# Synchronous location-aware Media and Augmented visualization for Real world Tourist (SMART)

## An application for Khalifatabad heritage site, Bagerhat, Bangladesh

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***Abstract* — The ancient city of Khalifatabad in Bangladesh (also known as Bagerhat ) is famous for Hazrat Khan Jahan Ali and his monumental creations of various mosques and mausoleum. UNESCO proclaimed Khalifatabad as a world heritage site in 1985. Driven by both cultural and religious interests , millions of local and foreign tourists visit this site every year. At present, there exist several historically significant mosques, mausoleum , residence , ruins, large water reservoirs, archaeological excavations and artifacts. However, due to limited knowledge about the local context, less accessibility to historic information , and the poor guiding system the visitors are unfortunately being kept from a deeper understanding of the cultural values of the site. In such context, this research aims to develop an application for handheld devices that can feed seamless authentic information and visual aids to the tourists for them to enjoy an engaging and immersive tour at Khalifatabad. A literature survey on existing apps reveals that most of the tools are developed for certain objectives and rarely fit for direct implementation at Khalifatabad . Therefore , the challenge remains twofold . First to develop a conceptual framework , which would help the tourists to have a deeper understanding of the significance of Khalifatabad. Second, to develop an application through adopting the conceptual framework. In this, the paper proposes a four-step conceptual framework i.e. ' SMART ' (Synchronous Location -Aware Media and Augmented Visualization for Real-world Tourists ) solution , for presentation of the information and user engagement . Supported by location -based service (LBS) and various data structure to feed different interactive features this framework sets the 'user-experience ' at the top. Being part of an ongoing research project, this paper presents possible scenarios explaining how the seamless and synchronous information may help the real-world visitors to reveal the past in a compelling and memorable way, and how it may provoke better understanding and appreciation of the context . This paper expects that the proposed SMART solution will uphold the significance of Khalifatabad to the real-world visitors, besides, as a prototype; will open the possibilities of further use to the other heritage sites of Bangladesh.**

***Keywords*** *— Tourist, Khalifatabad, Location based service, Augmented visualization, Synchronous media, SMART, Interpretation.*

## I. INTRODUCTION

### *A. Background*

Khalifatabad is one of the most significant cultural heritage site in Bangladesh. It was an influential city developed in mid-15th century, which was adorned by more than a dozen mosques of magnificent architectural beauty. The main attraction of the site, the sixty dome mosque, is a UNESCO World Heritage Site, which has been described as "the most impressive Muslim monuments in the whole of the Indian subcontinent" [1]. Besides the religious and cultural factors; due to its heritage significance, the site is getting an increasing attention from both local and international touristsday by day. However, little or no knowledge about the local context, language barrier, accessibility to information and poor interpretive systems often hindered the overall experience in various ways, such as -

- Often most tourists and visitors miss to visit less popular but yet significant heritage spots other than the popular Saith Gumbad Mosque (UNESCO world heritage site) and the Mazaar (Khan Jahan's mausoleum).

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- Lack of learning due to unavailability of detail information of the historic buildings and artifacts.
- Less satisfaction out of the visit due to unavailable interpretive tour or guide.
- No facilities to virtually visit the site for remote tourists, and especially physically challenged and impaired people.
- No visualization aid/tool to watch those dilapidated monuments (as 3D reconstructed view) in their original state.

These above-mentioned reasons therefore, lead this research to explore the technological potential for the best practice and provide services for the tourists to help them to explore and interpret the site through providing authentic heritage data and visual aids. It seems, with synchronous location aware narrative with augmented visualization of the virtual reconstructed views; this heritage site would be ready to come back to life. However, the question is, how to present such information to the audience as effectively as possible.

