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Augmented Reality in changing and evolving the viewing experience: the DigiOrch research project

Keywords: Cultural heritage, Augmented Reality, 3D visualization.

Summary
The experience of attending live performances (e.g., a play, a concert, or a sporting event) nowadays has changed and continues to change at a rapid pace. Today, other audio-visual products are added and integrated to this experience, and it is possible to enrich it with the digital media and devices we have at our disposal. For example, Augmented Reality (AR) applications are gaining ground either as standalone artistic creations or as part of performances, offering possibilities for immersion or even interaction at times.
As part of the DigiOrch research project, an Augmented Reality application is being developed which combines spatial as well as thematic information (i.e., the venue and the event), for a performance of the Thessaloniki State Conservatory (KOTH), such as the stage and the orchestra, the positions of the musicians etc. The project includes, in addition to system development, the collection, the digitization and the processing of a large amount of data (websites, videos, animations, images, audio files, texts, 3D models, drawings, maps, etc.).
This application can be used in the future in other venues such as ancient theatres, monuments, historic sites, etc. and connect with other innovative technologies offering unique viewing experiences to users.

Introduction

Augmented Reality is a visualization technique that superimposes computer generated data, such as text, video, audio files, graphics, animations, 3D models, drawings, maps, GPS data, and other multimedia formats (websites), combining real and virtual worlds in 3D while being interactive. Especially, Augmented Reality can augment one's view and transform it with the help of a computer or a mobile device and enhance the user's perception of reality and of the surrounding environment (Kounavis *et al.*, 2012).

Various industries, retail, healthcare, real estate markets, entertainment, academics, tourism, hospitality, aeronautics and military are increasingly recognizing the need to research, develop and invest in Augmented Reality in order to increase and improve productivity. Mobile technological devices, both hardware and software, have made it possible for many sectors to change the way people interact and engage with games, sports, tours, live performances (e.g., a play, a concert), among other activities (Parekh *et al.*, 2020). Use of these innovative technologies has positive effect on competitiveness of the national workforce and contributes to the country's position in global economic space. It is therefore necessary to carry out series of national and international events on dissemination and application of Augmented Reality technology (Iatsyshyn *et al.*, 2019).

Augmented Reality popularity will grow in the next years thanks to the evolution of cloud technologies and the possibilities that they can contribute to Augmented Reality. Moreover, there will be several ad-

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vances in the near future in collaborative environments and collaborative interactions (e.g., devices from different manufacturers and with different encoding could be integrated into a single virtual environment), if future works focus on developing standards in this way (Muñoz-Saavedra *et al.*, 2020).

Regardless of the type of the application, Augmented Reality is a medium used to alter the real world around us and one that can tell a story beyond conventional and traditional storytelling, e.g., orally, on paper with words, pictures, in a play or movie where actors reenact the story (Locke, 2017). In this context, DigiOrch research project, an Augmented Reality application is being developed which combines spatial as well as thematic information (i.e., the venue and the event), for a performance of the Thessaloniki State Conservatory (KOTH), such as the stage and the orchestra, the positions of the musicians etc. The project includes, in addition to system development, the collection, the digitization and the processing of a large amount of data (websites, videos, animations, images, audio files, texts, 3D models, drawings, maps, etc.). This application can be used in the future in other venues such as ancient theatres, monuments, historic sites, etc. and connect with other innovative technologies offering unique viewing experiences to users.

The main axes of the DigiOrch research project

Until today, the concert programs are in printed form and provide specific information about the works, their creators, performers, time and place of the concert. The available area on the concert program is specific, in order not to lead users to information overload, while at the same time their presentation is not dynamic. The texts are small in size, with simple content, without interacting elements, and -in some cases- contain musical terminology, which many of the visitors are not able to decode. The project "*Development of a Model System for the Visualization of Information of the Cultural Activities and Events of the Thessaloniki State Conservatory (DIGI-ORCH)"*, concerns the design and development of "smart" concert brochures and educational programs of the Thessaloniki State Conservatory (KOTH), as well the development of an innovative system that will visualize this information with the help of smart mobile devices (smartphones and tablets) (Fig. 1).

