

Web based application for Sigiriya

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Web based application for Sigiriya

**A dissertation submitted for the Degree of Master of
Information Technology**

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2017



Declaration

The thesis is my original work and has not been submitted previously for a degree at this or any other university/institute.

To the best of my knowledge it does not contain any material published or written by another person, except as acknowledged in the text.

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This is to certify that this thesis is based on the work of Mr. Umesh Asanga Hapuarachchi under my supervision. The thesis has been prepared according to the format stipulated and is of acceptable standard.

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Abstract

Sri Lanka is a touristic hotspot, which attract millions of tourists each year. Among these attractions Sigiriya is a unique place due to its attractive design and wonderful architecture and UNESCO has identified it as a cultural heritage site. Several countries have successfully integrated modern technology into tourist industry by creating various applications that work as virtual tour guides. No such implementation has been done in Sri Lanka to obtain maximum benefit. If modern technology is effectively used, country could attract more tourists and popularize its unique features to the rest of the world. The goal of this project was to create an interactive web application, which uses VR/AR and GIS to retrieve information on desired locations of Sigiriya that can be viewed through any mobile device or PC. Embedded Google map shows all identified attractive locations in sigiriya. By clicking on that icon, directly select from menu or by QR code scanning at relevant location you can access and refer all information about that place. Its contain text, images, narrations, panoramic views and videos. 3D modeling and animations of selected sites were developed and compared with the current view. 360 panoramic views and VRML models were created to give live experience for users. CMS used to develop the web application by using Word Press as a tool, Bootstrap for responsiveness and MySQL for the data base handling.

Further developmental areas have been identified for the application. One interesting thing is mobile app can be synchronized with this web application to smart detection of the locations of the visitor.

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List of Abbreviations

UNESCO:	United Nations Educational, Scientific and Cultural Organization
3D:	Three Dimensional
CAD:	Computer-Aided Designing
HTML:	Hyper Text Markup Language
UI:	User Interface
PHP:	Hypertext Preprocessor
RF:	Radio Frequency
GPS:	Global Positioning System
GIS:	Geographical Information System
WLAN:	Wireless Local Area Network
FPS:	Frames per Second
CMS:	Content Management System
DBS:	Digital Binocular Station

Chapter 1

1.1 Introduction

Sigiriya is one of our ancient heritage sites with attractive design and wonderful architecture. Its surprising design, architecture, urban planning, water engineering, technology and arts signify the beauty and pride of our ancient heritage making Sirigiya a unique place. Water engineering technology, paintings and architectural design are some of its key attractive features. Water garden consists of variety of ponds and fountains. There are evidences that people have used pressure works to distribute water across the ponds when there is enough rain water accumulated in the upper ponds. In addition, archaeological evidences discovered so far have conclusively suggested that hydraulic engineering was an important element of the overall design of Sigiriya. Undoubtedly it would regenerate a dust free cool environment, which was surely the original design intended of the ancient Sigiriya Garden. It is recorded that if the water level at Sigiriya lake would be maintained throughout the year above the 200 m height, an adequate volume will be available to supply and activate all the water gardens of Sigiriya [1]. Therefore, Sigiriya has been identified as the eighth wonder of the world and UNESCO declared it as a World Heritage site in 1982. Therefore, Sigiriya has a high potential to attract foreign exchange if modern technology is effectively used to publicize its uniqueness to the world. For many tourists, visiting Sigiriya is just another hike/rock climbing event without visualizing and understanding how it could have been long ago and why it is unique.

Based on the central bank annual report, by the first quarter of 2015, 1,798,380 of tourists have visited the country and it is nearly 300,000 of increment[2]. According to the Sri Lankan tourism Development Authority annual report, by the year 2015, Sigiriya has attracted 452,301 tourists generating Rs. 1,625,116,904.00 foreign revenue[3]. This number will be drastically increased within next few years with the peaceful environment and political stability of the country. However, Sri Lanka is not technologically ready to face the challengers of increasing tourist visits and the biggest challenge is to make sure that everyone gets accurate information. Often times it has been reported that tourists are misguided by these untrained and unprofessional tour guides. Unlike in the past, with the freely available internet access, visitors can write reviews on the websites such as Tripadvisor and Lonely planet destroying Sri Lankan image. The country should have a proper plan to handel increased tourist influx and provide

accurate information in a professional manner. On the otherhand, tourists from different cultures have hard time imagining our ancient heritage and cultural values. Therefore, it will be very much important for the country's tourist industry to have a sophisticated application so that it will help visualizing how main attractive points of Sigiriya would have been long ago and get detailed descriptions. Many countries have introduced technology based applications to support tourist industry. For example, Buhalis and Yovcheva [4] explained 10 unique applications, which use Augmented Reality (AR) in tourism, showcasing the potential of the technology in tourist industry. AR is a recently introduced computer technology, which is a live direct or indirect view of a physical or real-world environment whose elements are augmented (or appended) by computer-generated sensory input such as sound, video, graphics or GPS data. This term is often interchangeably used with virtual reality (VR) even though there is a slight difference between these two. VR means giving one an opportunity to experience things that don't really exist with the use of high-performance computers, mobile devices and sensory equipment, like headsets. The overall goal of AR/VR technology is to create the targeted item more and more similar to the real world situation or more authentic and the user feels that he is actually there. However, no such application has been introduced to the tourist industry in Sri Lanka to date.

