Tour Guide System using Augmented Reality: A Review

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Abstract*— One of the largest, most important and constantly growing industries in the world is, without doubt, tourism. Such rapid growth calls for enticing ways to engage tourists and keep them interested, which is a big challenge for the professionals, having to maintain standards and increasing expectations of tourists. Tools such as augmented reality (AR) hold a vast potential in attracting and retaining visitors. The rise in smart mobile devices only boosts this further as it becomes possible to have information and tour generation at one's fingertips. In this paper, we first try to enlist all the limitations and challenges encountered while utilizing concepts of AR to develop a tour guide system. We describe various state-of-the-art AR applications that provide such service, having their own set of drawbacks, and we give a brief introduction to our proposed system. All the facts and literature we have surveyed and studies related to various aspects of developing an AR-based tourism system are presented in the paper, which include several methods and algorithms that can be used for image comparison required to recognize objects of interest.

***Index Terms*— Augmented reality (AR), image comparison, tourism, mobile AR**

I. INTRODUCTION

Augmented Reality (AR) is a collection and combination of technologies that enable mixing computer-generated content with live-video display, giving the effect of a seamless fusion of virtual content with real-world scenes. Thus, AR not only interacts with the virtual world but also has significant interdependence on the real world. This makes it an interactive form of design and with the rise of mobile devices, AR is gaining popularity in several fields such as tourism, entertainment, training, education, advertisement, medicine, research and so on. It is important to note how significant a role augmented reality, gamification, social media etc play in improving tourists' experiences. They provide new means of participation which, only few state-of-the-art applications claim to give. Mobile devices in the form of smartphones fall under the category of body-borne or wearable computing devices, in the sense that these smart devices have become an indispensable part of our lives.

Revised Version Manuscript Received on November 03, 2015.

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Mobile augmented reality has emerged as the most popular and convenient form of augmented reality, mainly due to the proliferation of mobile devices and ubiquitous computing. Having such a strong alignment with the real world, it is well suited for enabling applications that provide the ground for location-based interactive and innovative services within the ecosystem of smart cities.

Mobile augmented reality is thus, a natural fit for tourism applications, because of minimal intrusion, high portability, wide social acceptance of mobile devices and its ability of enhancing the surroundings of the tourist. Although AR and social media have not yet a big impact in the area of cultural heritage, it seems to have a great potential to foster the engagement of people by means of interactive tourism applications.

Augmented reality systems are built upon on the following major buildings blocks: tracking, recognition and registration, display technology and real-time rendering. An AR system has to deal with vast amount of information which must be filtered in such a way, that only useful information is displayed and presented. Another basic challenge of Augmented Reality (AR) is the registration and super-imposition of digital information onto physical objects. Moreover, for a moving user, the system needs to constantly determine the position of the user surrounding the virtual object within the environment, because the identical object generated by the computer must appear to be fixed. Due to specific mobile platform requirements, mobile AR has other limitation such as that of computational power and energy. It usually has to work in unknown environments and hence has an additional requirement of being self-contained. Managing the visualization of available content in AR view so as to maintain the legibility of the information is another challenge, especially on mobile devices with small displays. Coming up with a solution to tackle these problems while maintaining the usability and standard of the AR application will enable further adoption and proliferation of these types of applications among tourists as also facilitate the development and deployment of highly relevant mobile tourism systems and services.

II. STATE OF THE ART APPLICATIONS

Cultural tourism is a domain which provides high potential for deployment of augmented reality technologies. One of the first projects in this area is PRISMA, an interactive visualization system that is a combination of tourist binoculars and augmented reality. Mobile AR applications for tourism can be classified into three types:

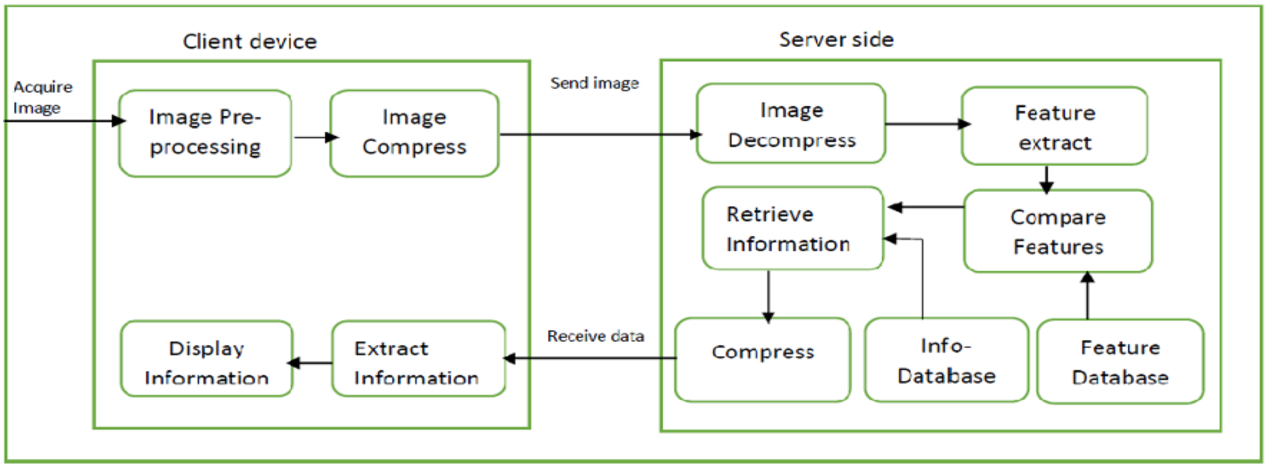

Fig.1 Flow diagram of proposed system

A. **AR browsers**, which, similarly to web browsers, allow service providers and content providers to publish thematic content like Layer and Wikitude,
B. **Dedicated AR applications** such as Augmented Reality UK, Cyclopedia, London AR Guide, and
C. **AR view**-enabled applications such as mTrip.

A popular category is composed of mobile augmented reality applications that display historic images on top of the current landscape. Well-known projects are PhillyHistory in Philadelphia and StreetMuseum in London.

When we talk about tourism-specific functionality, many of the state-of-the-art applications allow to *search* and *browse* through available information. All these augmented reality applications offer map-based services, although they vary in form and implementation. Almost all of the current applications provide an interactive display and annotations clicking on which, that expand to deliver more information about the selected POI (Wikitude), open map view (London AR guide) or lead to a different screen with more detailed information (Tripwolf, Cyclopedia). One of the main problems with current AR applications however, lack of any pre-defined specification of what the user wants to search for, available content in AR view ultimately results in an overloaded and cluttered display [4].

Most of the AR applications propose the use of AR browsers and rarely explore the image recognition-based AR like Google Goggles, as engagement mechanism, and we wish to explore in greater depth, the latter. Here are a few examples:

Wikitude: This is a popular browser which provides location-based augmented information in GPS-enabled phones. This AR browser offers web-based information on focusing on an object that is wished to obtain description or details of. In addition to GPS, compass and accelerometer also take part in calculating position of the object of concern. ARML (Augmented Reality Markup language) and KML (Keyhole Markup Language) formats are used to store geographic annotations and for augmented visualisation data.

MTrip: Offers mobile application services and solutions based on augmented reality for travel and tourism industry. It allows viewing the environment and the places to visit in real-time, with ratings, distance, cost, opening hours. Some of the available destinations include: Amsterdam, Budapest, Chicago, Moscow, Copenhagen, Dubai, Hong Kong, Istanbul, London, Madrid, New York, Paris, Lisbon, Prague, Rome, Singapore, Florence, Stockholm, Tokyo, Venice etc.

Street Museum: An iPhone tourism application based on augmented reality, developed essentially to bring the collections of The Museum of London out to the streets. The app is based on location tagging and recognises different heritage sites within the radius of where you are. On clicking on any of the pins on the map indicating the points of interest, you can get information about the same in the form of text, and based on your location it also overlays historic images. The advent of this app caused the visitors to the museum to be tripled and was indeed monumental in increasing tourism.

III. PROBLEM DEFINITION

The goal of our application goes beyond just providing static information on the smart mobile devices. We aim at providing heritage information to tourists at any time, and anywhere within the country utilizing Augmented Reality, enabling them to have a greater interactive experience by superimposing or retrieving virtual information on cultural heritage sites, offering context aware services based on points of interest (POIs) in recognized tour maps.