### *B. Heritage interpretation*

*"The chief aim of interpretation is not instruction but provocation"* - Freeman Tilden [2]

The term 'interpretation' is often used to indicate the storylines adopted to help visitors to engage with and understand the place or objects in a real-world heritage site or museum. Disciplines such as Archaeology, History or Heritage Management consider 'interpretation' as a learning, communication and management tool that increases the visitors' awareness and empathy to the site and artifacts. Freeman Tilden [2] defined interpretation as "an educational activity that aims to reveal meanings and relationship through the use of original objects by first-hand experience and by illustrative media rather than simply to communicate factual information". Therefore, in a broader sense, interpretation is integration of 'presentation', 'supplementary education' and 'visitor satisfaction' [3]. Interpretation is not just a thing like a board of exhibit or a presentation of information through multimedia, but a communication process [4] designed to reveal the meaning and relationship of natural and cultural heritage to the public. According to Rahaman and Tan [5, 6] from the point of an interpreter, the act of interpretation must support (i) embodied interaction, (ii) cultural learning and (iii) an effective presentation (or communication) within an environment that supports (iv) dialogic interaction among participants and experts.

Several interactive application development tools (commercial/non-commercial) such as DroidAR, DWARF, Layer, IN2AR, PanicAR etc. are available for developing interpretive apps for tourists. However, these tools themselves have been developed for specific objectives and can only support specific experiences, and may not be able to provide an integrated solution to develop a complete tourist experience. Therefore, the question still remains how to provide synchronous location-aware media and augmented visualization for real-world tourist to have a deeper understanding of the past of a significant heritage site such as Khalifatabad, Bagerhat, Khulna.

This paper hypotheses that, a seamless and synchronous information which is location based and aided with enhanced visualization (i.e. augmented reality) may help the real-world visitors/tourists to reveal the past in a powerful and memorable way, to enrich the visitors' understanding and appreciation of the context and to give them some curatorial senses as well. This paper therefore attempts, to enhance visitors experience through developing an application for handheld devices (for both iOS and Android based systems) by applying a framework presented in Fig.2. The interaction level here would allow tourists to explore integrative maps, information retrieval through QR tag, location aware voice guide, and augmented visualization of ruins. However, the tempo-spatial information from users that could be shared through the apps and might help social networking; would not be entertained.

### *C. Project objectives and work process*

This paper aims to develop an application (or apps) for portable/handheld devices that allow tourists to roam around the site, understand its background and interpret the site in a deeper way. In this, a conceptual framework has been developed (Fig.1) and the application would be developed based on the proposed framework. The interface has to be prevalent and easy to use for anonymous real-world users. This also indicates that, the app should be compatible with different operating systems and browsers. Moreover, the platform has to host and run rich online media including both audio and video contents, which demand the support of handling large data with high bandwidth to ensure smooth experience.

The main tasks of this research are therefore to explore the ways to satisfy the visitors query, provide deeper knowledge about its' past, provoke them to conserve the site, and help them to understand the site from multiple perspectives (adopted from the interpretation model proposed by Rahaman [6]) through the following process –

- Study and Identify the significance of the heritage site
- Convert and represent significant cultural data into digital format (2D/3D) so that, it can be accessible via digital devices
- Enhance tourist experiences with the aid of the interpretive mobile application.

## II. HERITAGE SITE AND MOBILE APPLICATION

In recent years various visualization tools including Augmented Reality (AR) has achieved a remarkable expansion in heritage sectors based on various navigators/browsers. To establish user's location, these navigators use a combination of outdoor GPS and electronic compass sensors, which is available on most smart phones and tablets in present days, and add more values to explore the existing sites with its real past.

Gleue and Dähne [7] presented a system, as a first trial, at ancient Olympia in Greece through the prototype used in ARCHEOGUIDE project. This is a unique case to understand the problems that early researchers faced in the field of tourism. The first prototype consisted of an HMD, a laptop, a WLAN antenna, a GPS receiver, many cables and a backpack to carry out all this equipment. Thanks to the technological advancement that, nowadays all this hardware is integrated into one mobile device. Fritz et al. [8] described the development process of an interactive visualization system, based on Augmented Reality Technologies, and its integration into a tourist application in the PRISMA project. Another project under 'Re-yuangmingyuan program' has been developed by Gongli et al. [9] for the reconstruction and representation of an imperial garden in Beijing. Mobile LBS (Location-Based Service) services have been used here based on iOS platform. Michele et al. [10] have developed "VisitAR", a mobile AR application that allows users to have immersive sightseeing experience, providing tourist information of the city of Oulu (Finland). Joint collaboration of different Institutes of the Italian National Research Council (CNR) developed LecceAR, which allows tourists to enjoy 3D reconstruction of cultural heritages sites located within the city of Lecce, Italy [11]. Similarly there are several attempts found that have been taken by various authors [12-17] with various methods and approaches to explore heritage sites.