In the modern technological era, traditional tour guide jobs are being replaced by AR/VR based tour guided in many countries. This technology can extract information from the environment through image recognition of objects or geographic information system (GIS) to link virtual image that can be viewed in real-time. When a tourist points his electronic device towards an interested place in real world, he/she is able to find more details of the site and virtual information overlaid into that. This brings the visitor to a whole new level of tourism. Various apps and VR based tour support systems have been developed for most of the important UNESCO heritage sites in many other countries and have helped attracting tourists, popularizing ancient heritage sites and protecting these historical places [5]. India recently launched many educational mobile apps targeting its historic places attracting world class tourists [6]. Unfortunately, Sri Lanka has not started creating its own apps to educate and attract tourists and to provide virtual views of historically important places regardless that the country has the highest literacy rate in South East Asia. Among the tourist attractions in Sri Lanka, Sigiriya has so much potential to increase its anual visitors by attracting world class tourists who love culture and history, if the technology is effectively used to create new software and popularize them world wide.

1.2 Objectives

The goal of this project was to create a web application, which uses VR/AR and GIS to retrieve information of a desired location of Sigiriya that can be viewed through any mobile device or PC. The visitor can interact with the system through touch input, QR code scanning, acquiring GPS coordinates or via web browsing. Overall long term goal was to digitize and implement new technologies to the cultural heritage to attract foreign exchange.

Specific objectives of this project were to,

- create an application that work as a virtual tour guide
- deliver information to the visitors by providing accurate information via three-dimensional views and virtual visualization of ancient beauty and prestige of Sigiriya
- design and implement a proof of concept web application supported by the framework
- determine the capabilities and limitations of the web application
- explore Sri Lankan history to the world in an attractive manner using digital technology to help boosting tourism industry

In achieving these objectives, necessary information of Sigiriya were collected using ground and aerial photographs, scanning images, direct measurements of objects (whenever possible) and using drawings. At the same time archaeologists were interviewed. For identified locations, 3D visualization and walk through were created and also included narrations and historical data to make tourists aware about the ancient heritage of Sigiriya. User can login to the system and navigate through the site. If the user is away from the location, he can navigate through the application to an interested location, visualize, feel and enjoy virtual tours. For users who are in the location can browse details and can view details relevant to the GPS locations or through QR code scanning. This helps imagining how the selected location might have been long ago. It also provides an option for the user to watch videos and 360 views, listen narrations, view images or read the history.

This thesis is consisted of 4 chapters. Chapter 2 describes the background of the project including concepts, augmented reality, localization techniques, AR applications in tourism, virtual

reconstruction of historical places, its application in Sri Lankan context, why Sri Lanka should use these technologies effectively, multimedia, multimedia projects, structured multimedia project development lifecycle and functional and non-functional requirements. Chapter 3 describes the methodology of historical data collection, software used, hardware requirements, analysis of the application. Chapter 4 describes the implementation, evaluation of the application and testing. Last chapter describes the proof of concept application that has been built to demonstrate and validate the framework functionality, assumptions, conclusions and identifies possible future work.

1.3 Scope of the project

The proposed application works as a virtual tour guide specially targeting foreign tourists. The app will help locating the current location of the tourist visiting Sigiriya and will open up more options and locations to view. Logged users can experience every aspect of the app whereas the unlogged users can interact with the app to a certain extent. With the GIS incorporation, the application has an ability to track the location of the user and it will provide direction from the current location to another. This will help visitor to decide going to the nearby important locations. Once the rough location is found, the visitor can find nearby locations, distances, time taken to reach and detailed descriptions. This will give the visitor an option to choose, ignore or add to favorite list. This feature is very important since in some instances visitor might have missed important attractions. This application will let the visitor/tourist stand at a specific location, place the smart phone into a Google Cardboard VR viewer to experience most memorable and important moments and events that had occurred in a particular location via 360° VR videos.

Another important feature is that the visitor can estimate time taken to cover every location and plan accordingly. This application has the ability to collect details of visitors, most visited locations, their favorite routes and time spend in each location, which can be useful in future statistical analysis and promotional activities of the tourist industry.

Chapter 2

2. Background/Literature review

2.1 Augmented Reality/Virtual Reality (AR/VR)

When visiting historic landmarks, one might feel like turning back the clock to get a first-hand look at the historical events. With the modern technology and Augmented Reality (AR) applications it is possible now. The term AR is often used with the Virtual Reality (VR) eventhough they are slightly differnet. AR refers to a system in which the user views and acts within an enhanced version of the real world. Milgram et al. [7] identified that AR is a continuum relating purely virtual environments to purely real environments. The enhancements are virtual (computer generated), and can include objects or information. A combined system of real and virtual objects and information is referred as mixed reality (Figure 1). Bimber and Rasker [8] defined AR as a combination of a real scene viewed by a user and a synthetic virtual scene that augments the scene with additional information.