The project has the following objectives:

• The design, the development and the implementation of a system for mobile devices that will extend the experience of the concerts and the educational programs of the KOTH. This application will offer an attractive and a full view to the visitor of the cultural activities and the events of the KOTH, a personalized interactive information retrieval through smart mobile devices, as well as an important tool for its promotional strategy implementation. The system will integrate augmented reality technologies and databases.

• The use and the integration of augmented reality algorithms in mobile devices. The system will have free access to information on the context of the concerts and the educational programs of the KOTH through a user-friendly environment, combining the information of the database, which will be presented on the smart mobile device in real time and will be displayed on screen by overlaying the digital information and content on the program.

• The improvement of visitor interaction and experience with the KOTH, as - in addition, through the system - they will be able to send comments in a digital guest book.

• The thorough testing, the evaluation, the implementation and the demo installation of the system in concerts and educational programs of the KOTH.

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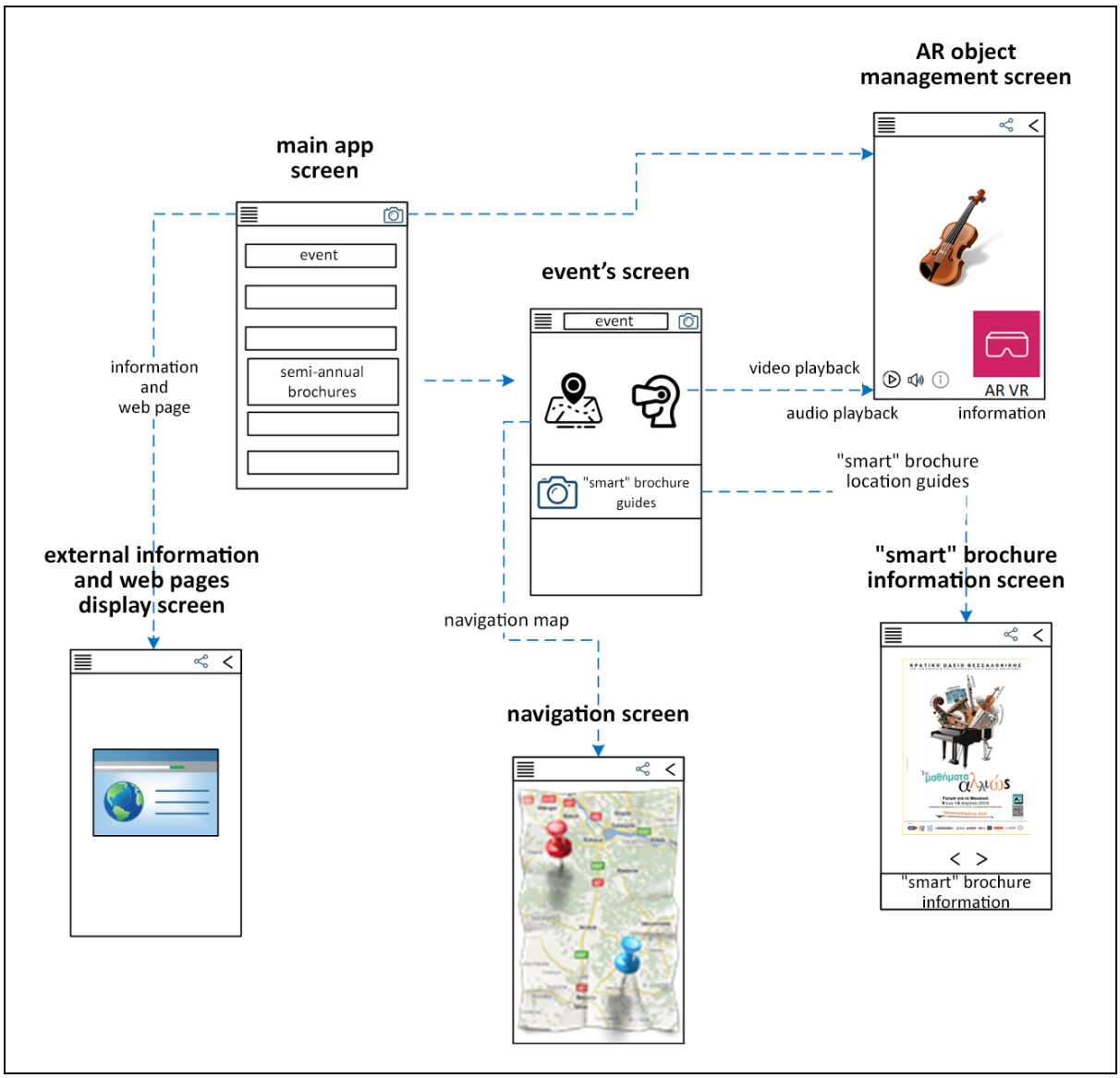

