EnterCY: A Virtual and Augmented Reality Tourism Platform for Cyprus

Soteris Constantinou*, Andreas Pamboris†, Rafael Alexandrou†, Christoforos Kronis†, Demetrios Zeinalipour-Yazti*, Harris Papadopoulos† and Andreas Konstantinidis†,*
*University of Cyprus, P.O. Box 20537, 1678 Nicosia, Cyprus
† Frederick University, 1036 Nicosia, Cyprus

Abstract—This demo paper presents EnterCY, an integrated Virtual and Augmented Reality Tourism platform for Cyprus. The platform's web-based, spatio-temporal virtual exploration component allows potential visitors to explore the rich cultural heritage, variety of activities, and wealth of sightseeing locations in Cyprus before their visit. EnterCY also enhances tourists' experiences during their visit through its mobile component, which offers on-site visual and audio guidance, personalized recommendations, as well as entertaining and learning features (e.g., story-telling), based on cutting-edge Augmented Reality, location-awareness and Machine Learning technologies. Through Immersive Reality technologies, the platform provides for an after visit experience by creating personalized 360 video mementos of tourists' tours and supporting integrated features that allow for sharing one's experience in popular social media platforms.

1 Introduction

The Tourism industry is a vast market that faces various challenges, which have been heightened during the past decades by global catastrophes such as the financial crisis of 2008 and the COVID-19 pandemic outbreak. These challenges primarily relate to the industry's long-standing pursuit of novel and effective ways for: (i) increasing tourism satisfaction, which affects destination loyalty intention [1] in the form of repeat visits and a keen willingness to recommend destinations to others; and (ii) effectively promoting destinations to attract travelers, who currently lack the means for discovering and exploring the hidden gems of different tourism destinations.

While previous work has focused on addressing said challenges by leveraging (in a fragmented manner) state-of-the-art technologies (e.g., AR, VR, AI), they typically focus on supporting flagship destination Points of Interest (POIs) in isolation and/or solely improving a particular aspect of the tourist's experience. Examples include standalone VR/AR systems designed to support museums and other tourist attractions by offering virtual tours and user guidance when on site [1, 2, 3, 4], as well as context-aware tourist applications [2] that serve as decision support systems (using AI to suggest destinations according to user preferences/interests).

To the best of our knowledge, no unified solution exists that tackles the stack of challenges spanning the entire experience life-cycle of tourists, accounting for an abundance of available POIs/services in a given geographical location, in an end-to-end manner. EnterCY is an integrated platform that leverages and gracefully combines the state-of-the-art technologies to enhance tourists' experiences before, during and after their visit to Cyprus[5]. The platform comprises a web-based VR Exploration Platform (VEP), a multi-platform AR smartphone application, and an IR-based 360 video generation module, and employs machine learning and location-awareness techniques.

2 EnterCY Platform Overview

This section introduces EnterCY's services and provides an overview of its architecture. The EnterCY services can be classified based on the tourists' lifecycle as follows:

- *Pre-visit services*, namely, VR-based spatio-temporal exploration facilities intended to allow potential visitors to remotely explore the rich cultural heritage, variety of activities, and wealth of sightseeing locations in Cyprus.
- *In-visit services*, consisting of: (i) AR-based facilities for location-aware visual and audio guidance, including story-telling features, to enhance the tourists' on-site experiences; and (ii) a ML-based personalized recommendation system for sites, activities, and services based on user profiles.
- *Post-visit services*, namely, IR-based technologies that produce personalized 360 video mementos of a tourist's on-site tour, with options to share their experience in real-time through popular social media platforms.

As illustrated in Figure 1, the platform is composed of three main components, namely the *Web-based*, *Mobile*, and *Back-end* components. These are described next, along with EnterCY's supportive modules, i.e., the *location-awareness* and *AI-based recommendation* modules.

Infrastructure: The proposed platform is fast, reliable, and secure. Fault tolerance is achieved through sufficient replication employed at various levels of the platform's infrastructure,

1. Louvre Virtual Tours, URL: http://www.louvre.fr/en/visites-en-ligne
2. Vatican Museums, URL: http://vatican.com/tour
3. Eternal Egypt, URL: http://www.eternalegypt.org/
4. Chateau Falaise, FR, URL: https://tinyurl.com/y6vtefhk

5. The proposed solution can be applied to any country for promoting cultural dissemination and enhancing tourists' experiences, provided the availability of corresponding media content

