, possible semi-annual material, and the modules to access the content through smart form functions.
The basic UI design concern three central sections:

1. Section serving General application and operator information.
2. Information section on current events, event history, and possible bi-annual forms
3. Event=specific information management module and smart forms

In this context, to cover the first section, a menu is created in the application for providing the end user with the necessary information about the application and the operator. The following image (Figure 4) shows the design of the initial screens.

Figure 4. Initial Informational Screen.

In the second section (Figure 5) of the mobile application, "Information section about current events, event history, and possible six-monthly forms", the user is provided with the ability to select a specific event, operate the camera, and target directly on a smart brochure and to get information on the location of the event.

Figure 5. Current Events and Periodical Material Screen.

In the third section Figure 6 of the mobile application "Specific event and smart brochures information management module" the user is provided with full access to smart brochures functionalities such as:

- Function of displaying external links such as Websites of operators, information links for specific content
- Functions of augmented reality objects and their enrichment with
- Video
- Sound
- Information
- Multimedia viewing functions

Figure 6. Access Content using AR and Camera features.

2.5 In-App Dynamic Content Management System

All mobile application sections have content that dynamically updates based on the event, the organization, the brochures, posters, and the "markers". A mechanism to produce the multiple "components" (buttons, icons, etc) and dynamically load image galleries, videos, and text is developed providing a fast and easy way to deploy the application for different events. This mechanism is created in the form of an in-app DCMS. The main idea is to manage the Content catalog that is delivered to the application through the Main Content Management System as output in a json format. Two json files are the main input for the mobile application.

The 1st json file concerns the upcoming events and the 2nd json file concerns the events' content.

The main json entity is each "marker" on the analog brochure or poster and all the necessary content is cataloged as a collection connected to the "marker".

The mobile application on the build collects the content catalog (json files), parses them to check if the existing files registered in the application are up to date, and modifies its content if additional files and events need to be included. The next step is to download the new or modified data and incorporate them into the system or if no new data exists simply start the app. These steps are processed by the in-app DCMS.

The In-App DCMS subsystem is based on 4 modules to serve the general initialization workflow (Figure 7).

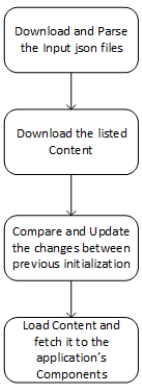


Figure 7. Mobile App Initialization Workflow

The first module is the ***parser***, which is responsible for reading a downloaded .json file and creating content-linked objects. This module starts along with the application initialization and downloads the necessary json files from a given REST API endpoint. This module calls the **third module** to decide if the content should be updated or not. The json files are the main content management catalogues. If differences between the json catalogued content and physical existence of them on the device exist, the app proceeds to the 2nd module to download and register these changes. If no differences exist, then the app starts and proceeds to the scene with the User Interface to access events and their contents. (Figure 8).

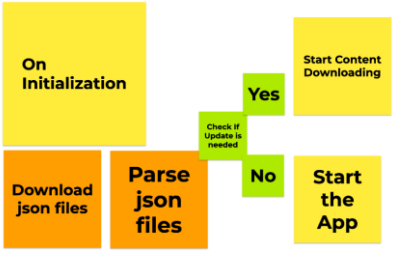


Figure 8. Initialization parsing and update module Workflow

The second module supports the ***download*** process which is responsible for downloading the overall content and information by iterating the content-linked objects, created by the previous module. Downloads the necessary content and updates their record in the json file (catalog). (Figure 9).

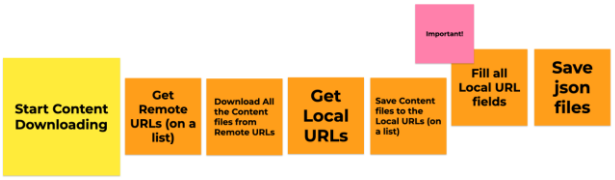


Figure 9. Mobile App Initialization Workflow

The third module is developed to check if an ***update*** to the content or information is needed, by iterating the initial content file and the local file system. As described in the first module process the update module recognizes the differences and decides whether a content update is necessary.