Gradually AR is becoming more admired by both developers and user. Several Augmented Reality SDK (Software Development Kit) are also emerging to provide the tools and libraries toward developers for easy development of AR Applications. A recent online survey shows the presence of several professional tools (table 1) available for various platforms in the market to support augmented visualization.

TABLE I. AR TOOLS FOR VARIOUS PLATFORMS

| Product name | Supported platforms | License type |
|---|---|---|
| Metaio (now Apple inc) | iOS, Android | Free, Commercial |
| DriodAR | Android | Free, Commercial |
| Vuforia | iOS, Android | Free, Commercial |
| Wikitude | iOS, Android | Commercial |
| Robocortex (ROX AR SDK) | iOS, Android | Commercial |
| ARLab | iOS, Android | Commercial |
| D'Fusion | iOS, Android | Commercial |
| Xloudia | iOS, Android | Commercial |
| Catchoom | iOS | Free, Commercial |
| ARToolkit | iOS, Android | Free, Commercial |

Although, different types of AR tourism applications have been designed and applied however, none of these take into account the tourist experience as a whole. The moment the tourists arrive in the heritage site, they need a complete guide and understanding of the site based on a synchronous information flow to have a seamless experience. For this reason an application is required that takes into account the entire touristic needs especially for Khalifatabad, and can provide as many information as possible in a simple and intuitive way. Another lesson learned from the literature review is that, the criticalities for the use of AR in tourism applications, such as the availability of free Wi-Fi connection, the cost of data roaming connections, the interoperability across mobile platforms etc. needs to be considered from the very beginning of the project.

## III. TOWARDS THE SMART SOLUTION

The interpretive mobile app will work here as a tool to establish a SMART (Synchronous location-aware Media and Augmented visualization for Real world Tourist) heritage site. Based on established facts from literature survey with augmented visualization, tourists enjoy an engaging and immersive tour when the system provides real-time and location-ware media to support learning, embodiment, presentation and dialogic interaction [6, 18].

Khalifatabad is a heritage site where most of the tangible heritages are dilapidated, and almost lost their original appearances due to their age and wrong repairing initiatives, to some extent. To achieve an immersive visual experience with synchronous location-aware media and augmented visualization a conceptual model has been developed which shows how various data can be processed to achieve the desired experience (Fig.1).

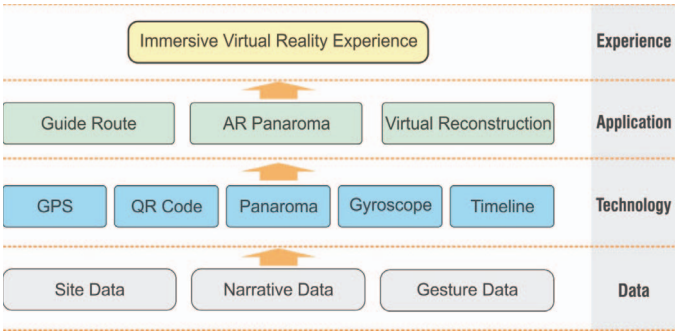


Fig. 1. The conceptual model showing the transformation of data to experience

A four-stepped strategy has been applied to reach the desired experience. Data from previously collected secondary sources and real-time gesture data will feed various embedded tools within the handheld device to result the immersive experience through specific applications.

The way to implement the location-based service (LBS) in the site is to install/erect quick response (QR) code to complement/identify visitor's point of interest. While reading the code, the mobile app will trigger relative information including reconstruction views and audio information. This audio-visual will enhance tourist's on-site experience. Beside AR (Augmented Reality) views, the application/app will also feature panoramic views, which may also be viewed by scanning the QR code. This will allow the tourist/visitor to enjoy a 360-degree (3D) virtual reconstructed environment from every possible angle. The embedded gyroscope will capture user's gesture data and combines it with simultaneous movement within virtual scenes; this will ignite realistic

experience. As the panorama requires larger data and better rendering engine/hardware, therefore, only important spots will be selected for this purpose. Development of the mobile app will be based on the framework shown in Fig.2. Keeping the user-experience at the top, the data structure will create the base to support various information in display.

