Using Web Technologies to Implement a Modular Integrated System for Augmented Tourism Destinations

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Abstract. Identifying and promoting attractions and points of interest to visitors, especially through multimedia and – lately - AR/VR technologies, has been shown to enhance the pre-traveling and on-site overall experience. Throughout this paper, the development of a modular, web-based, generally applicable platform, consisting of interconnected modules and based on open-source technologies is presented. Not long ago, the deployment of engaging, rich-media user experiences required special equipment and native development tools. The present work demonstrates, how recent advancements in web technologies and modern web browsers (e.g., the WebGL), enable the deployment of such cutting-edge services, on mainstream mobile devices, using exclusively well-established web technologies like HTML, CSS and JavaScript.

Keywords: Multimedia, Augmented Reality, Digital Tourism, Web Technologies, Mobile Applications.

1 Introduction

Considering the wealth of information available on the types, components, and advantages of gamified applications, there is currently no established technique for creating applications suited to a given sector (such as educational or touristic). Future Immersive Media appears to be based on computer games, although there are both technological and practical challenges with this idea. Therefore, based on existing models of persuasion technologies, gaming methodologies, and cognitive processes, we decided to create an application running on contemporary computing devices and targeting mostly tourists' visitors, without disregarding the broader public. Immersive VR and AR technology can offer extremely high degrees of authenticity and a real-world experience [1]. Performance, as well as the perceived sensation of presence, engagement, and general usability, are all greatly impacted by both visual and interaction fidelity.

Our strategy involves navigating an unfamiliar virtual environment in an intelligent way in order to improve both the physical and virtual visitor experiences. This research is a part of a larger context in which a system or platform can improve alternative/rural tourism destinations through the creation of interactive applications like self-guided tours & Augmented Reality models (AR) [2]. The target platform for the development of modern software applications to advertise are mobile computing devices such smart phones, tablets, and smart watches (for on-site visitors), as well as a web browser (for remote visitors) [3].

Most of the existing implementations are based on multimedia, augmented, and virtual reality apps, which, despite having grown mature and even being able to be deemed "mainstream" today, are still heavily dependent on proprietary, custom-made solutions. These implementations demand significant resources (such as funding) from the implementing entities as well as technical know-how and specialized capabilities. As a result, we suggest an open, standards-based platform that is flexible and relevant to all users. This platform enables end users to submit their own content and to give feedback by observing their behavior.

Beginning with the associated state-of-the-art, current work, based on the most recent literature, is how this study is structured. The system's design and architecture are then presented, together with a description of the goals, specifications, and fundamental components of the suggested platform. Finally, the system's deployment and difficulties will be covered.

2 State of the art

In recent years, the concept of "smart tourism destinations" that make use of ICT infrastructure has grown in popularity. Such destinations are anticipated to boost the destination's competitiveness by spreading information and expertise among stakeholders and giving tourists with personalised experiences. Virtual reality and augmented reality are new technologies that are predicted to transform the tourism sector by providing multimodal experiences without the use of direct contact. The COVID-19 epidemic has also spurred the use of augmented reality and virtual reality technology in the tourism industry. Several research projects are under underway to explore new technologies to improve the tourism experience, such as context-based marketing strategies and game-based mixed museum learning services. It is critical to boost user confidence in the usage of new technology in order to achieve high levels of user satisfaction with the deployment of AR technologies in tourism.

To begin, Chiu et al.'s [4] study outlines the design and implementation of an augmented reality system for tourism that uses image-based recognition. The technology provides users with information about tourist locations via a smartphone app that recognises items or landmarks using image recognition. The software then shows augmented reality information about the object or landmark, such as historical and cultural value, as well as local attractions and events. The system was evaluated in a real-world environment and proved to be beneficial in improving the tourist experience and giving users' useful information. The authors conclude that image-based

recognition technology has significant potential for improving tourism and advocate for additional research in this field.