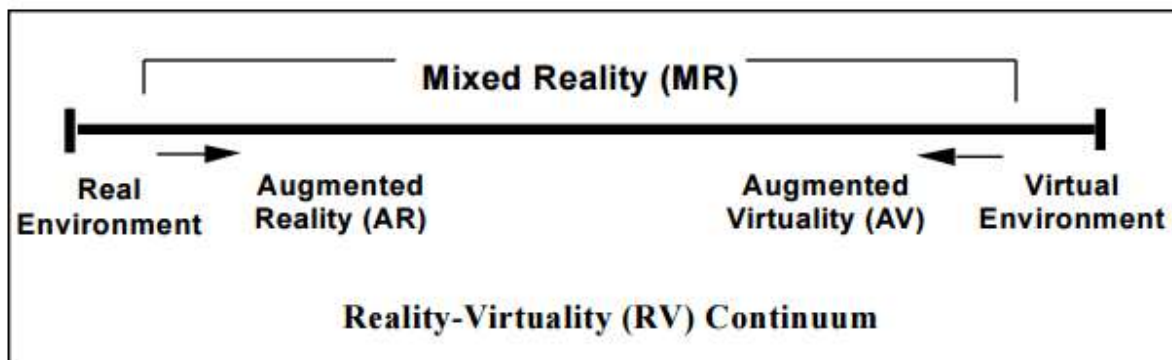


Figure 1: Simplified representation of RV continuum [7]

The term VR first introduced by Jaron Lanier in 1989 [9]. Virtual environments (VE) are described as being systems that will enhance the communication between humans and computers. Online oxford dictionary defines Virtual Reality as “the computer-generated simulation of a three-dimensional image or environment that can be interacted within a seemingly real or physical way by a person using special electronic equipment, such as a helmet with a screen inside or gloves fitted with sensors”. The overall goal of VR is to create the targeted item more

and more similar to the real world situation or more authentic and the user feels that he is actually there.

Since 1990s US government has identified the importance of AR/VE and has advised its National Research Council to prioritize the research in this area [10]. 3D visualizations and VR have been using in practical applications, such as advertisement industries, civil engineering, architecture, urban design, journalism, weather reports, scientific world, geography, medicine, engineering and in fine arts. In education, interpreting complicated scenarios of scientific findings/theories in a realistic manner has helped distributing the knowledge to a wider audience. Children with mild autism and hearing problems are benefitted with the use of VR technology and it was found to be a very effective methodology [11]. VR has entered into medicine as well [12]. For example, Dr. Neil Martin and his team at the Ronald Reagan UCLA Medical Center, USA used VR to take a test drive through the patient's brain before a surgical procedure to remove a tumor. Another example of effective use of VR was when building Martin Luther King Multi-Service Ambulatory Care Center in Los Angeles, USA. Doctors and nurses wore VR headsets to provide inputs on logistical details such as where the equipment should be placed for the actual rooms. Companies like McCaethy and DPR constructions, in USA have a long history in construction and have been effectively using VR.

2.2 AR Context

Three requirements have been recognized by Azuma [13] that needs to be full filled by an augmented reality (AR) system. They are; combine reality and virtuality, interact in real time and register in 3D. *Combine reality and virtuality* is fundamental to AR systems since their purpose is to support the reality with virtual content. As AR is a manifestation of “mixed reality” with a tendency towards reality this combination is a must. AR is mostly based on the reality with mixed-in virtual objects. *Interact in real time* implies that an AR system should react to the user in real time, unlike, for instance, computer graphics in movies. For example, a change of viewpoint of the user should be reflected in a change of displayed information. *register in 3D* mean virtual objects are registered in the real world in 3D, i.e. virtual content is placed in the real world environment using a three-axis coordinate (x,y,z) in three-dimensional space, reflecting its latitude, longitude and altitude (Figure 2).

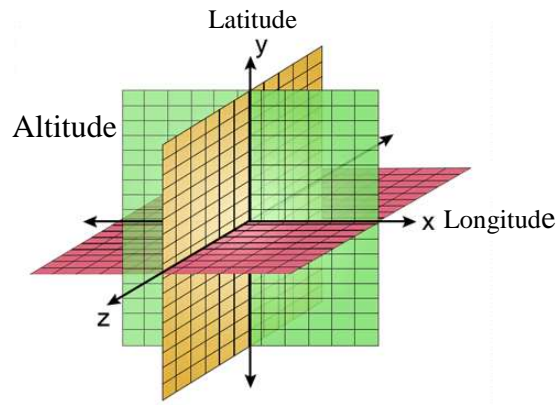


Figure 2: Three-axis coordinate (x,y,z) in three-dimensional space, reflecting its latitude, longitude and altitude

Categorization of context information types is necessity in AR and should help application designers establish what context information is useful for their applications. Four categories of context information have been distinguished, *Location* (where is the user) *Identity* (who is the user) *Activity* (what is the user doing) and *Time* (when is the user using it).