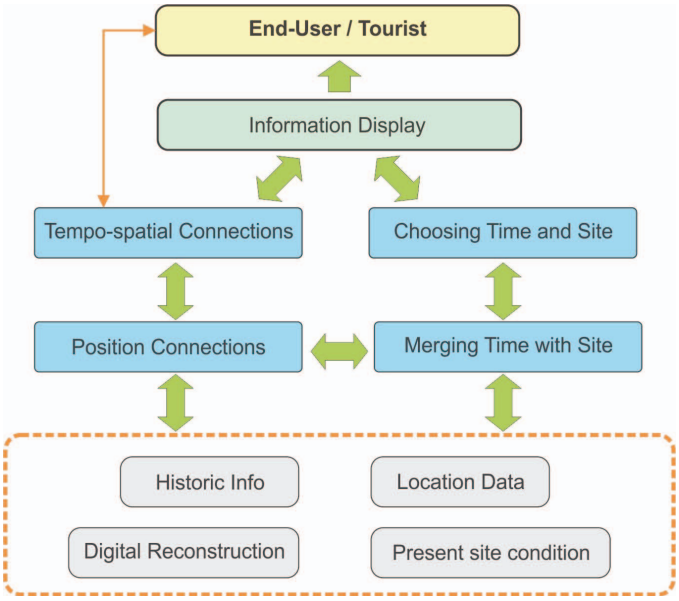


Fig. 2. Framework for the proposed mobile application (adapted from Gongli et al [9].

## IV. Work Approach

Three main objectives of this research have been outlined in section 1.3. These objectives are going to be achieved through 03 phases and 10 tasks. Phase 1 covers Literature review, Site survey and Documentation. Phase 2 includes Data entry, Drawings preparation and 3D modeling. And finally Phase 3 will conduct Prototype development, Evaluation and Reporting. The relationships between the project objectives, phases, and tasks are shown in Table 02.

TABLE II. Work Phases and Tasks

| **Objective 01**<br>**Identify the significance of the heritage site** | |
|---|---|
| **Phases** | **Tasks** |
| 1.1<br>Literature review | 1. Visit local museums, libraries and heritage authorities to collect historic information about the site.<br>2. Conduct online literature survey<br>3. Collect old maps, new papers, travellers' notes etc. |
| 1.2<br>Site survey | 1. Gigapixel photography to get great detail of the site.<br>2. Measure the existing tangible monuments/ruins.<br>3. Capture the 3D data of both buildings and artefacts with laser scanner.<br>4. Interview heritage experts and locals for oral histories, beliefs and popular stories. |
| 1.3<br>Documentation | 1. Analyse and sort authentic data.<br>2. Generate point cloud from laser scanner data.<br>3. Sort and categorize information (such as text, audio and video data) according to sub-themes. |
| **Objective 02**<br>**Convert and represent the data to be accessible via digital devices** | |
| 2.1<br>Data entry and conversion | 1. Digitize analogue data such as written scriptures<br>2. Scan old maps and images<br>3. Voice transcription of oral histories and interviews |
| 2.2.<br>Preparation of 2D Digital Drawings | 1. Preparation of 2D CAD based drawings of the site and buildings<br>2. Preparation of info-graphics for tourist. |
| 2.3<br>3D virtual reconstruction | 1. Construct virtual 3D models of the site<br>2. Develop 3D models of artefacts<br>3. Develop VR content and AR panorama suitable for both on-site media installation and mobile devices |
| **Objective 03**<br>**Enhance tourist experience with the aid of the interpretive mobile application** | |
| 3.1<br>Study the state of art interpretive tools/technologies for cultural heritage visualization | 1. Study state of art interpretive technologies and media installations<br>2. Identify requirements for SMART services.<br>3. Study state of art mobile applications/apps<br>4. Adapt the tool/media to support the development of the SMART heritage site. |
| 3.2<br>Selection of app engine, Installation of media server and data network | 1. Installation of media server and WiFi hotspots<br>2. Develop online hosting platform for models, scripts and other digital assets in both English and Arabic to access via portable devices.<br>3. Benchmarking and selection of app engine. |
| 3.3<br>Develop the app and support infrastructure | 1. Installation of static interpretation board<br>2. Installation of QR tags<br>3. Development of the app for both iOS and Android platform. |
| 3.4<br>Testing, verification, monitoring and reporting | 1. Cognitive walk through/testing the application<br>2. Performance analysis, validation, up gradation and documentation.<br>3. Upload the app to app-store for download. |

