Design of a Modular Integrated System for Augmented Tourism Destinations

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***Abstract*— In the tourism sector, identifying and promoting relevant attractions and points of interest to visitors, especially through AR/VR technologies, has been proven to enhance the on-site overall visiting experience. Throughout this paper, the use of multimedia, augmented and virtual reality content is presented, as a means to improve the experience of both on-site and remote (website) visitors. Therefore, a generally applicable platform, consisting of interconnected modules and based on open source technologies is proposed, which in turn allows the end-users to provide their own content and stakeholders to gather meaningful metrics and feedback.**

Keywords: e-Tourism, Augmented Reality, Virtual Reality, Multimedia technologies, Web Applications.

I. INTRODUCTION

Despite the abundance of literature about the types, elements and benefits of gamified applications, a standard methodology for developing a domain specific application (i.e. educational or touristic), does not exist yet. Computer games are promising to form the content of future Immersive Media, but this prospect faces both technical and usability issues. Thus, we chose to design an application running on modern computing devices and targeting mainly tourist visitors, without neglecting the general public, based on existing models of persuasive technologies, gaming methodologies and cognitive processes. Immersive Virtual Reality (VR) and Augmented Reality (AR) technologies can provide high levels of fidelity and a genuine experience [1]. Both visual and interaction fidelity significantly affect performance, as well as the perceived sense of presence, engagement, and overall usability.

Our approach aims to enhance the physical and virtual visitor experience by moving through a complex virtual world in an intelligent way. This study is part of a broader context where a system/platform can enhance alternative/rural tourism destinations with the development of interactive applications such as self-guided tours & Augmented Reality models (AR) [2]. Modern mobile computing devices such as smart phones, tablets and smart watches (for the on-site visitors), as well as a web browser (for remote visitors), are the targeted platform for the development of modern software applications to promote and highlight the natural, cultural and tourism wealth of destinations [3].

The current implementations are mainly based on multimedia, augmented and virtual reality applications, which, although they have reached a certain degree of matureness and can be even considered “mainstream” nowadays, are largely based on proprietary - custom tailored solutions. These implementations require technical expertise, specific skills and considerable resources (e.g. budget) by the implementing bodies. Therefore, we propose an open – standards based, versatile and universally applicable platform that is easily implemented and deployed, which in turn allows end-users to contribute their own content and to provide feedback by monitoring their behavior.

In this paper we begin by presenting the related state-of-the-art current work, based on the recent literature. Subsequently, the design and architecture of the system is presented, where the objectives, requirements and building blocks of the proposed platform are described. Finally, the deployment and challenges of the system will be discussed.

II. STATE OF THE ART

Over the last few years, there has been growing interest in the concept of smart - enabled tourist destinations, supported through ICT applications and infrastructure [4]. On that notion, there is a broad acceptance for the contribution of ICTs, the Internet of Things and Cloud Computing, providing the tools and the context to enable the dissemination of information and knowledge between stakeholders, thus enhancing innovation and destination competitiveness [4]. Furthermore, smart tourism destinations should take advantage of Big Data by offering “custom-tailored” services that suit users' preference at the right time [5]. Understanding the needs, wishes and desires of travelers, becomes increasingly critical for the competitiveness of destinations [5]. In this context, designing and developing a location-based service, integrating Web, multimedia, augmented/virtual reality and geolocation services and technologies has been proposed by several researchers. This can be further enhanced, by identifying and promoting

relevant user attractions and points of interest, enhancing and personalizing the on-site tourist experience.

More specifically, virtual reality has the potential to offer three educational features: immersion, imaginativeness and interactivity. Researchers went on to explain that virtual reality shares the qualities of controllability, authenticity and sensory input, providing participants with a mobile, tactile, touchable and playful simulated object that replaces interaction and experience in the real context [5]. Virtual reality has been implemented in a variety of fields, such as arts, architecture, business and tourism. A number of prior research projects have identified that the application of virtual reality has led to a positive effect on enrichment of experiences and learning achievements [6].

A recent example of wider application of AR can be attributed to the recent COVID-19 pandemic (the biggest pandemic of the 21st century so far), having a devastating impact on almost all economic spheres. In order to avoid impoverishing, due to lower mobility, augmented reality (AR) and other ICT-based tools, set to lead the reboot of tourism after COVID-19. Mohanty et al. [7] highlighted that ICT technologies, including AR and VR, have proven to be innovative tools that can provide multi-sensory experiences without direct contact, which can ensure both the satisfaction and safety of tourists. Therefore, the future of tourism will be heavily influenced by VR/AR systems, and the cost of these systems is expected to decrease with greater demands for entry-level systems.