Also, Shih et al.'s research [5] describes ARTS, an AR tourism system that combines 3D scanning and smartphone AR for cultural heritage tourism and pedagogy. Users can scan physical artefacts and receive augmented reality information on their smartphones, boosting their experience and comprehension of cultural heritage locations. The paper describes the system's technical aspects and examines its possible uses in tourism and education.

On top of that, Wei's study [6] analyses the integrated growth of countryside ecotourism in the context of AI applications with the wireless Internet of Things (IoT). The author contends that combining AI and IoT can improve the visitor experience as well as the efficiency and sustainability of rural tourism development. The study also presents a framework for the integrated development of rural ecotourism utilising AI and IoT technology, which encompasses smart tourism services, environmental monitoring, and smart management. The author believes that this framework will be a good guide for future rural tourist development.

Safari Bazargani et al.'s article [7] analyses the advantages and disadvantages of integrating GIS with AR and investigates different uses such as urban planning, disaster mitigation, and tourism. The authors also present an overview of the existing literature on GIS and AR integration and indicate relevant future research areas. Overall, the article emphasises the need of integrating GIS and AR for sustainable development and provides a roadmap for future research in this field. In particualar, several tourism-related uses of GIS and AR integration are mentioned by the authors, including producing interactive guides for cultural and historical places, upgrading museum exhibits, and facilitating virtual tourism experiences. They also point out that such technologies can deliver personalised and immersive experiences to tourists, which may lead to improved engagement and satisfaction. Furthermore, the authors argue that integrating GIS and AR can support sustainable tourism by informing tourists about ecologically beneficial activities and boosting conservation initiatives.

As a result, rather than relying on exclusive and costly implementations, we suggest a broadly applicable, modular, and open standards-based architecture. Potential beneficiaries and stakeholders can simply and affordably adopt VR and AR technologies in tourism sites, focusing on the content rather than the underlying technologies' complexity. Visitors to the site and remote users in general will have a richer, enhanced experience, while stakeholders will receive valuable feedback and metrics on visitor behavior and preferences.

3 System Design and Architecture

The system aims to provide stakeholders, an open and cost-effective solution to augment and enhance cultural, activities, tourism etc. destinations with meaningful information and multimedia content, attracting potential visitors and enhancing the

experience of on-site travelers. Additionally, it aims to provide travelers with a useful tool assisting their pre-traveling selection and planning process.

3.1 Objectives

The specific objectives of the system can be summarized into providing:

- a back-end infrastructure/application, based on open source, established and proven web technologies, following the Content Management System model, content creators will be able to publish, link, and update multimedia content related to their marketed locations.
- a general applicable, mobile application, based on web, open-source technologies and featuring modern presentation techniques, such as Augmented Reality and 360 multimedia content). The application will be used by travelers, either on-site or remotely, to access the system content and provide useful feedback.

3.2 Requirements

The main system requirements are:

- Compatibility with modern mobile devices and popular web browsers.
- Support for modern multimedia content formats e.g., streaming video, 360 photos and video, 3D objects.
- Featuring of modern content presentation methods such as Augmented Reality
- Modular system design.
- Personalization
- Users feedback mechanisms

3.3 System Architecture and Components

The system follows a modular design, consisting of a set of interoperable components with discreet functionality, building upon the 3-tier architecture, most of the web applications are based on:

- Client Mobile Application: responsible for the content presentation and user feedback (presentation tier)
- Multimedia Content Repository/Database: responsible for the maintenance of the information (data tier)
- Content Management Application: providing the back – end system infrastructure/functionality: content administration web application, user profiling and content customization mechanisms, the API (application tier)

The system modules and functionality as well as the main user scenarios are presented in **Fig. 1.** System modules, functionality and user scenarios