## V. Possible Scenarios

As soon as a visitor reaches the heritage site that he or she is about to explore, a sudden sense of disorientation is natural. Being new in the physical location, the individual faces some specific problems that start with the vital question, 'where to start' and 'how to go'. That is where the application (or app) first comes in. The 'interactive maps' will help to solve this issue through LBS service based on GPS functionality to notify visitor's present position and relative geo-location of spots of interest and possible travel routes (Fig. 3).

To avoid the feeling of being lost, the app will show the present location of the visitor with respect to the site of Khalifatahbad. The interactive map will act as a physical mapping of the site that includes the site plan, different heritage buildings, significant artifacts scattered around, other touristic spots and features like water bodies, old trees etc. Visitors will first see the map with a pre-defined route in red line, firm ones for major route and dot for the secondaries. All the spots will be a tiny red bubble with written labeling. There will be a similar red popping bubble showing the visitor's own location in the master plan. These will help the visitor to have an idea about- what to visit, which way to go, and the

optimum travel route that includes all the heritage and scenic spots, and what mood of transportations will be involved etc. Moreover, visitor can also create a customized route by connecting specific spots by tapping finger on two or more red dots on the screen. Thus a new blue line will be formed and information such as distance, time, facilities available around the way, ticketing and transportation system and so on about that new user customized route will be listed beside to guide the individual's desired tour.

Fig. 3. Interactive map track visitor's present location and show points of interest

Once the visitors have found their way in the site and decided the buildings or spots they want to experience by creating their own customized map, the journey of exploring Khalifatahbad has already begun. During the journey, visitors will come across different age old dilapidated structures with unparallel heritage value, as well as they will be indulging into various interesting features of those buildings or their related surroundings. That is a moment when an intrigued explorer will feel the thirst for more information on things he is encountering. Traditional interpretive boards may serve this purpose, however, they usually contains limited information and hindered the natural views and deeper interpretation of the site. As a solution this app will offer 'Augmented information' on top of specific heritage site and artifacts (Fig. 4).

Fig. 4. Real-time augmented information at specific locations

If the visitor feels like that he/she needs to know more about any specific area or thing, for example, a broken mehrab (Mehrab', a niche design in the middle of a Muslim prayer rug, pointed toward Mecca during worship) inside a old mosque of Khalifatahbad, pointing the hand-held device toward that will provide augmented information superimposed on real time view. General details like built time, details of original features, reconstruction phases, basic dimensions etc. would be provided through this mean. Here, it is also possible to have more detailed and technical information like the measurement, angles of the lines incorporated in the detailing etc. by secondary input from the visitor displayed in real time.

Among others, one of the most common feelings of a heritage site visitor is the eagerness to know how a ruined structure really was. In general, people are also fascinated about the virtual reconstruction of the decayed buildings. To have a deeper understanding of a heritage ruined virtual model superimposed as augmented 3D therefore can fill the gap by presenting lost part of the ruin in real-time view (Fig. 5). Rather than just giving an original reconstructed view of the ruin, the app will offer the visitors to visually compare with the existing condition as well as superimposed as photomontage. To avail that, visitors will have to hold the device and swap it on a ruin real time. We hope through this, the visors will help to gain a perception about the past condition of the present dilapidated heritage buildings, including the total spatial qualities of the surroundings.

Fig. 5. Real time superimposed 3D image to aid greater interpretation.

For an example, the case of Khan-Jahan's residence, where only the basement is left, and thus a real time superimposed 3D will help the visitor to have a greater interpretation of how the residence was, its simplicity and construction details. For specific structures, where there are more than one construction phases involved, reconstructions of the successive periods of the same site will be rendered and explored as layers by swapping top layers.