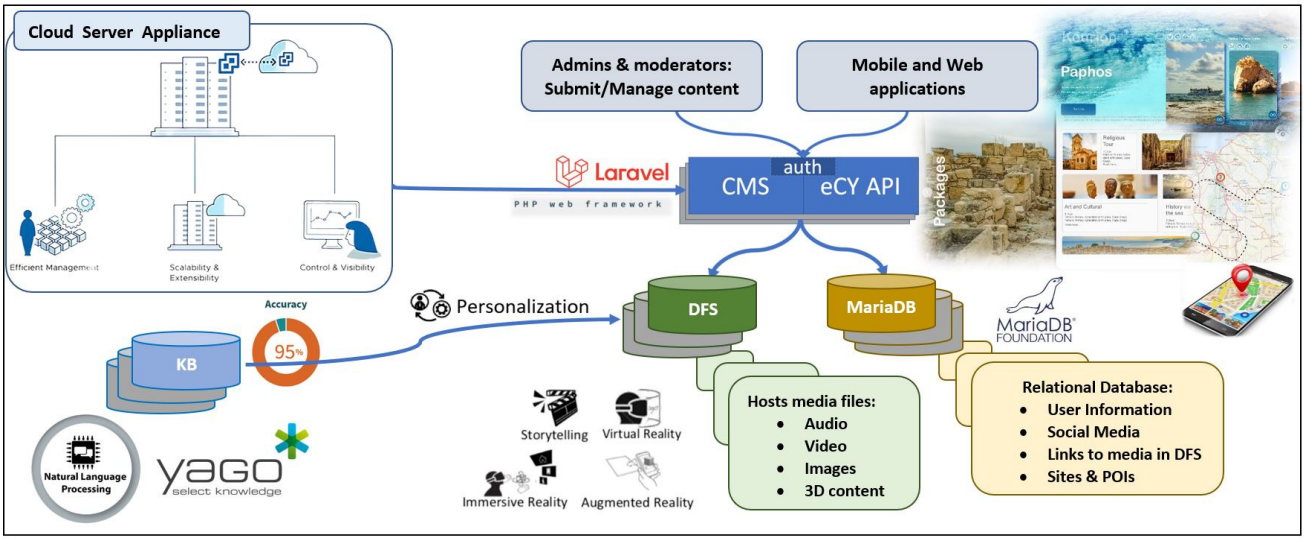

Fig. 1. EnterCY platform overview.

ensuring no loss of data and/or service downtime due to hardware or software failures. Replicas in Figure 1 are resembled as gray stacked elements behind a main component such as the DFS, KB, CMS, and MariaDB database.

Additionally, load balancing techniques are used to ensure that the workload among the various platform components is balanced, thus avoiding bottlenecks and offering a faster response time. For the front-end, an HAProxy Load Balancer on a Linux VM is used. This VM contains all necessary certificates for providing secure HTTPS connections through a service like LetsEncrypt[6]. Any required renewals for the certificates are automatically installed through a time-based job scheduler, like cron on Linux. The Load Balancer points out three independent VMs that are responsible for serving user requests on a round-robin fashion. Each of these VMs employs the NGINX Web Server, which serves a web application to the users using the Laravel[7] framework.

The platform's back-end is implemented using the Laravel PHP web framework and follows the Model–View–Controller (MVC) architectural pattern, using MariaDB as a database server (which is based on the open-source MySQL code). The Laravel-based application provides the platform's authentication service. VMWare ESXi Bare Metal Hypervisor is used for effectively partitioning hardware resources to consolidate applications and cut operation costs.

2.1 Web-based Component

Virtual Environment Platform (VEP): The VEP is a web portal that presents tourist information and educational material about Cyprus, its cultural heritage, traditional activities, and sightseeing locations. It provides potential visitors the opportunity to preview, by means of virtual spatio-temporal navigation and exploration facilities, selected attractions and activities prior to their visit. Virtual reconstructions of archaeological sites, as they stood at different points in time, are included in the platform to provide users a historical perspective about the country's chronicles (see Figure 2). The relevant content is classified into virtual development for navigation in existing spaces, virtual 3D models of non-existing environments, and 2D videos of activities associated with areas of interest.