2.3 Location estimation in AR

Two areas of localizations can be identified, namely wide area and local area deployment. It is important to note that several wireless network technologies can be used for location determination. For wide area localization, GPS and cellular networks can be used whereas for local area, Wireless Local Area Network (WLAN) and Bluetooth can be used. Global Positioning System (GPS) localization technique is based on satellite-communication used worldwide. Several variations of GPS, Assisted GPS, Differential GPS can be used for improved results [14]. With the technological improvements today, number of cellphones with integrated GPS capability has become a norm. However, certain devices lack GPS and use cellular-based systems for wide area localization. In comparison with GPS, these systems have an added advantage of being able to work effectively in indoor environments, however accuracy is compromised compared to the GPS in outdoor environments. WLAN is a widely used wireless network infrastructure based on Radio Frequency signals (RF). Even though Bluetooth is not suitable for high accuracy in localization, it is advantageous as many cellular phones include a Bluetooth-adapter [15].

2.4 AR and tourism

It is clear that AR technology allows combining physical world and virtual information creating mega potential in tourism industry. It is still under-utilized in this area. In a recent report titled “Augmented reality in tourism, 10 unique applications explained” described 10 highly innovative AR experiences. This report explained the potential of the technology to revolutionize the way we experience new destinations and services within the industry [4]. “Two Treasures 3D Tour” is one of the most successful examples described in the report that is developed by the Saint Petersburg Clearwater Bureau that used AR to offer a cutting-edge 3D experience to potential tourists. AR has a huge potential in involving tourists in learning and experiencing various historical settings and artifacts like never before. Buhalis & Yovcheva [4] further illustrated how Digital Binocular Station (DBS), makes the static contents of a museum come to life, leading to an interactive, dynamic and interesting adventure, which increases visitor retention time and return visits.

“Timelooper” is another recently developed app that will give an option for the visitor/tourist stand at a specific location, place the smart phone into a Google Cardboard VR viewer to experience most memorable and important moments and events that had occurred in a particular location by delivering 360° VR videos. This will enable the visitor to experience major events that occurred in history while visiting that particular location. For example, authors have created great Fire of London happened in 1666 to this app.

Currently there are several examples of AR/VR applications available for ancient historic places where tourists can get a virtual experience. In an article published by Neovesky and Peinelt [16] mentioned that virtual tours and panoramic images of historical places give access to monuments and architectural complexes to the user. They have created a virtual tour to the Inscriptions of the UNESCO World Heritage Site, St. Michael in Hildesheim, Germany. In this project the user can navigate through the church using mouse and keyboard on the screen and when clicking one of the information points, a popup will open, which contains textual and audio information to the object as well as an image. The author’s objective was not only to create a virtual tour for the St. Michael’s in Hildesheim, but to create a generic tool that would enable to create virtual tours for other objects as well.

2.5 Virtual reconstruction of historic buildings

Recreation of historic buildings with 3D techniques is useful for many different reasons. Digital replica of historical buildings can be created for any point of time in the past even when the building/structure is not available today or not accessible or even never realized that there was such thing existed [17]. During the past years several countries have initiated such projects. For an example, recently Department of Architecture Urbanism and Planning in Belgium developed several architectural designs and virtually reconstructed many historical buildings using 3D models [17]. Authors used different applications and techniques from generic modeling with CAD and 3D software for visualization and animation. With the recent development of the technology many such projects have been initiated as published in several articles [18, 19, 20, 21].

2.6 Sri Lankan ancient history and Sigiriya

Sri Lanka has nearly 3000 years of history and it holds some of the world's ancient cities including Anuradhapura, Polonnaruwa, Dambulla and Sigiriya. Among these cities, Sigiriya also known as Sinhagiri, is an ancient rock castle located in Dambulla in the Central Province, Sri Lanka. Sigiriya holds remnants of glorious ancient cities, parks, recreational sites, temples, hospitals, castles and theaters intricately carved and modeled amidst the elevated mountains and forests. The rock is considered as Asia's oldest landscaped gardens and ponds, and historic records indicate that it is King Kasyapa's "palace in the sky" (Figure 3). According to the Mahawamsa, king Kashapa killed his father king Dhatusena, to get the throne otherwise it would have belonged to his brother Mogallan. Mogallan fled to India with the hope of returning and revenging and knowing that his brother Mogallan's inevitable return, Kasyapa build his palace on the summit of Sigiriya as a castle. Later Mogallan came into power and turned this place into a monastery complex and abandoned in the 14th century. However, there are evidences that even before King Kasyapa's time this place, specially the caves in the rock base, had been resided by Buddhist monks form around 3rd century BC. Many of these caves still have Brahmi inscriptions dating back from 3rd Century to 1st Century. In 1907, British explorer John Still rediscovered this amazing place and has mentioned that "the whole face of the hill appears to have been a gigantic picture gallery". It was found that the paintings would have covered most of the western face of the rock, covering an area of 140m long and 40m height and approximately

500 ladies must have been in these paintings. Another point of view was found regarding these paintings was found in a book written by Dr. Raja De Silva, an archaeological commissioner, Sri Lanka. According to Dr Raja De Silva, these paintings do not portray ladies from Kassapa's court, but they were to represent Tara Devi, an important Mahayana Buddhist goddess [22]. Whatever the assumption is, Sigiriya has already attracted many tourists and today it is declared as a UNESCO World Heritage Site and is one of the most attractive tourist destinations in Sri Lanka. Sri Lankan Cultural Fund hopes that in future tourists will come to the country just to see this Lion Rock mountain similarly that they would go to visit other places like Great wall in China and Pyramids in Egypt [23].