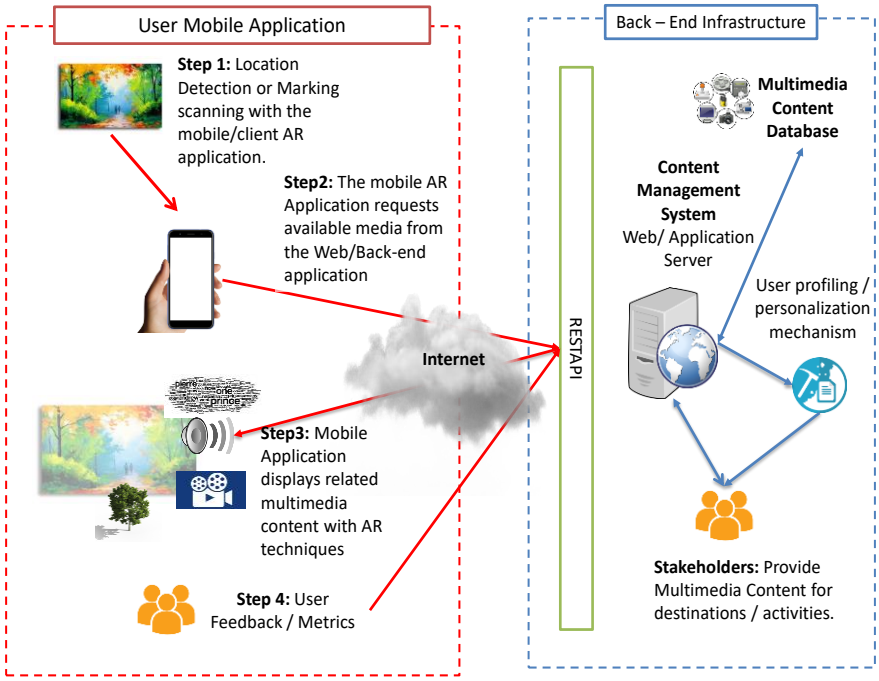

Fig. 1. System modules, functionality and user scenarios

4 Implementation

4.1 Implementation of the back-end infrastructure.

The back-end infrastructure was developed using the MySQL RDBMS and the PHP, a programming language targeted, mainly, on web application development. A RESTful web API was developed as an interface for the Client Mobile Application to exchange information with the system's back-end services.

The data is transferred to the mobile client application using the JavaScript Object Notation (JSON) lightweight data-interchange format, a choice which facilitates their handling via JavaScript code on the Client mobile app.

The featured REST API calls, their input parameters and the resulting data are briefly presented on Table 1.

Table 1. Featured REST API Calls.

REST API Call	Input Parameters	Result
activities	UserID (integer)	JSON formatted data about the activities featured by the system
pois	UserID (integer)	JSON formatted data about the Points of Interest (POIs) featured by the system for each activity
media		JSON formatted data about the media sources featured by the system for each POI
postRating	UserID (integer) poiID (integer) poiRate (0-5)	Registration of a user's rating (1-5) for a POI
postVisit	UserID (integer) poiID (integer)	Registration of a user's physical visiting of POI (tracked by geolocation services)

4.2 User Mobile Application Implementation

The user mobile application acts as the system's client, utilizing the REST API to obtain information from the back-end services and provide user feedback/metrics to the system. It implements the presentation layer of the system's 3-tier architecture.

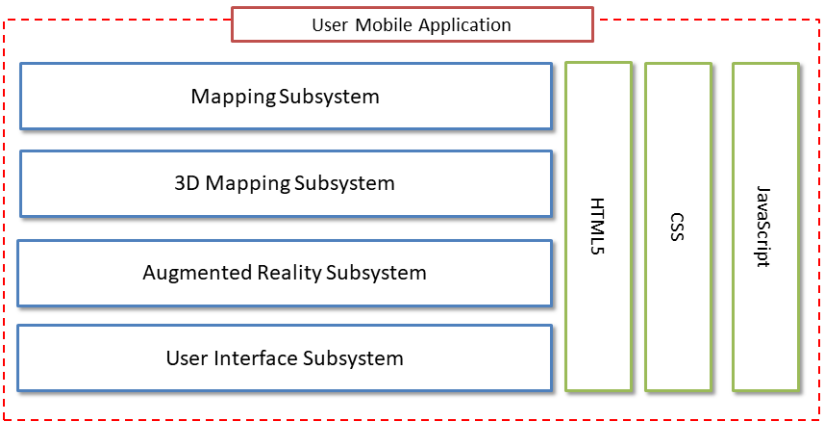

Fig. 2. Mobile Application - Subsystems

The mobile application was implemented as a mobile-friendly web application, utilizing exclusively web technologies and more specifically, HTML5, CSS and Ja-

vaScript, along with a collection of JavaScript frameworks which provide the basis and core functionality of the various subsystems which are presented on **Fig. 2**.

