Enhancing Local Tourism Using an AR Based Mobile Application

Saksham Agnihotri[1], Akshay Singh[2], Mr. Mukesh Raj[3]
[1,2,3]*Department of Computer Science and Engineering, Galgotias University Greater Noida, India*

***Abstract*—The lack of progress in a synchronization between the size of information offered by the tourist for the surroundings and the history of that specific city or that specific part or structure, which makes it an ailment to local tourism in traditional Indian cities, has no counterpart. Nonetheless, even after the Indian cities like Varanasi and Mathura are constantly flooded, each year, with millions of foreign visitors, it does not support them to sail in these multidimensional frameworks of cities and understand their host society more deeply. The majority of the current computer-based tourist systems can be easily understood and described by saying they all possess a digital explanation or a digital map, which has only a minimum of interaction in it and nothing is physical at all. The nature of this paper identifies the application submitted in relation to the mobile augmented reality and the application offered in order to contemplate a workable resolution to this very problem of local tourism by incorporating this digital information into a real physical location and position which exists in the actual reality by a use of a new combination of augmented reality, GPS and multimedia cultural expression to enable effective and concise navigation into the cities in real world in real time.**

Index Terms*—Mobile Augmented Reality, Cultural Traditional Tourism, Location-Based Information Systems, Digital Navigation in Historic Cities (key words)

I. INTRODUCTION

Tourism is a significant economic activity in India and in many countries and according to the estimates made by the government in the recent past, tourism constitutes approximately 7.6 percent of the gross domestic product and empowers over 39 million individuals [1]. These aggregate numbers tend to hide the situation on the ground; in fact, the quality of the tourist experience usually develops a dangerous circle of cultural and economic payoff that reinforces itself. The popularity of the traditional cities of India is both global and quite contradictory in nature: the ancient cities are literally unreachable or unseen by most people that visit them for the first time.

One central question, under the approach of digital-first, is why the experience of visiting a 2,000-year-old temple, as frequently as possible, seems disconnected with the information that can be found on domestic gadgets. On-site experiences, which are typically strongly equivalent, are often slower to be digitized (hotel bookings and transportation being the most prominent exceptions). To the first-time visitor to the city strolling through the lanes of the Indian traditional city, the discontinuity between the immediate environment and historical background often creates a shallow and checklist-oriented form of tourism, with very little knowledge or substance.

A. Background Context

A slight change in the tourism sector of India has occurred since 2020 in India as we can say. The digitization of industries accelerated more after the COVID-19 pandemic and tourism was not an exception. Contactless services, use of the mobile gadgets to find out information and self-discovery tourism became more evident as the tourists attempted to find a method of accessing the destinations which was more secure and flexible [2]. Even though the cities in an urban setting could relatively adapt, traditional cities also came across a number of unique challenges.

Indian cities: Mathura, Varanasi, Jaipur and Hampi are characterized by the denseness of urban fabrics, deep and stratified histories and organically developed infrastructure. At this point we can speak about Varanasi, where we have an example, the maze of narrow gliyaan (lanes) to the ghats of which even a visitor of olden day is prone to losing their path.

Direction boards are not universal, language is an issue and there are minimal official sources of information. In most cases the tourists do use the assistance of local guides or informal support and it is highly diversified in the quality and accuracy. The issue is magnified during the high seasons and festivals in which the thickness of the crowds makes the navigation and safety even more difficult.

B. Technology in Tourism

The new features that have been added to the list of the modern-day tourist are Google Maps, travel blogs, and audio guide applications. In Tradition rich spaces, these tools are likely to fail despite their convenience. A text or audio message is not as immediate and maps are not so good in congested areas on GPS accuracy. Cultural heritage is a spatial phenomenon; the more information is distanced to the physical space the less efficient.

The specific advantage of augmented reality in question is that it integrates the real-world and the digital content. Unlike the standard mobile application, AR allows tourists to view historical facts, visual representation, and guide points right over the location that they are at. In the case of location alignment, they have an opportunity to be more engaged particularly in traditional tourism in which narrative depth equally matters as the visual context [3].

C. Research Gap and Motivation

Even though there is growing interest in the use of AR in tourism industries, most of the solutions that have been deployed are in museums or landmarks that are favored globally. There is little attention paid to less famous local sites that render a city a cultural identity. During our first tours in Varanasi, we realized that tourists used to stand at places of great importance, which lacked marks yet they were not aware of the historical or cultural significance of the places. In another instance, the visitors crossed a small courtyard, which was next to the Kashi Vishwanath corridor, without taking into consideration that it was a section of the ancient pilgrimage routes.