Figure 1: Wireframe of the mobile app: a "smart" brochure and the display of additional digital information on a mobile screen with the help of Augmented Reality and databases.

The implementation phases of the project are distinct and include:

• The development of the system (user needs analysis, determination of technical specifications, system design, experimental development of the system and pilot application of the final prototype),

• the collection, the digitization and data processing, such as the design of the reference framework and the digital content of "smart" concert brochures, the digitization of existing material, the creation of new digital material, e.g., website, videos, animations, images, audio files, texts, 2D navigation maps and 3D models that will be the digital cartographic background of the application, etc., which are related to the content of the artistic program.

• the dissemination of results (conference, workshop, publications).

The project is structured into seven (7) work units with twenty (21) deliverables. The key components of the system are the database, the content management system and the content presentation system (Fig. 2). The outcome will be the creation of low-cost applications, so that it is possible to mass produce and distribute them to other cultural organizations. The proposed platform and innovative applications can be easily and quickly adapted and used by other cultural organizations and institutions, such as e.g.,

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public and private theaters, ancient theaters, ballets, museums, exhibition spaces (paintings, sculptures, etc.).

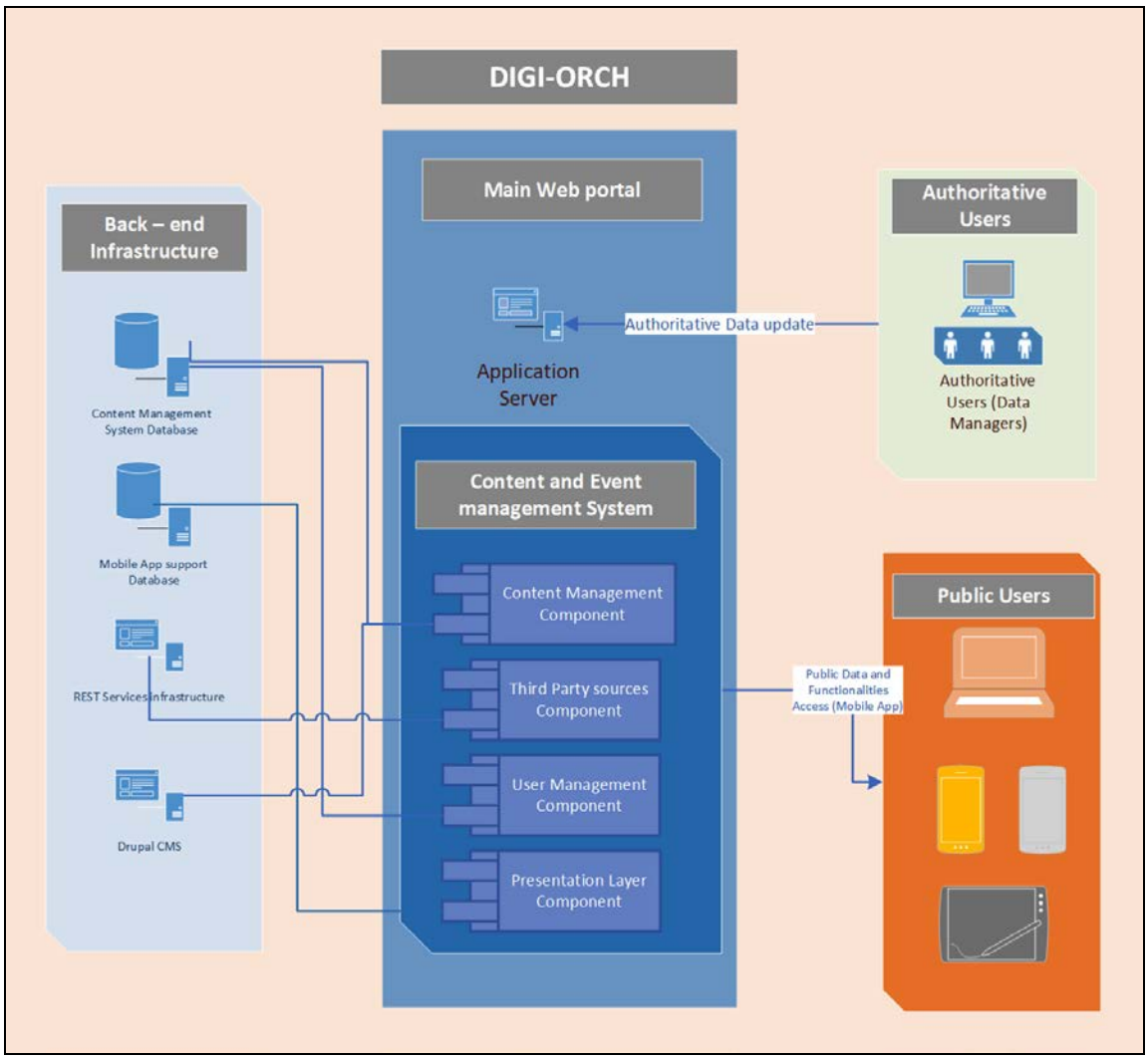

Figure 2: The flow chart of the DigiOrch research project.

Spatial backgrounds and their visualization

Emerging technologies, such as Augmented Reality have been widely used as an additional tool for cultural institutions to engage their audiences. The Augmented Reality (AR) technology is widely used for enhancing the human perception of the world and enriching the cultural experience. Ac-cording to Azuma, Augmented Reality