A hands-on deployment by Destination Management Organizations (DMOs), of a gamified mobile experience on real world applications, has been proposed by Garcia et al. [8]. They introduced a valorization process that reviewed and identified the advantages of these formats, to enable enriching the visitor tourist content and providing improved services to selected visitor groups. In particular, they underlined a number of aspects that need to be considered beforehand, to measure the impact of a highly effective gamified mobile experience.

On the other hand, Dou et al [9] developed a context-based marketing approach - enabled by mobile technologies - that augments consumer purchase intention and experiential quality, in a hedonic recreation and cultural environment. The researchers adopted an experimental design process based on video stimulus scenarios and a follow-up survey questionnaire involving a total of 151 participants. Participants were randomly assigned one of the available scenarios of an art museum visit, which helped the authors to develop contextually relevant souvenirs that positively influence museum visitors' intention to purchase, without undermining the experiential quality.

Another example, in the field of museology, is the work of Hsu and Liang [10] through which a universal, game-based mixed museum learning service is being developed, to attract museum visitors of varying age groups and promote return visitation. In particular, they proposed a unified facility with versatile educational content, targeted at all ages, through a viable and affordable approach for supporting different guests on a specific venue. It is worth mentioning that their practice consists of a real-world adventure game system, with flexible learning content and various types of learning support, which was evaluated through two questionnaires used to examine visitors' museum experiences and subjective measures of cognitive load.

More broadly, Cai et al. [11] presented the harmonization of Information Systems (IS) into the tourist industry for their application as a domain - specific technology. In their in-depth exploration, the model of technology acceptance in the tourism sector and the unified theory of technology acceptance and use are distinguished. Virtual world and mobile AR applications are distinguished, for enabling tourism and hospitality service providers to design a wide range of experiences. However, a key requirement to enhance confidence in the use of new technologies, is to achieve high levels of user satisfaction with the introduction of AR technologies in tourism.

Wei's paper [12] highlights recent and key research developments in virtual reality (VR) and augmented reality (AR) for the hospitality and tourism sector. Fruitful directions for tourism-oriented (especially VR and AR) applications are identified. This study draws together the stimuli, dimensions and consequences of users' VR/AR-related behavioural experience, and then develops a theoretical framework. This in turn, highlights the adaptive nature of the technology that goes beyond the intrapersonal level of a focal user and extends to the interpersonal level, as VR/AR technologies add tourist attractions, through the structured classification of related information in broader structures such as social networks and web portals.

In the area of serious games research, Hall et al. [13] proposed a game evaluation approach, adding value and entertainment to the player's experience while providing the ability to gather useful data. Their approach leverages seamless evaluation to manage the expectations, perspectives and requirements of players, guests in our case. Therefore, they recognize that in game evaluation procedures, the whole interaction process, including the evaluation, should be enjoyable and fun for the user.

The above mentioned works are just indicative of the extensive research in progress, on the applications of AR and VR technologies on every form of tourism, from mainstream to alternative and thematic ones, while further technological solutions do exist and have been applied in tourism, e.g. 3D printing [14]. Our approach aims to lower the “barrier to entry”, for stakeholders seeking to implement and deploy such technological solutions, by following the paradigm of how the Content Management Systems (CMS) streamlined the process of web content creation. By proposing a generally applicable, modular and based on open standards architecture, instead of relying on proprietary and expensive implementations, stakeholders can easily and cost effectively implement VR and AR technologies on tourism destinations, focusing on the content itself, and not on the complexities of the underlining technologies. On-site and remote visitors will enjoy a richer, augmented experience, while, at the same time, stakeholders will gather meaningful feedback and metrics on visitors’ behavior and preferences.

III. System Design And Architecture

A. Objectives

The general objective of the proposed architecture is to provide a general applicable, cost effective solution for stakeholders to augment/enhance tourism destinations with multimedia content via AR techniques, while eliminating the need for advanced technical skills and proprietary development of custom solutions. By merging augmented reality with the physical environment, the visiting experience is transformed, helping stakeholders, operators, and visitors, all at the same time.

The specific objectives are, to provide:

- an open source, generally applicable, mobile Augmented Reality application, by which visitors will be able to access via AR techniques multimedia information linked by the content authors and provide essential feedback. Useful metrics such as the time spent by visitors exploring a location, popular sightseeing that attracted most visitors' attention, can be also performed by the mobile application. The information will be accessed either on-site (by geolocation or by scanning appropriately placed marking e.g. QR codes) or online, through a Web Browser or VR Headset, in order to provide a close-to-reality remote experience of the destination.
- A web/back-end application, following the paradigm of the Content Management Systems that streamlined the web content creation process, by which content creators will be able to upload, link and maintain multimedia content related to tourism destinations and which will be accessed by the users of the mobile AR application. It can be developed by using exclusively popular and proven open-source technologies / software tools / platforms and thus can be cost effective and easily installable on proprietary servers or web hosting services.