It is during moments like these that a break in information accessibility is observed though more to the point, contextual provision. The present applications assume the constant navigation, the prior knowledge or the existence of the continuous connectivity promises that cannot always be implemented in the Indian heritage settings. The justification of this study is that it attempts to address such a gap through the use of technology, which is place, movement, and culturally sensitive

D. Research Objectives

The aim of this study will be to grow by 200 percent. It will be developed as an AR-based mobile application, whose target market is local tourism in traditional cities, first of all. Second, the system will integrate cultural stories and real time and contextual navigation. Third, the paper evaluates the success of this type of integration in making user experience and interaction effective compared to traditional tools. Finally, the paper recommends a scaling architectural model, which may be applied in other culturally significant Indian cities other than Varanasi.

II. LITERATURE REVIEW

The technologies that enable the digitization of the digital information on top of the real world in real time and enhance the perception of the reality of a user rather than replacing it are called the concept of augmented reality [4]. Unlike in virtual reality that requires users to be in totally simulated settings, AR does not lose a continuous connection between the actual world. Mixed reality is a further development of the concept and enables more interplay between real and virtual objects but these less usual systems are deployed in mobile applications.

AR systems are technically founded on three primary components, including tracking, rendering, and interaction. The position and the orientation of the user are determined by use of sensors such as GPS, gyroscopes and cameras in tracking. AR using markers is also based on utilizing predefined visual cues (markers) to give a reference point to digital data, but markers less systems are based on sensor fusion and computer vision algorithms like simultaneous localization and mapping (SLAM). The advertised innovations of mobile hardware and systems such as ARCore and ARKit have also helped in the improvement of reliability of marker less AR in smartphones [5].

A. Rise Of Mobile AR Applications

Mobile AR has recently turned into more than a single experimental prototype, and turned into a business

opportunity. The improvement of the processing power, improved cameras and optimisation of AR SDKs have enabled the stable real-time overlays even with mid-range devices. This has greatly expanded the horizons of application of AR to other areas such as education, health, and tourism where contextual visualization can be applied in an effective manner thus giving more information to the users and making them more engaged [6].

B. Tourism AR Comparative Study.

The adoption of augmented reality in tourism-related applications has already gained momentum during the past decade and is used primarily to enhance the interaction of the visitors and provide the background information where necessary. However, the effectiveness of these applications is highly varied depending on their technological position, degree of content and sensitivity to cultural situation.

One of the most popular applications of the Real-world use under implementation in museums and heritage sites in Europe and North America is ARtGlass. ARtGlass is primarily based on the smart glasses to overlay the visual and textual data on objects and buildings. It has good visual clarity and hands-free interaction but depends on special hardware and thus is not as scalable as in other locations like India where more feasible solutions that are smartphone based are attainable. Besides, it is also highly localized in its focus in terms of indoor/semi-controlled environments, thus cannot be applied to more complicated outdoor heritage cities such as Hampi or Mathura.

C. Limitations of AR in Traditional Tourism

ARCore is a weakerly developed location-based AR browser, and it supports the delivery of marker based and GPS based content. The benefit of it is that it is extensible and can be easily coded. However, applications developed in ARCore are more informative rather than first-person narration which are used in tourism. In thick traditional space such as the ghats of Varanasi or the temple corridors of Madurai it ends in discontinuous user experiences in which cultural narrative is no longer attached to space.

D. Google Lens: Benefits and Limits in Tourism

Google Lens is not a product that specifically targets the tourism industry; however, it has demonstrated the application of using computer vision in recognizing landmarks. It is also instant visual information as it determines monuments and objects with the help of the camera. Nevertheless, this is a rather passive communication. This is blocked by the fact that it has no guided tours, it is not guided in any way and it cannot be used to guide tourists through some of the most historically rich sites like Hampi, where ruins are found in a few kilometers, with little evidence of their existence.

There have been a number of successful audio-visual storytelling solutions to museum-related applications, such as Museum Mate and other AR guides. These systems are effective in terms of delivering curated content but do not work at a city scale implementation. The heritage cities like Mathra and Madurai would require adaptive structures which can dynamically adjust to the movement of people, crowd density and outdoor light conditions factors which are barely taken into account when developing museum-based designs.

The analyzed systems suggest differentiating three general types of AR tourism applications, information centric applications, which are premised on the factual overlays; navigation centric applications, the focus of which is on the way finding; and experience centric applications, the emphasis of which is made on the deep focus and narration. Most of the solutions provided are only inclined towards one or two of these dimensions. Indian traditional tourism needs a compromise though that would integrate all the three owing to spatial intricacy and agglomeration of cultures in cities such as Varanasi, Mathura, Hampi and Madurai.