The JavaScript libraries/frameworks that were used for the implementation of each subsystem are listed on **Table 2**. The JavaScript API of each framework was used to implement functionality specific to each subsystem, while additional custom JavaScript code handles the integration of the subsystems and core functionality of the mobile application such as geolocation and data exchange with the back-end infrastructure.

Table 2. JavaScript libraries/frameworks used for the implementation of the mobile app. subsystems.

Subsystem	Library/Framework	Short Description
Mapping	Leafllet [8] & OpenStreetMap [9]	Leaflet provides a JavaScript programming interface for the development of interactive maps, while OpenStreetMap provides open-source GIS/Mapping services.
3D Mapping	CesiumJS [10]	CesiumJS is an open-source JavaScript library for creating 3D globes and maps with performance, precision, and visual quality.
Augmented Reality	AR.js [11]	AR.js is a lightweight library for Augmented Reality on the Web, featuring Image Tracking, Location based AR and Marker tracking.
User Interface	OnsenUI [12]	OnsenUI provides a framework for the development of web and hybrid mobile applications, with the look-and-feel of native Android and iOS mobile apps.

5 Discussion

The present study presents an approach for the implementation of a web based, modular system, multimedia material and augmented/virtual reality deployment are used to improve the experience of tourism places and attractions both before and during travel.

Rather than depending on proprietary technologies, the system solely relies on relevant, modular, and open-source solutions. The primary objective is to prioritize content over complex technological matters, aiming to facilitate the simple and cost-effective deployment of VR and AR technology in tourism destinations..

The system implements its functionality based on the classic 3-tier architecture and distributing the overall functionality on a set of sub-systems/modules, residing on the back end or front-end of the system. This approach enhances the upgradability, expandability, and serviceability of the system.

The implementation of the back-end services of the system is based on well-established and proven technologies for the development of web applications and services. A REST API has been developed as an interface between the back-end functionality and the client-mobile application, while JSON has been proven an effective means of data inter-exchange between the mobile application and the system's back-end services.

The approach followed for the implementation of the client/mobile application, has proven the feasibility of deploying complex, location/map-based, Multimedia and Augmented Reality applications, using exclusively web technologies (HTML, CSS, JavaScript) and modern web browsers' features (e.g., WebGL). Sophisticated mobile applications that - not long ago - required development with custom SDKs and native development tools on the targeted mobile platforms, now can be deployed as cross-platform, web, or progressive web applications, while maintaining the required level of functionality and the user-interface of each platform (e.g., Android application).

A wide variety of modern JavaScript frameworks, provide the basis for developing demanding, modern mobile applications, implementing advanced technologies such as location-based services, interactive maps, location and tracker based augmented reality, 360º videos and 3D content. On the downside, programming – and especially JavaScript - frameworks' longevity and life cycle, has always been a concern and critical ingredient in project success. Metrics like community size, popularity, and big company support can justify the choice of framework to invest in and base application development on.

Moreover, the Virtual and Augmented Reality industry has consistently been characterized by rapid changes and fluidity. These traits are even more pronounced in web-based implementations, which are currently in a premature state. Therefore, it is essential to closely monitor emerging developments in the field to improve the provided services and capitalize on newly available resources such as updated or new Software Development Kits (SDKs), Application Programming Interfaces (APIs), Frameworks, and more..

Finally, some components of the system, such as multimedia material, may necessitate internet connectivity, which may result in user fees. However, as mobile internet becomes more accessible and affordable, and as free options such as public Wi-Fi become more widely available in urban areas, this issue may become less of a concern.

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