is "a system that combines real and virtual content, provides a real-time interactive environment, and registers in 3D" (Azuma, 1997). It enables digital information to be integrated in the physical environment. In this merged world AR provides visual augmentation and valuable visualization capabilities that can superimpose 2D and 3D information to the real world in real time. According to Milgram and Kishino's Reality-Vituality Continuum (Milgram and Kishno, 1994) AR is part of Mixed Reality technology, in which the surrounding environment is real, and that real environment is enriched / augmented with digital objects. In augmented virtuality and in a Virtual Reality environment the surrounding world is completely virtual. The AR apps have location-based capabilities, and they can be used indoors and outdoors, online or offline.

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From the first attempts of AR application to Cultural Heritage, such as ARCHEOGUIDE (Vlahakis et al., 2001) and Augmented Representation of Cultural Objects (ARCO) project (Wojciechowski et al., 2004) till nowadays many things have changed and advances have been presented in scientific publications. Some characteristic examples are the article of Bekele et al. (2018) (Bekele et al., 2018) that provides a meticulous survey of Augmented, Virtual, and Mixed Reality for cultural heritage and the article of González Vargas et al. (2020) that provides a survey on how to use Augmented Reality to improve learning motivation in Cultural Heritage studies (González et al., 2020). AR technology is characterized by its high portability since almost everyone can use an AR app with the help of his/her smartphone. An Augmented Reality Application has input sensors, processing procedures, such as tracking and registration, virtual environment modeling, tracking and interaction and outputs, such as smartphones and tablets (Siriwardhana et al., 2021). Concerning AR display technology, it can be video-based AR displays, optical see-through AR displays, projection-based AR displays, eye multiplexed AR displays (M. Billinghurst et al., 2015).