Figure 3: Aerial view of full landscape of Sigiriya

It is evident that Sigiriya can be promoted to be one of the top touristic destinations in the world if we could publicize it effectively and if modern technology is used. Currently there are several websites and information sites available in the web providing useful information using traditional media such as photographs, small pieces of video, art works and google map information. However, none of the government maintained websites have used technology effectively to promote the importance of this unique place and only one 3D art work is available in the

YouTube named “Alakamandawa” created by Jayasekara [24]. That is also a piece of video and no interactive educational tools are embedded. No virtual tours of the place have been included in any of these sites whereas other countries have started using the technology effectively to publicize their historically important places to attract tourists, who have interest and passion for the history and ancient sculptures. AR/VR systems can employ a tremendous persuasive power and provide a lucrative opportunity to market services successfully and this is a feature is still underutilized in the tourism and hospitality industry.

It is obvious that the rest of the world is moving forward mixing the fast growing technology and heritage together and for us it is high time to start our own system so that we can bring our history to the world effectively.

2.7. Multimedia

Multimedia applications often use of more than one kind of media to deliver content and functionality. Multimedia items generally fall into one of five main categories namely, text, images, audio, video and animation.

Text is the basic element of multimedia. It involves use of text types, sizes, colors and background colors. For an effective multimedia program, the position of the text on the screen, length of the message and legibility of the message should be considered. Images make the multimedia application attractive. Two types of audios; analog and digital, are used in multimedia applications to full fill the requirements of the use of speech, music and sound effects. Videos provide a powerful impact in a multimedia program. Due to the facts such as that digital videos can be edited easily, can be stored like other files and can be transferred within a computer network, digital videos have become very popular in multimedia projects. 2D or 3D animations have also become important elements of a multimedia projects. These elements should be edited to be effectively used in a multimedia project. For text editing, software such as note pad, Microsoft word and open office writer are often used. Microsoft paint, Adobe Photoshop, Adobe Illustrator, Corel Draw are used for image editing whereas sound recorder and Adobe Audition, Sound Forge, Cake Walk can be used for audio editing. Adobe Premiere, Pinnacle studio are used for video editing and Adobe Flash, Asymetrix 3DFX, Magic Morph and Ulead GIF animator are

often used for 2D animations. 3D Studio Max, Maya, Blender are some of the commonly used software for 3D Animation.

In some of these items, choice of color is important for a successful multimedia project. It should be in agreement with the color theory, which includes complementation, contrast, and vibrancy. Complementation is the way one sees colors in terms of their relationships with other colors. Colors should occupy opposite ends of the color spectrum, so that they lead people to consider a design visually appealing. Contrast refers to the effective selection of background and text color reducing eyestrain and focuses user attention by clearly dividing elements on a page. Vibrancy refers to the emotions of a design. Brighter colors help user to focus more on the subject whereas darker shades relax the user allowing mind to focus on other things.

2.8 Multimedia project

Producer, consumer and the product are the three main components of a multimedia project (Figure 4). Producer is the creator of the project and responsible for managing the budget, resources, tools and schedule. Consumer is the sponsor for the project. He defines the needs, skills of the end user, and the benefits of the product. Product includes contents such as audios, videos, images, functions, how the product works and the technology.

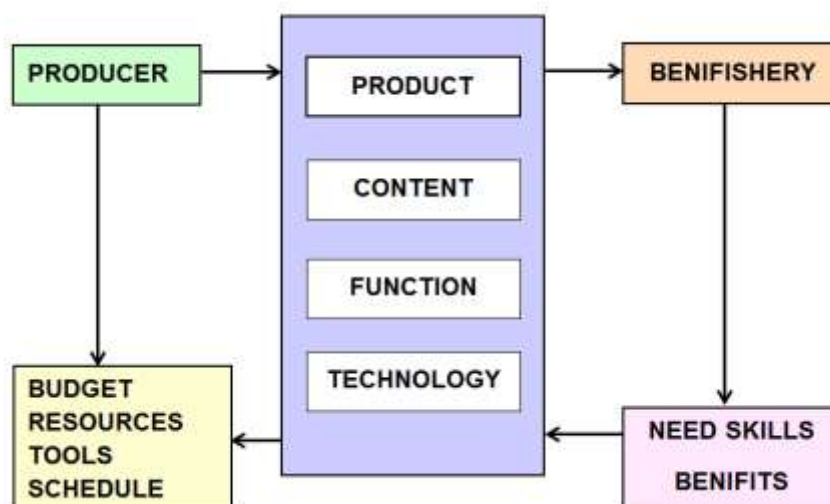


Figure 4: Cycle of a multimedia project development

2.9 Structured multimedia project development life cycle

Any project initiates with defining followed by planning (analysis and design), implementation, construction and evaluation. Having a structured multimedia development methodology provides a necessary structure for the successful implementation of a multimedia project. It saves time allows accurate cost and recourse estimate and provides a plane for members of the team if multiple individuals are involved. A structured multimedia project has sequential of events as shown in Figure 5, which initiates with planning as any other project [25].