The digital collection of tourist attractions and cultural heritage items is captured in high resolution 3D. Due to the extensive heterogeneity of these items, ranging from small exhibits in museums to large archaeological sites, particular focus is given on capturing shapes, textures, and colours as accurately as possible. To this end, scanning existing environments and objects entails the use of the following methods:

- **Drones (UAV):** Aerial captures of large area sites and hard to reach objects (e.g., tall statues).
- **Infrared and laser scanning:** High-end cameras with infrared sensors for 3D scanning of existing locations. XYZ points in space are created by calculating the distance between the sensors of the cameras and the real environment. When the points are combined together, a 3D model of the real space can be constructed. 360 panoramic photos of the same environment are then stitched on the 3D models to create a realistic virtual model that can be navigated remotely.
- **Photogrammetry:** Various stereo-capture techniques offer the capability to digitize objects of different sizes, ranging from very large-scale open air archaeological sites, to fabrics with intricate designs and small artifacts, a few millimeters in size. To this end, software analysis packages for processing lighting properties, conducting measurements, and performing parametric optimizations have been used.

2.2 Mobile Component

The Mobile component is a location-aware Augmented Reality (AR) application, available on both Android and iOS mobile platforms (see Figure 3). It encapsulates functionalities for:

6. LetsEncrypt service, URL: https://letsencrypt.org
7. Laravel-PHP web framework (MVC), URL: https://laravel.com/

Fig. 2. EnterCY VEP: 360 spatio-temporal navigation with interactive material (e.g., reconstructions).

(i) creating user profiles via carefully-designed and structured questionnaires; (ii) generating tourist journeys based on personal travel information and preferences; (iii) viewing recommendations of site visits in an intuitive calendar view; (iv) physically navigating sites with the help of AR facilities and story-telling guidance; (v) recommending services and dining options based on the tourists' location and preferences; and (vi) downloading/viewing personalized IR 360 videos.

Augmented Reality: The AR mode of execution leverages the tourist's smartphone camera to superimpose (in real time) information on the device's screen about the current site. Initially, the localization module is utilized to identify the tourist's location. Based on the location, the AR mode is enabled only if there is available content for that location. The AR environment is then populated with pins indicating the availability of content. Multiple content types are usually available for each pin/location, which include 2-D images, audible stories, 3D-models of artifacts, reconstructions, etc.

Story-telling: Artifacts or even whole sites are accompanied by stories in audio format. Each story consists of audio files and their meta-data (location, monument, size, duration etc.) and is available for tourists on demand.

Immersive Reality Viewer: During the tourist's journey, the AR application logs the sites that the tourist has visited. The logs are then used by the IR generator to generate a personalized 360 video for each individual tourist, which serves as a memento of his/her visit in Cyprus. The 360 video can then be shared on popular social media platforms.

2.3 Back-end Component

Content Management System (CMS): The CMS is used by administrators to manage the various data/media types utilized by the platform's components and modules. The platform hosts a diverse set of data, ranging from structured text, unstructured or semi-structured text, images, videos, audios, 3D content, etc. All structured data, such as the users' personal information, user preferences, sites, and POIs that users may visit reside in a Relational Database. The media content is transferred by the CMS to a distributed file-system. A link to the exact location of the media files is added to a relevant entry in the relational database in order to accommodate any future requests. For example, when adding a new POI to the platform, information such as the year, coordinates, description, and media files is included. The unique path of the media files is then stored in the relevant POI entry in the database, under the URI scheme. Similarly, for externally-hosted content, e.g., VR videos hosted on YouTube, the same process is followed, however, a URL is stored instead of a local file path URI. Each site consists of helpful information such as visiting hours, accessibility (e.g., support for wheelchair users), pricing, and others. A site might consist of multiple independent POIs. Furthermore, the platform exposes activities that users could engage in. Finally, users are prompted to consent to and submit anonymous personal and social information that can be used for site and activity recommendations. The EnterCY API suite provides access to the data and facilitates the communication between all other components and the platform's back-end.

Knowledge Base: The Yago Database is used as the basis for generating a fact-based search engine to provide advanced search capabilities for EnterCY. Yago is a huge schematic knowledge base database that was originally derived from Wikipedia, WordNet, and GeoNames. It contains more than 10 million entities and 120 million facts about these entities. Its accuracy is estimated at 95%, through manual evaluation, and all relations are marked with a confidence value. It has spatio-temporal semantics to its facts and entities, and supports many languages. To enrich the search engine, the platform integrates Natural Language Understanding suites, such as the FOSS AmbiverseNLU suite, which perform name-entity recognition and disambiguation, information extraction, entity salience estimation, and concept linking.

2.4 Supportive Modules

The **Location-Awareness Module** is responsible for accurately localizing tourists in both indoor and outdoor environments, providing the relevant spatial information to the AR smartphone application. This information is used to superimpose 3D AR models and artifact reconstructions over the user's camera feed in real time.