It is observed that when it comes to effective support of mobile on-site needs of tourists, a smartphone AR application must:

- Provide access to location-based information, that is to the immediate surroundings of tourists,
- Enable access to variable content, which is timely and updated,
- Are flexible in terms of delivering text, video, or images,
- Can deal with the problem of cluttering due to smaller screens of mobile devices is by enabling the user to display only one thematic layer at a time.

We take into account these criteria and aim at building an AR application that caters to all needs and demands of users giving them the most elevated tourism experience. Geo-referenced positioning and image-recognition are two main approaches currently applied for developing AR browsers. The technologies that we intend to employ in our application support the same principle; they follow a magic lens configuration which means that the user sees the augmented space directly behind the display.

Moreover, we also aim to provide further tourism-related functionalities such as feedback, routing and tour generation, which are rarely supported in current applications.

On focusing the lens of the camera on the monument of interest, frames of live video display are sent to the server for recognition (Fig.1). There is a large database of location-tagged images at the server side, with which received images, i.e. frames are compared. This database consists of images of each heritage institution taken from several different angles and image received from the user's device is matched against the images present in the database. This virgin image must first be pre-processed using techniques like greyscale conversion, sharpening, and other such adjustments to obtain better accuracy and lesser dependency on variable factors.

IV. VARIOUS METHODS FOR IMAGE COMPARISON

A. SIFT- Scale-Invariant Feature Transform

It is an algorithm that gives a way in which the local features of any image can be identified and described. For any object in an image, various interesting points on the object can be extracted which help obtain a "feature description" of that object. This description, extracted from a prior static image used to train the system, can then be used to identify the object when attempting to locate the object in a test image containing many others. SIFT is robust as it can identify objects even in a welter as also under partial occlusion. The SIFT feature descriptor is invariant to uniform scaling, direction and orientation, while partially invariant to affine distortion (like transformation, rotation, reflection about an axis) and changes in illumination of the surrounding and of the object [1].

B. SURF- Speeded-Up Robust Features

SURF is a detector and a descriptor for points of interest in images where the image is converted into coordinates. Its major feature is the use of multi-resolution pyramid technique with which special blurring effect called Scale-Space is achieved on the given original image. The technique is to make a copy of the original image with Pyramidal Gaussian or Laplacian Pyramid shape and obtain image with the same size but with the bandwidth reduced. This algorithm has three important concepts: interest point detection, local neighbourhood description and matching. This technique ensures that the points of interest are scale invariant.

C. Perceptual Hashing

Perceptual hashing is an algorithm that produces a snippet or fingerprint of various forms of multimedia. Perceptual hash functions are a match if features are similar, whereas cryptographic rely on the avalanche effect of a small change in input causing a drastic change in output. Perceptual image hash functions produce hash values based on the visual appearance of the image. Such a function calculates similar hash values for similar images, whereas for dissimilar images hash values that do not match are calculated. Then, using an adequate distance or similarity function to compare two hash values, it can well be decided whether the two images are different or not, perceptually. It may also be called a fingerprint or a robust hash. Applications of perceptual image hash functions include the identification or integrity verification of images.

V. MOBILE COMPUTING PLATFORMS

With rapid increase in the number of mobile devices as well as their ease and convenience of access, it becomes important to be able to deploy any application on such devices supporting OS platforms like Android, Windows, iOS.

1. **Laptops and Notebooks**: Desktop computers can be quite consuming in terms of energy, power, space etc. In contrast, notebook computers are more flexible to take alongside. However, size and weight is still the hurdle for wide acceptance by most users. Notebook screen is only used for the use of profiling and debugging.
2. **Tablet personal computers**: A tablet simply put, is a larger version of an average smartphone. Tablet PC is a personal mobile computer typically smaller that a notebook but bigger than a smartphone. Having a bigger screen and multitouch facility enable better display of the AR content and better interactive operations.
3. **Smartphones**: Smart mobile phones have nowadays various built-in important features like camera, powerful sensors, CPUs and even dedicated hardware for graphics. Built-in sensors help obtain pose tracking while embedded camera makes them suitable for live video-based AR display.
4. **AR glasses**: A hands-free form of AR system, this new technology offers a whole new experience of mobile AR with least device intrusion. AR glasses are the most handy form of AR devices simply because of the elimination of the need to look down at the mobile devices constantly. Currently the most promising AR glasses technology is offered by Google Glass. It supports features including GPS, navigation, email, taking pictures etc.