Although, augmented 3D views of certain objects/buildings will give the visitors the knowledge about the past glory of a specific ruin. But in Khalifatahbad, there are many spots where the surroundings displayed a great impact on the development of magnificent architectural style, and needs to be presented to the visitors to trigger their empathy. This issue has been taken care of by introducing

360-degree panoramic views of some certain spots. Integrating the gyroscope and GPS of a handheld device, visitor may able to view 360 degree reconstructed panoramic views of the buildings and its surroundings of a past time. While holding the device and rotating 360 degree from left or right, a whole new rendered reality can be seen through the device which will give the impression of watching the past as a time traveler (Fig. 6).

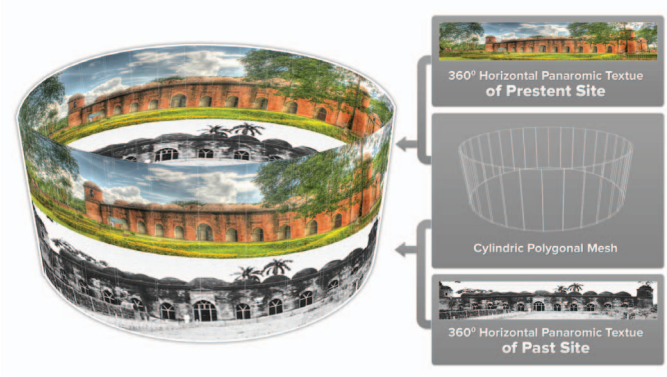


Fig. 6. 360 degree reconstructed panoramic views of the past

With the above-described features the app will not only to guide the visitors at the heritage site but also will help them to have the best possible experience within least possible time. Moreover, the most important feature of the app is the integration of the Quick response (QR) tags reader. Tiny, low impact tags will be embedded at various artifacts, ruins, details, landscape items, objects, building elements and so on. These QR tags will be referenced and linked with heritage data hosted by a central server and scanning these tags therefore will provide the visitors with detail information about the object/ruins within seconds. The best thing about quick response tags are beside texts they can also be linked with audiovisual data and can be retrieved on demand (Fig. 7).

Fig. 7. QR tag at various location to allow visitors to have detail information.

## VI. Conclusion

Khalifatabad, not as a world heritage site but for religious purpose, receives a large number of tourists every day to visit especially the Saith Gumbad Mosque and Hazrat Khan Jahan's mausoleum complex. However, lack of any synchronous location-aware media and augmented visualization for real-world tourist is therefore, limiting the overall experience and deeper understanding of the site and history. In this situation, this paper aims to develop an application for handheld devices that feeds seamless authentic information and visual aids to the tourists to enjoy an engaging and immersive tour at Khalifatabad. As part of a research project, this paper tried to present a concept of Synchronous Location-Aware media and Augmented Visualization for Real-world Tourists (SMART) and presented its methodology on implementation and possible scenarios which aims to provide the visitors a greater interpretation of the heritage site of Khalifatabad. Interactive maps tracked with GPS, location-based service (LBS) linked with quick response (QR) code at various points, 360-degree panoramic views, augmented 3D views layered on physical ruins; all are aimed to offer the utmost immersive experience for the visitors.

Presenting information through handheld device to tourist is not new, nor is the usage of augmented reality app for heritage visualization. What is new is the praxis of research based knowledge that converges with the state of art technology and substantiated the past of Khalifatabad to the real-world tourist. The taxonomy on which the application is conceived here, will comprise several aspects of the mobile applications space, including context awareness, client architectures, mobile user interfaces, as well as offered functionalities which will highlight functional, architectural, technological, and implementation issues.

At this time of writing this paper, there is no such interpretive app available in the market that can help present visitors/tourists to engage with the site, help them as a guide to roam around, provide synchronous interactive narrative with visual aid and immersion with the multimedia content for Khalifatabad. The development of the app therefore opens the possibility to use as a prototype for further development and application to other heritage cities of Bangladesh. A successful completion of the SMART system therefore will present the significance of Khalifatabad, Bangladesh not only to the real-world visitors but also to the world tourists who might be interested in future to visit the site. Besides, we believe, this app will also help educators and researchers for teaching and research in subjects like archaeology, history, heritage conservation, heritage management and user experience study (HCI).

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