By the implementation of the research program DIGI-ORCH 360° degree VR images will be used that will integrate valuable information about the concert venue, including the entrances and the exits from the venue, the orchestra, the seats of the audience, etc (Fig. 3).

Future upgrades of the application after the completion of the project could be as follows:

• the use of 2D analog map of a building complex in the form of a floor plan, where AR points with information about navigation will be displayed on screen using the mobile device functionalities,

• 2D digital maps in the form of a floor plan and use of sensors (e.g., beacons) to determine user's location and to ensure navigation inside the building,

• 3D models from a laser scanned point cloud for the 3D presentation of both the exterior and the interior of a building.

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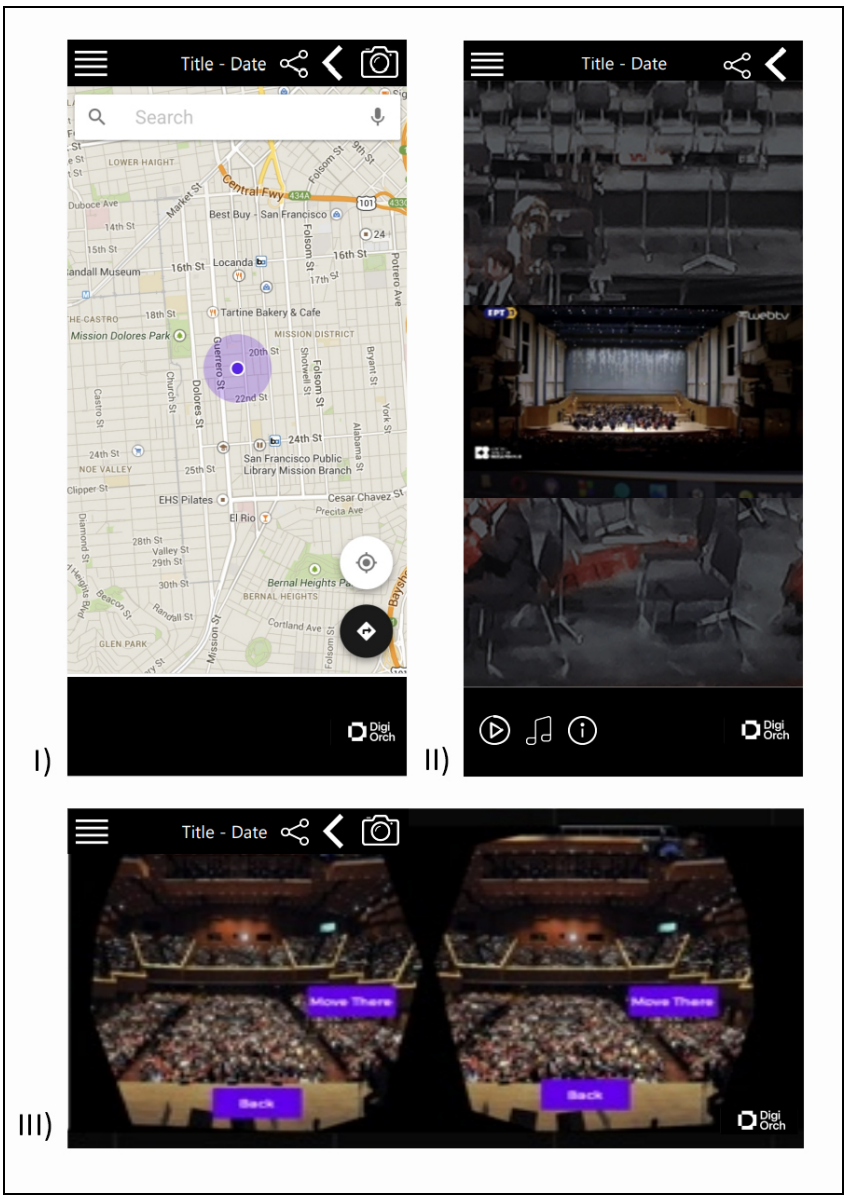

Figure 3: Future upgrades of the DigiOrch research project I) navigation using 2D analog map, II) 3D models from a laser scanned point cloud, III) 360°-degree VR images.