E. Mobile Technology Adoption in Tourism

AR-based tourism apps largely rely on the application of mobile technology and its acceptance among the users. Cell phone usage in India has been undergoing a massive cell phone proliferation with a documented figure of over 750 million smart phone users over the past years [11]. The most significant are the mobile devices as a kind of means of navigation, information search, taking photos, and socializing, which tourists use.

According to mobile tourism behavioral studies, tourists are choosing to experience the place on their own tours, particularly the younger generation of tourists and international visitors [12]. However,

perceived usefulness, ease of use and contextual relevance as described in technologies acceptance models such as technology acceptance model (TAM) determine technology acceptance. Other factors such as language access and data affordability and device performance are highly imperative in the Indian heritage environments.

In urban cities like Jaipur, urban tourists will be able to adapt to modern applications without much trouble, in pilgrimage-based cities like Mathura and Madurai, visitors make up a broader range of demographics. The examples of such examples might include elderly pilgrims who can rely on audio instead of on graphical interfaces. In addition, the lack of a stable network connection in both the buildings and the archaeological sites of the temples affected the further use of the app. These facts explain why easy-to-carry and adaptable mobile AR systems are demanded, which should consider various user profiles rather than considering them as similar regarding technological literacy.

F. Local Tourism Challenges in the Indian Context

The technological constraints do not merely present challenges facing the Indian heritage tourism in terms of its structure. Inconsistencies between regional physical infrastructure such as the signage and information kiosks and access to guided tours exist. the large open areas and the fact that there are random ruins at Hampi make it difficult to become oriented, as opposed to Varanasi and Mathura, where urban sprawl and inability to plan make it difficult to navigate. Information delivery is also not easy, due to the heterogeneity of the language. Although both English and Hindi are widely spoken, the regional languages dominate in such cities as Madurai where the cultures of Tamil have strong foundations in the temple traditions. The cultural experience is generally less deep especially when the simplified or commercialised interpretation of the past is offered to the tourists.

The other issue is the bias in publicizing the tourist places.

Minor temples, heritage streets and craft clusters are not given attention as landmarks are being given one. It is not just the tourist experience that is affected by this imbalance, but also the economic benefit of the local communities is limited by the imbalance. The expectations of tourists have also changed due to the consequences of the COVID-19 pandemic since they are more concerned with contactless travelling and crowd management [13].

G. Research Gap Identification

Synthesizing the reviewed literature reveals several critical gaps. First, existing AR tourism applications rarely address the spatial and cultural complexity of Indian heritage cities. Second, there is limited integration of navigation assistance with immersive cultural storytelling. Third, most systems neglect local economic participation, focusing solely on tourist-facing features. Finally, few studies propose scalable frameworks adaptable across cities with varying urban forms, such as compact pilgrimage towns like Mathura and expansive archaeological sites like Hampi. Addressing these gaps forms the foundation of the proposed AR-based tourism system.

III. METHODOLOGY AND SYSTEM DESIGN

The study design of the research is a mixed-method and design science research. The quantitative component is founded on the indicators of usage and performance, and the qualitative data are delivered by watching the users and their feedback. The best methodology is the one that measures the interactive systems at the same value of user experience and technical performance. Some of the ethical considerations include informed consent, data privacy, and respectful reflection of the cultural narratives

The implementation process will be systematized into four phases, i.e., requirement analysis and design, development and content creation, testing and refinement, and field deployment. The content is informed by the stakeholder consultation with the tourists, the local guides and the historians to determine the accuracy of the content. The basic aspects of AR are created initially followed by the sophisticated functionality. The frequent testing will ensure functionality between different groups of users, particularly, in the real world, where the systems can be applied, such as in the temple complexes and archeological regions.

A. System Overview

The touristic application mentioned above is an AR-based, which has been seeking to be more mobile and assists in exploring the heritage cities utilizing the

immersive and context-centered interactions. It follows a user-oriented design philosophy whereby ease of use, cultural authenticity and flexibility in various forms of urbanity is of primary importance. The application will fill the gaps set out in the existing tourism solutions directly through the combination of real-time visualization of the environment into AR and superimposed cultural narratives and navigation.

Unlike generic AR browsers, the system will be geared towards cities and heritage-rich urban areas, such as high urban densities in Varanasi and Mathura, extensive archeological sites in Hampi, and ritual-specific Indian temple platforms in Madurai. Architecture is concentrated on modularity and cultural content, navigation logic, and AR can be created independently.