B. System Requirements

The present study proposes the architecture of an integrated, web–based service, featuring state of the art Web, Multimedia, Augmented and Virtual Reality and Virtual Walkthrough technologies. The service will be accessible by on-site users, through a mobile application, and by remote visitors through a web interface. The primary system requirements are:

- Accessibility through the most popular smart/ mobile devices, e.g., smart phones and tablets for the on-site provided content.
- Compatibility with all modern Web Browsers and Virtual Reality Equipment for the on-line content.
- Modular design: based on distinct modules, each one providing part of the overall functionality and transparent integration on the end-user interface, either the mobile application (for on-site visitors) or the web site (for remote visitors).
- Support for a variety of modern multimedia content formats: streaming video, 360o spherical/panoramic video and photos, virtual walkthroughs, 3D objects to augment visitors' experience.
- User profiling functionality: end-user metrics and personal profile maintenance in order to receive custom tailored personalized information.
- Visitor notification: end users of the mobile application should be prompted about nearby places (sights) of interest matching their personal preferences.
- Feedback/evaluation and metrics functionality: by allowing end users to provide feedback and evaluation information and by performing useful metrics on users' behavior during the visit, the system should provide valuable information to stakeholders, by utilizing modern data mining and machine learning techniques.

C. System Architecture and Components

The overall System Architecture is featured on Figure 1.

Two typical usage scenarios are depicted on Figure 1:

- An on-site user using the mobile A-R application, either automatically by geolocation or by scanning marking receives related multimedia content which is displayed by Augmented Reality techniques enhancing the real experience.
- A remote user, using a computing device and perhaps a Virtual Reality Headset, enjoys a virtual walkthrough experience, enriched by multimedia informative content and providing a - close to the real – virtual visiting experience.

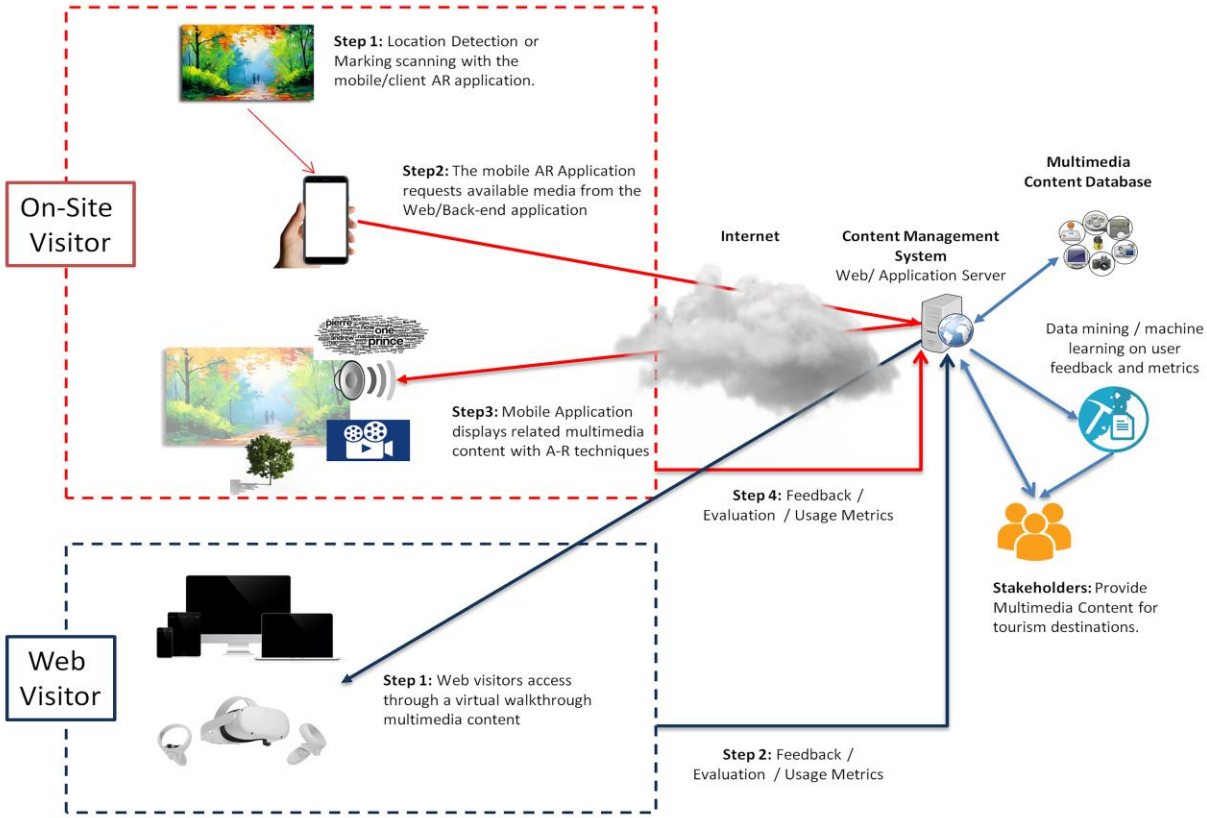

Fig. 1: System architecture and components.