The fourth module is the ***loading*** process, which is responsible for fetching the content on runtime to fill the content-holding components, such as 3D Models and UI photo galleries, of the AR scenes on runtime. (Figure 10).

Figure 10. Mobile App Initialization Workflow

As soon as the loading process is completed the interface of the application is provided to the end user to navigate through the smart brochures. All these procedures provide the ability to make minor or major changes in the content and the application automatically takes them into account. In this process the main sections of the app that are affected are the following:

- Initial informational Section
- Current Events and Periodical Material Section
- Access Content using AR and Camera features Section.

3. THE CASE OF THE STATE CONSERVATORY OF THESSALONIKI, GR

Two evaluation Events should be established during the DIGI-ORCH project's timeline. In this context, an event was prepared and took place in TSC. The development of the app was completed and the In-App DCMS subsystem was tested on the concert real scenario "Musical Kaleidoscope". The brochures were designed, "Markers" were selected on the analog material and the necessary content is linked to them. The appropriate *.json files were produced. The first section is created as presented in Figure

11. The initialization screen has a loader, and the Informational screen is completed with the information regarding TSC.

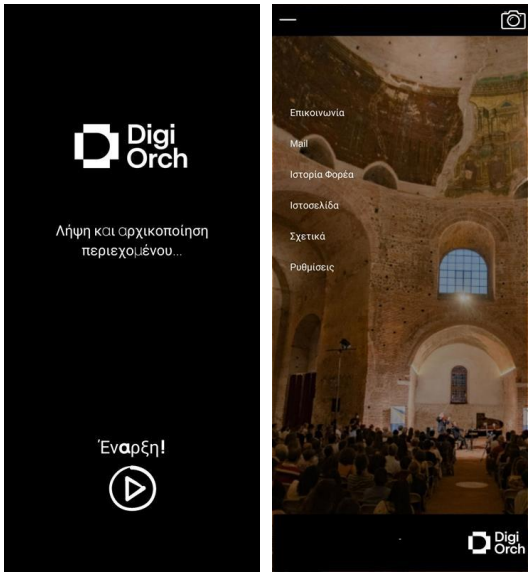


Figure 11. Initial Informational Screen with loaded information

In the second affected section (Figure 12) of the mobile application, "Information section about current events, event history, and possible six-monthly forms", the user is provided with the ability to select a specific event, operate the camera, and target directly on a smart brochure and to get information regarding the location of the event. The event that is loaded in the "Current Event" list is the "MUSIC KALEIDOSCOPE "

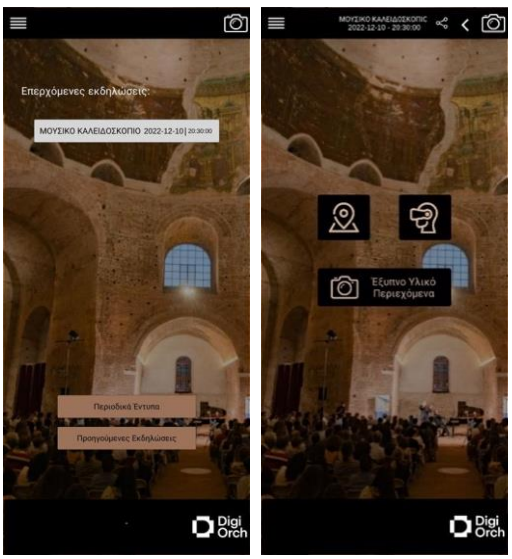


Figure 12. Current Events and Periodical Material Screen updated by the current information and content.

Selecting the Musical Kaleidoscope event (as it is loaded by DCSMS) brings up a screen with three options.

- The first option provides access to the map with the location of TSC.
- The second option provides access to the virtual tour inside the TSC.
- The third option provides access to intelligent material content.

More specifically, the map screen allows the user to navigate on the Map to the TSC location and receive instructions on how to get there and travel time by different transportation modes((Figure 13).