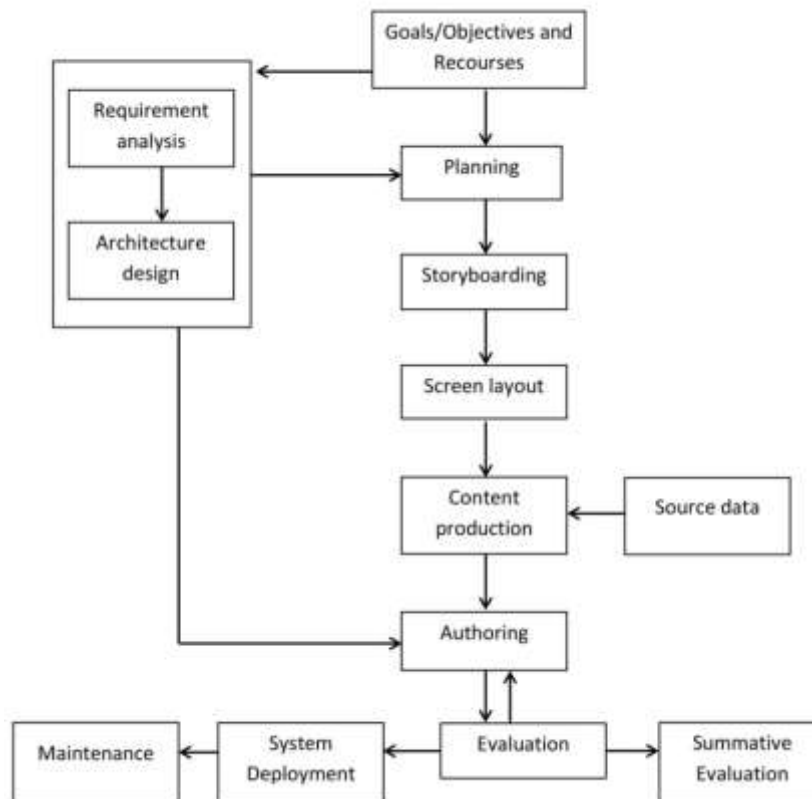


Figure 5: Sequential events of a multimedia development process for an application

Requirement analysis:

Requirements analysis is one of the most significant and tedious task of software development process. It includes the tasks required to determine the needs or conditions to meet new or altered product. During this process the developer should take account into the requirements of the various stakeholders, such as beneficiaries or users. Requirements must be actionable, measurable and testable. Requirements are gathered by interviews, referring similar systems and making observations.

Architecture design:

System architecture design is a structured solution that meets most of the technical and operational requirements of the software, while enhancing quality attributes such as performance, security, and manageability.

Planning:

Planning includes, developing concepts, defining project goals and answering several questions such as; what do we need to do, who will be using the product, how the product will be used, what resources are available, how long it will take to complete the project, who will be involved in designing, planning and testing, what hardware and software to be used and what are the critical parameters that determines the success of the project? Define hardware and software requirements and architecture for a multimedia project is another aspect to consider. Performance, user interface, specific features of the hardware will be recognized and the architecture transforms these requirements into a design by identifying specific software and hardware.

Storyboarding screen layout and logical flow:

Storyboard is used as an overview of a project, to provide a guide (road map) for the designer/programmer, to illustrate the links among screens and to illustrate the functionality of the objects. Storyboarding is useful in describing what the application is going to do, how it is going to do, and inspiring people/users to think about possibilities. Storyboarding is important to make changers before starting the project designing part.

Content production:

In producing the contents, several issues need to be addressed; what is the level of quality for the content, how will the content be generated, how will the content be achieved and documented, and how to get copyright? Content production includes, identification of new resources to be created, obtaining copyrights, digitizing pictures, audio, video into compatible format, production of original materials and format data.

Authoring:

Authoring is the process of bringing them all together or assembling the content into multimedia software development following the map provided in the storyboard. This would be the place to ask does it work the way it was planned.

Prototype:

In some instances, prototypes of the real systems are requested. This is useful in selling the concept, test the design strategies and capabilities, and assess the content effectiveness. Prototype allows seeing all the design ideas and solutions in action.

Evaluation/Testing:

Testing is an important part of design and development. Multimedia product should be tested by the users and through this process developers can locate flaws ahead of time and repaired them before releasing the finished product. During the test developer may consider whether it is user friendly and interactive or not. There are two formal testing procedures; alpha testing and beta testing. Alpha testing usually conducted in house and restricted to the development team. The idea is to “try and make it crash” and every plausible action (point and click) and navigation path should be explored. Alpha testing is done relatively early in the development phase. Beta Testing on the other hand, is the final functional test before release. The idea is to get feedback from as wide as variety of potential users as possible, to have the test done on as many different computer configurations as possible and to fix any bugs and content mistakes.