B. Core Features and Functionality

It overlays historical imagery, labeled labels and simplified recreations of the 3D on physical features of the world. They are capable of seeing a reconstructed monument of temples at sites such as Hampi but at Mathura they put their mythological accounts of certain sites into context. The AR techniques that are markerless give these overlays permanence so that they remain constant when the user moves. AR arrows and spatial cues given on the camera feed provide the navigation support. This method has been used particularly in the narrow streets in or about the ghats of Varanasi or the bustling temple walks of Madurai where conventional maps do not work. The system also highlights the points of interest within the vicinity and suggests other turnabout routes during the period of heavy congestion. The information is contained under different layers of the culture whereby the users are able to retrieve matters of information in a shortened form or get to learn other in-depth stories about the culture. Audio story telling is targeted at multilingual accessibility, i.e., Hindi, English, and regional languages. In order to preserve the originality of the story, there are the incorporation of local legends and the application of ritual practices.

C. Technology Stack

The mobile application is built on Unity 3D and AR Foundation that provides an opportunity to deploy AR on different platforms. Android and iOS operating systems include ARCore and ARKit that can be utilized to track markers instead of tracking them. The principle of RESTful architecture is the implementation of the backend services, and the structured data is stored in PostgreSQL, and the user-generated content is controlled with the help of MongoDB. Scalability is provided through the area of cloud deployment and local caching is used to give the functionality of partial offline.

Unity was chosen over native development due to the fact that it already had a well-developed AR platform, and the assets would be easily traversed, but it marginally pushed the performance limit of low-end devices. This trade-off is in terms of flexibility of developing and scalability in the future.

D. System Architecture Diagram Description

This is a client-server system architecture. The AR rendering engine, camera module, local database, and user interface layer are included in the mobile application on the client side. Secure REST APIs are used in back-end communication. The authentication, cultural content delivery, analytics and moderation are performed by the server layer. The app is then enhanced by addition of third-party services such as mapping APIs and translation engines. A modular design additionally implies that the change of an AR content or navigation logic does not disrupt the underlying system functionality.

E. User Study Design

The work of the user consists of visiting Varanasi together with 50-100 participants and a comparison of observations made in Mathura and Madurai. The participants are guided with the help of the application, after which there are surveys and interviews. The application of a control group of traditional guides makes it possible to analyze using a comparative method. The data sources are considered to be app analytics, questionnaires, and observational notes (moderated within the course of four weeks).

F. Evaluation Metrics

The user engagement measures such as time spent during the session and use of features, the technical performance measures such as AR stability and battery usage, and the experiential measures such as the System Usability Scale (SUS) scores are some of the evaluation measures. The success levels will be established to define whether the application will be a major addition to the tourism experiences.

Table I Type Styles

Category	Details From Research
Core Technology	Unity 3D and AR Foundation using ARCore/ARKit. Uses markerless AR (SLAM) and GPS for tracking
Primary Features	AR-Enhanced Visualization (3D reconstructions), Smart Driving (AR arrows for navigation), and Multilingual Audio Storytelling.
Target Locations	Heritage cities with complex layouts: Varanasi (ghats/lanes), Mathura, Hampi (ruins), and Madurai (temples).
Key Challenges	Hardware limitations (older phones), GPS slippage in dense areas, battery drain, and unstable internet in heritage sites.
User Results	Increased engagement compared to paper maps; higher immersion in Hampi due to 3D ruins and better navigation in Varanasi's narrow lanes.

REFERENCES

[1] R. Azuma, "A survey of augmented reality," *Presence: Teleoperators and Virtual Environments*, vol. 6, no. 4, pp. 355–385, 1997.

[2] M. C. tom Dieck and T. Jung, "Value of augmented reality at cultural heritage sites," Journal of Destination Marketing & Management, vol. 6, no. 2, pp. 110–117, 2017.

[3] R. Yung and C. Khoo-Lattimore, "New realities: A systematic review of virtual and augmented reality in tourism research," Current Issues in Tourism, vol. 22, no. 17, pp. 2056–2081, 2019.

[4] D. Buhalis and A. Amaranggana, "Smart tourism destinations," in Information and Communication Technologies in Tourism, Cham, Switzerland: Springer, 2015, pp. 553–564.

[5] D. Han, T. Jung, and A. Gibson, "Dublin AR: Implementing augmented reality in tourism," in Proc. Int. Conf. Information and Communication Technologies in Tourism, 2014.

[6] N. Chung, H. Han, and Y. Joun, "Tourists' intention to visit destinations with augmented reality applications," Computers in Human Behavior, vol. 42, pp. 189–200, 2015.

[7] P. S. Reddy and A. Kumar, "Augmented reality for digital heritage preservation: A case study of Hampi," Journal of Cultural Heritage Management, 2021.

[8] S. Sharma and R. Mishra, "Technology-driven pilgrimage tourism in India," *Tourism Recreation Research*, 2020.