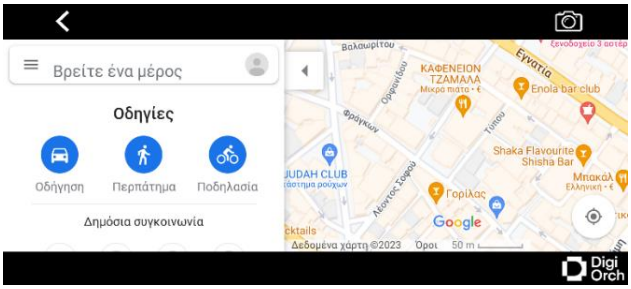


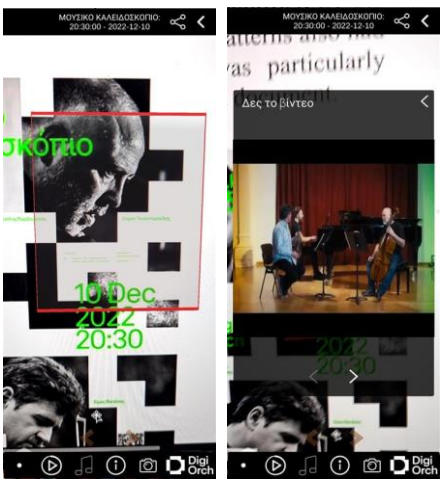
Figure 13. TSC location and Navigation on the Map.

Regarding the virtual tour, the user can select the relevant icon, to switch on the screen where he can navigate to the interior of the State Conservatory of Thessaloniki in 360 degrees (Figure 14).

Figure 14. 360º TSC Virtual tour.

The third option leads the user to the application section that visualizes the content using AR capabilities.
In the third section (Figure 15) of the mobile application "Specific event and smart brochures information management module" the user is provided with full access to smart brochures functionalities such as:

- Function of displaying external links such as Websites of operators, information links for specific content
- Video
- Sound
- Information



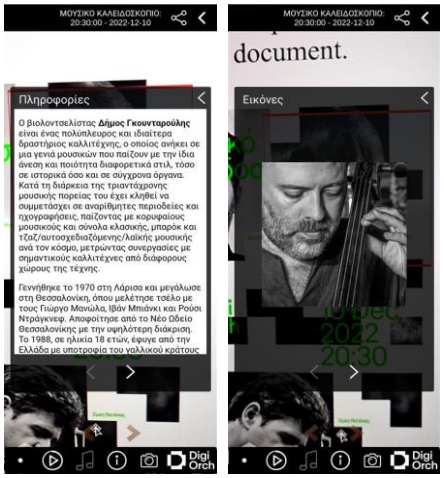


Figure 15. Access Content using AR and Camera features loaded content screens.

4. DISCUSSION

The use of AR technologies can contribute significantly to enhancing user experience in several fields with culture proving to be a major beneficiary. An AR-enabled application can turn our mobile devices into sources of knowledge with exclusive content being prepared specifically for each event, concert, museum, archaeological site, etc.

DIGI-ORCH is a research project that brings together partners of different backgrounds with one common goal: to create smart printed communication materials (e.g posters, concert program booklets) and an accompanying AR application to provide this enhanced audience experience to classical music lovers. The main issue is that event-specific digital content creation occurs in very close time proximity to the actual event. This condition does not allow for the deployment of an application that can be available for the event and that its content can be updated in a short period. The most time-consuming process is to modify and update the application for each event.

Using the approach of the DIGI-ORCH project regarding the in-app DCMS the event operators can register their content in the central Content Management System. The output of the Central system that includes the json catalogs and the content, video, text, images, 3D and navigation URL's is the initial content where all the in-app DCMS processes are based.

The in-app DCMS provides the opportunity to have a solid created mobile application that is formed based on the content. In this context, one application exists and provides multiple content experiences.

Based on this approach the goal that is achieved in this case is that the user can take the material with him and revisit the application and concert experience at his convenience without the event operator having the obligation to deploy a new application for every new event. The pilot project named "Music Kaleidoscope" proved to be a success regarding the in-app DCMS.

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