Deployment:

Deployment refers to the release of the product to the end user. Several tasks have to be completed; documentation of product in written including user and installation guide and troubleshooting instructions, mass production of CD_ROM, packing of product, marketing the product, mass production of hardware, installation of the software and training of personal to use the software.

Maintenance

Any product should evolve and grow with emerging technology or to meet user demands. In such instance, producer can redistribute complete product or distribution of portions of the product to replace the required segment/software. However, documentation of older version is important.

Chapter 3

3 Analysis, Design and Methodology

3.1 Analysis

3.1.1 Requirement gathering and analysis

Preliminary discussions were held with the officers attached to the Central Cultural Fund and the Department of Archaeology to determine the requirements for the software. In addition, visitors who have visited Sigiriya were also involved in the preliminary discussions. Outcomes of these discussions were used in determining the current needs, aspects to be addressed, options to be included and the target group.

3.1.2 Functional and non-functional requirements

With the preliminary discussions made with the stakeholders and visitors the requirements for the current application have been determined. These requirements were grouped into two categories, namely functional and non-functional requirements, i.e., what it should do and how it should perform.

Functional requirements

Functional requirements are the operations and activities that a system must be able to perform. This describes the set of inputs, the processing or manipulation of the inputs and the outputs with regards to the customers' expectations.

With respect to the users, following functional requirements have been identified:

- i. User registration: New users are expected to register to obtain full accessibility
- ii. Login: login to the system to access all the functions
- iii. Authentication of entered data: Every data point entered will be authenticated by the system.
- iv. Media access option: User has the option to choose video, audio or images from the media gallery.
- v. Search option: This will allow user to search items that he is interested in.
- vi. Sending feedback: This option gives a chance to user to send feedback.

For the system administrators following functional requirements were identified:

- vii. Activation and deactivation of the users: System admin has the administration powers to activate or deactivate user accounts.
- viii. Add new content to the system: System admin has the administration powers to add content
- ix. Update content: Adding information and sources to the application,
- x. Data analysis: Statistical analysis and viewing logs of the system.

Non-functional requirements:

Non-functional requirements specify the criteria that can be used to judge the operation of a system and they have direct impact on the quality of the proposed system. Non-functional requirements are often called quality attributes. For example, to work properly, i.e. providing a “believable” augmented reality view to the user, the application should respond rapidly to the user’s movements.

Following main non-functional requirements were identified.

- i. Security: This feature allows only the registered users to access full functionality. The user’s personal data, logged data and other privacy sensitive information should be kept secure.
- ii. Performance of the system: High quality compressed video and audio files for used for efficient usage.
- iii. Reduced complexity: Only important page links will be shown in the web page to make it less complex.
- iv. Maintainability: Changing, adding and removing content and information sources should be facilitated.
- v. Responsiveness: Depending on the device being used, display will adjust itself.
- vi. Usability: It should be easy to use. Menus and functions should be clear, easy to find and either self-explanatory or well-documented.

3.2 Design

3.2.1 System overview

This web based application give virtual experience along with historical details of Sigiriya. Being a fully responsive system user can access it with mobile, tab or computer. User can log in to the system by entering url in browser or QR code scanning to open the landing page.

User, system and server were the main components of this application (Figure 6).

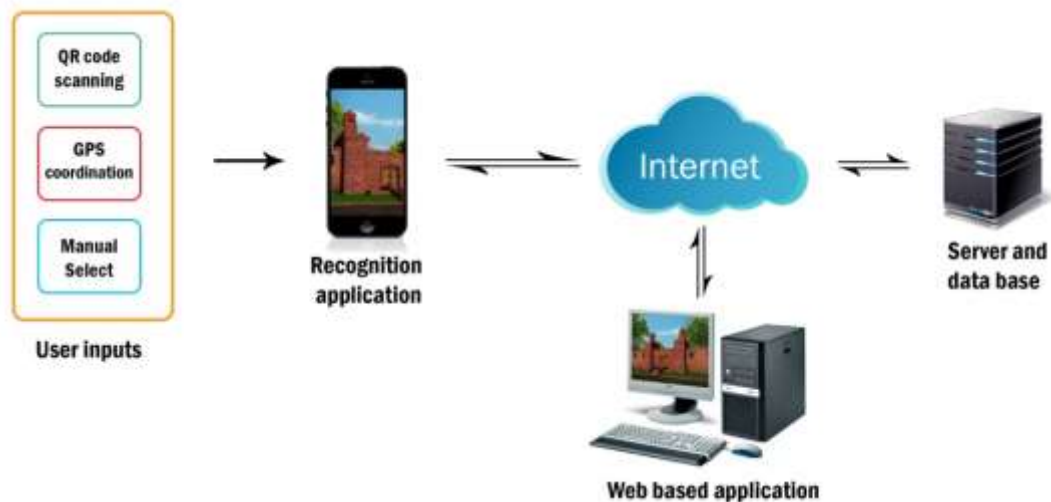


Figure 6: System overview

3.2.2. Use case diagram

Regarding the functionality of the context-aware augmented reality in web applications, a number of use case scenarios were identified. A new user has to register in the system to login. Then he/she can use navigational menus to access the options available. Already resisted user can directly log into the system using user names and passwords. The user case diagram for this system was shown in the figure 7.