Connection of the DigiOrch research project with other innovative technologies

The evolution of Augmented Reality applications depends on various factors such as the synergy between Augmented Reality and mobile computing, hardware and software used, interaction methods and visualization approaches on mobile devices, the use of geo-referenced data, 3D localization etc.

The DigiOrch research project can take advantage of innovative technologies such as Bluetooth Low Energy (BLE) antennas, Wi-Fi RTT and ultra-wideband (UWB) that make indoor and outdoor navigation much more viable than in previous years. One of the most useful applications of these technologies is for displaying Augmented Reality directions in large indoor and outdoor locations including concert halls, theaters, clubs, arenas, convention centers, stadiums etc. With Augmented Reality, on-screen directions can help users to navigate and find the information that they need such as for example the floor plan of the venue, the positions of the singers on stage, the orchestra, the chorus, etc.

The DigiOrch research project can make use of Information Systems functions, as the current state-of-the-art Augmented Reality and Information Systems are related with in many ways. Through these sys-

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tems, information in the form of text, photos, videos, etc. can be collected and distributed to Augmented Reality applications. Moreover, cloud services are critical enablers of Augmented Reality, allowing us to process, store, and analyze the Augmented Reality content and consumer data. Augmented Reality content can be stored on cloud platforms and make available on-demand as most Augmented Reality devices come with limited processing and storage capabilities. This approach reduces the need for high-end on-device processing, however, the device's distance from the remote server and network latency can inhibit the flow of content. Furthermore, WebAR can allow users to experience Augmented Reality content through web browsers such as Chrome, Edge, Safari, and Firefox rather than using a standalone application.

Practical and potential applications of the DigiOrch research project

The DigiOrch research project can be modified and be used in the future by other artistic organizations and agencies (e.g., National Theater of Northern Greece, etc.) that organize similar events live or remotely. Different geometric backgrounds of event venues, different composition of orchestra, ensembles and artistic activities, different artistic services offered, can be integrated in this application and expand the possibilities it offers.

Furthermore, the DigiOrch research project could greatly improve user experiences with Augmented Reality technical apparatus such as smart glasses, headsets or even contact lenses that could turn Augmented Reality into a more natural, intuitive, and accessible utility. A combination of audio and visual data would enable the user to enjoy a unique artistic experience.

Augmented Reality applications such as the DigiOrch research project can provide new platforms to visualize data in interactive ways and can be used to deliver innovative and immersive experiences to users. Augmented Reality can enable information and experiences to be augmented and shared to specific physical locations, as well as to save and display across applications and devices. Augmented Reality will be a key technology in the future of training, music streaming, education, travel, real estate, healthcare, retail and social messaging, among others, with visualization involving the use of images, videos or graphics to share information, communicate and interact at the same time.

Conclusion

Upon completion of the project, low-cost applications will be created, so that they can be mass-produced and sold to other cultural organizations. The creation and the distribution of "digital cultural goods" will be promoted as well as their connection with the education, the training, the entertainment and the artistic cultivation of the citizens.

The application will be a reliable, innovative and complete system for presenting information about the concerts and the educational programs of the KOTH. It will also allow the personalized information promotion, as the visitors can select on mobile screen the information that is of most interest to them and will deepen to the extent that they wish. The methodology of system implementation and algorithm development can be extended and applied by other cultural organizations in Greece or abroad.

In addition, the development of the system will provide a direct connection between classical music and technology and its tools, while at the same time it will demonstrate in practice how specific technological means can help to modernize the diffusion of information. Finally, the familiarization of the younger ages with the new technologies will increase their interest and will make classical music more accessible and attractive.

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