VI. SOFTWARE FRAMEWORKS

There are many software frameworks available for mobile AR application developers so as to reduce the complexity and time-consumption present in low-level implementations. These allow the developers to focus on the main high-level application development. Below are the important open-source tools frameworks:

1. **AR Tool Kit:** [developed by Hirokazu Kato in 1999, released by University of Washington HIT Lab]. This is a computer tracking library for augmented reality applications that overlays virtual content on the real world. It captures the real time camera position with its video tracking capability and maps it with a virtual camera to display virtual content. It solves two problems of AR namely, viewpoint tracking and virtual object interaction.
2. **Java CV:** This is a Java/Android interface to OpenCV (an open-source image processing library). It provides wrappers for Open CV, so as to be able to use OpenCV functions directly in Java. This is especially for developing mobile applications as Android is essentially based on Java.
3. **GRATF:** It stands for glyph recognition and tracking framework. It provides a C# library for detection, recognition, pose estimation of optical glyphs which is popularly used in 2D and 3D augmented reality.

Published By:
Blue Eyes Intelligence Engineering
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4. **Mixare:** (Mixed Augmented Reality Engine): Augmented reality browser for Android and iOS published under GPLv3.
5. **Droid AR:** This is an augmented reality framework for Android devices which allows development of applications with feature based and marker based AR. And AR is a similar project for developing AR based applications on mobile devices.
6. **Beyond AR**: This is another AR platform for developers and is based on geo-localisation on Android. Developer can place objects around the world easily and requires only taking care of what content is to be displayed.

VII. DATA MANAGEMENT

For any mobile AR application efficient data management of the large amount of data generated is essential for the application to function properly. This includes:

a. **Data acquisition**: The application requires a dataset model based on the environment that the user operates in. The database may also obtain the required information from other methods which then helps to complete the modelling of data. An example of data acquisition includes acquiring live feed from the user's camera. Applications may also generate data pertaining to the location of the device or the object using geo-location.
b. **Data Modelling:** Abstraction refers to the way data is viewed on different levels allowing to hide details and show only that which is necessary. No dataset follows a standard abstraction model. Data modelling is nothing but developing conceptual models of the dataset that is acquired in the application. For example, there are 3-tier or 4-tier models like those proposed by Nicklas and Mitschang [Nicklas and Mitschang 2001] and Tonnis [Tonnis 2003] [8].
c. **Data Storage:** Lack of any global data repository means that developers have to create their own way of managing the large amount of data acquired and required for Augmented Reality applications. Various methods of storing data include file systems, structured and unstructured database systems. From the user's point of view, it is important to retrieve data of most relevance from the mass data storage.

VIII. CONCLUSION

The paper has reviewed the growing trend and popularity of AR in tourism, it's limitations and tools and levels for building a full-fledged mobile AR application. As seen from the above survey and study, we find that there exist several approaches of cultural heritage institutions that attempt to attract their visitors using new technologies, such as augmented reality and social media. Although these technologies have not yet a big impact in the area of cultural heritage, they provide a huge range of possibilities to offer new ways to interact with cultural artefacts, personalise the cultural experience, share content and experiences and interact with the social environment. Thus, they have a great potential to foster the engagement of people on cultural heritage sites, not only of tourists but also residents. The ultimate goal of this project is to give the user a one-of-a-kind informative and interactive experience and allow them to have all features they desire in the palm of their hand by covering every possible approach of providing information and recommendations.

ACKNOWLEDGMENT

We are extremely grateful to our guide and HOD, Prof. Dr. N. F. Shaikh, Head of Department, Computer Engineering, MESCOE, for her valuable advice, guidance and support. Our special thanks to Mr. Prashant Muley for his indispensible suggestions.

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