In both scenarios, users can provide feedback while user-behavior metrics are performed for further analysis with data mining / machine learning techniques.

A short description of each module's functionality is featured on Table 1. The location on which the module resides (front-end / client side or back end / sever side) is also presented.

TABLE 1: SYSTEM MODULES

Module	Description	Module Location
User Feedback, Profiling and Metrics	This Module maintains each user's profile with personal interests, preferences, ratings etc. Will also automaticaly perform uer metrics e.g. how much time the user spends watching augmented information, hotspots that attracted the visitor's interest. Will provide the means/interface for end users to provide feedback for the content they receinve and the overall experience.	**Front-End (Mobile Application) and Back-End (Server).** The module splits its functionality on both client and server side. Metrics will be performed on the mobile application or the web interface and the results will be submitted to the server for further analysis. The user profile will be also maintained centrally on the Server-side which will also provide the user interface for the profile maintenance, user authentication etc.
Multimedia Content Database	A database with multimedia content (text, audio, video, pictures, 360 pictures and video, virtual walkthroughs etc) of places of interest and thematic itineraries (e.g. historical, religious). Based on the visitor's location or the scanning of marking, the A-R Mobile Application will regularly query the multimedia database to retrieve matching inforamtion to display via the presentation module.	**Server Side (Database Server, Web Server).** The database will reside centrally server-side. The module will also feature an administration web interface for stakeholders to maintain and update the content
Presentation	An Augmented Reality mobile application for on-site use and a Web Application for remote visitors. This module will present the Multimedia Content Database content to the visitors either by A-R techniques (superimposed on the natural environment) or through a Virtual Walkthough in a Web Browser or VR Headset providing a convincing	**Client Side (AR Mobile or Web Application).** The presentation of the Multimedia Content is executed on the visitors' mobile device (smartphone, tablet etc), Web Browser or VR Headset. The most popular platforms (Operating systems, web browsers, special equipment like VR Headsets) should be supported in order to

Module	Description	Module Location
	and media reach virtual visiting experience.	maximize the targeted audience.
Data Analysis Module	Will perform analysis on visitors' feedback, profile and metrics in order to provide valuable insight on stakeholders and enhance end user's experience (e.g. by providing the most relative content, sugest places of interest). Data mining and machine learning techniques can be utilised for information extracting.	**Back-End (Application Server).** This module resides on the Server-Side of the System, analyzing the gathered data. Will also feature a web interface to provide the extracted information to stakeholders in an intuitive and meaningful way.

IV. DISCUSSION

The present study outlines the design and a proposed architecture for the implementation and deployment of Augmented/Virtual Reality and Multimedia technologies and content, in order to augment the on-site and remote experience of tourism destination visitors. By utilizing a generally applicable, modular and based on open standards architecture, instead of relying on proprietary and expensive implementations, stakeholders can easily and cost effectively implement VR and AR technologies on tourism destinations, focusing on the content, instead on the complexities of the underlining technologies. On-site and remote visitors will enjoy a richer, augmented and personalized experience, while stakeholders will gather meaningful feedback and metrics.

The system implements its functionality by a collection of modules, of which some are back-end modules, residing on the hosting web/application servers and the rest are front-end modules, specifically: the mobile A-R application and the Web interface targeted to on-site and remote visitors respectively. Modern mobile and web technologies are used throughout the system and the implementation can be based on open source tools and platforms.

By dividing the overall system functionality in modules, the upgradability, expandability and serviceability of the system is enhanced. Each module can be updated and upgraded independently without affecting the functionality of the rest, e.g. the mobile AR application can be updated to provide support for displaying new media formats or the backend feedback / user metrics analysis can be upgraded to feature more sophisticated analysis methodology.

The chosen approach, is based on modern but mature enough and proven solutions and technologies and the implementation is not expected to encounter particular technical challenges. The accessibility through all modern smart/computing devices and the "penetration" of Web and Mobile Applications in everyday activities, guarantees a large base of tech-savvy visitors and the viability of the concept.

Privacy is always a concern, especially in location-tracking applications, and should be addressed during system design, implementation and operation. Anonymized data should be maintained, wherever applicable, for further analysis.

Finally, the requirement of internet connectivity for accessing part of the system's functionality (e.g. presentation module by on-site visitors) may induce charges by telecommunications service providers. However mobile internet connectivity has already become mainstream with constantly decreasing cost, while free alternative networking options (e.g. metropolitan public access Wi-Fi) are increasingly becoming common place.

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