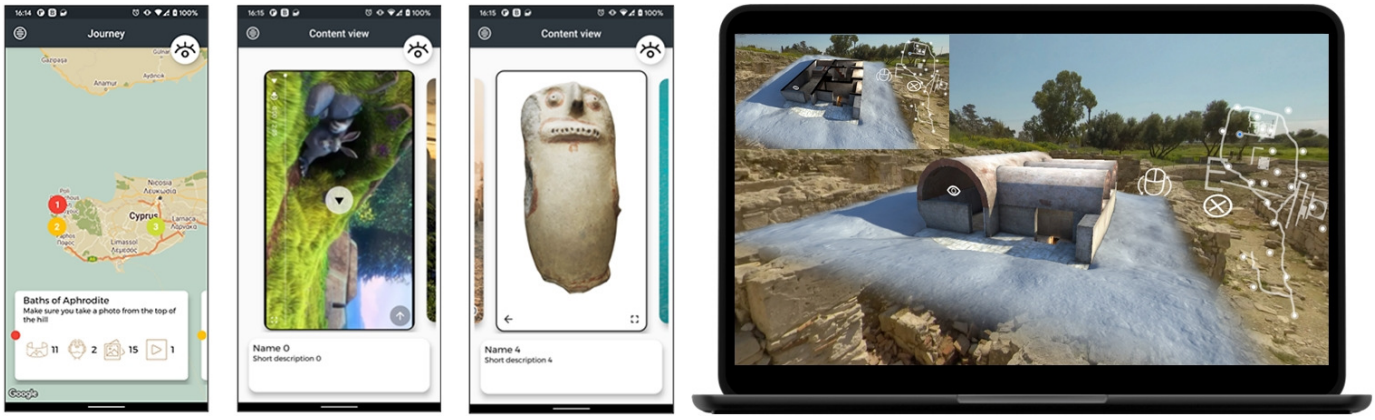

Fig. 3. Mobile component (location-aware AR application): AI-based recommended map journey, list of content, 3D artifact models); Web-based component (VEP): virtual 3D reconstructions of archaeological sites.

A dynamic selection mechanism based on a rule based algorithm is able to determine whether the user is in an outdoor or indoor environment at runtime. The supported sites are marked in the database as either *outdoor* or *indoor*. EnterCY's backend module determines if the current GPS geo-location of the user is within the boundaries of either an outdoor or an indoor site. If the user's environment is classified as outdoor, the user is able to localize using GPS and the AR integration is done with geo-location. If the user's environment is indoors, GPS technology is inappropriate due to signal attenuation while passing through solid walls and/or ceilings. Therefore, other indoor localization techniques are employed, namely the use of QR codes, Beacon Fingerprinting, and/or Wi-Fi Fingerprinting, based on what is supported in different indoor environments. Considering that indoor environments consist of Churches, Museums, Galleries, etc., emphasis is placed on supporting localization as discreetly as possible in different sites. For example, if the relevant authorities do not support Wi-Fi access points and consequently the site cannot support Wi-Fi Fingerprinting, BLE Beacons are discretely installed to provide localization based on BLE proximity and/or signal strength sensing.

The **AI-Based Recommendation Module** utilizes machine learning to provide personalized recommendations based on tourist profiles that incorporate individual user preferences. To this end, all available sites and services have been profiled by experts (from the Department of Antiquities and the Deputy Ministry of Tourism in Cyprus) in order to match initial tourist profiles with site/service profiles using the cosine similarity measure.

Two types of recommendations are offered by EnterCY using a Content Based (CB) filtering approach, namely recommendations of sites/POIs (included in a tourist's journey) and recommendations of services (e.g., for dining, events, and/or other activities). CB Recommendation Systems construct a user profile based on historical information regarding the users' preferences and attempt to recommend items that match this profile. Two types of questionnaires have been designed and are included in the platform, which include: (i) a compulsory questionnaire about the tourist's preferences with respect to sites and sightseeing, which is completed during the registration process; and (ii) an optional questionnaire regarding the tourist's preferences with respect to services (e.g., preferred cuisine or sport), which tourists may complete at any time. The questionnaire responses aim at dealing with the well-known cold start problem. Here it is important to mention that with the collection of an adequate amount of tourist information, the CB approach will be extended to a hybrid RS by hybridizing it with the Collaborative-based filtering approach.

3 Demonstration Scenario

During the demonstration, the attendees will be offered the opportunity to try out the different components of EnterCY. Initially, they will be asked to create an account with the platform and specify their traveling preferences. Thereafter, they will enjoy EnterCY's personalized services by remotely exploring recommended sites in Cyprus. To showcase the platform's AR features, an artificial POI (corresponding to the demonstration site) will be setup a priori.

Acknowledgement

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