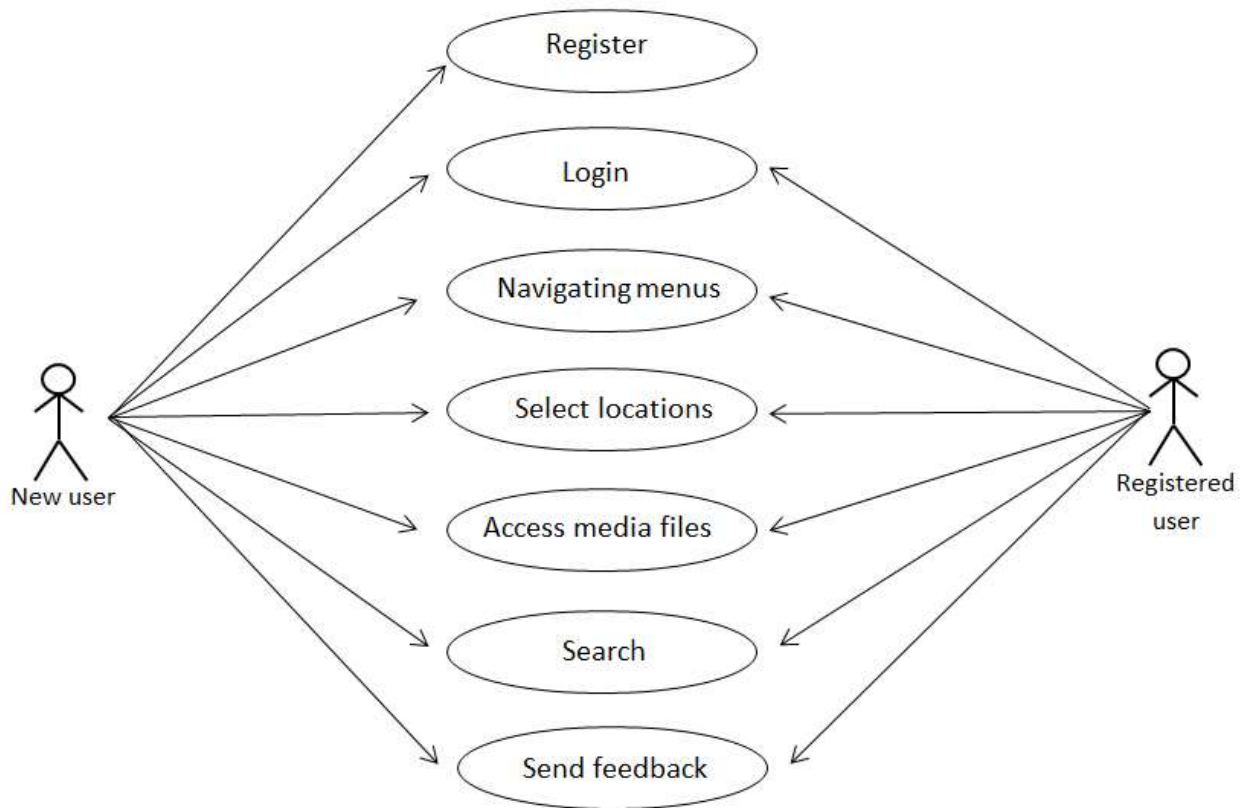


Figure 7: Use case diagram displaying two actors (new user and registered user) using the application

Use case descriptions for the primary actors were shown below.

Use case 1: Registration

Primary actor: New user.

Pre-condition: No prerequisites are required.

Main scenario:

Load the web page application.

User provide required details and submit.

Based on the details provided, access will be granted.

Login screen will be displayed.

Alternate scenario:

If authorization fails, user is required to reenter required data.

Use case 2: Login

Primary actor: All registered users.

Pre-condition: User must be registered before.

Main scenario:

Start the application.

User provides user name and password.

Authentication of the system.

Home page will be displayed.

Alternate scenario:

If authorization fails, user is required to reenter user name and password.

Use case 3: Navigation

Primary actor: All registered users.

Pre-condition: Must login to the system.

Main scenario:

Navigate through the system.

Access different web pages.

Alternate scenario:

Refresh the system.

Use case 4: Select desired locations

Primary actor: All registered users.

Pre-condition: Must login to the system.

User should be in the “Tour” page.

Main scenario:

Open the start “tour page”.

Select and touch the desired location of the provided map.

Alternate scenario:

Enter the unique location code.

Use case 5: Access media files

Primary actor: All registered users.

Pre-condition: Must login to the system.

User should be in the “Tour” page or “Locations” page.

Main scenario:

Open “Tour” page or “Locations” page.

Select videos, audios or images.

Alternate scenario: none.

System administrator controls the whole system. Once log in to the system, administrator is assigned a set of functions. Some of these functions include activate or deactivate users, add or remove locations and contents, assign user roles and data analysis as shown in the figure 8.

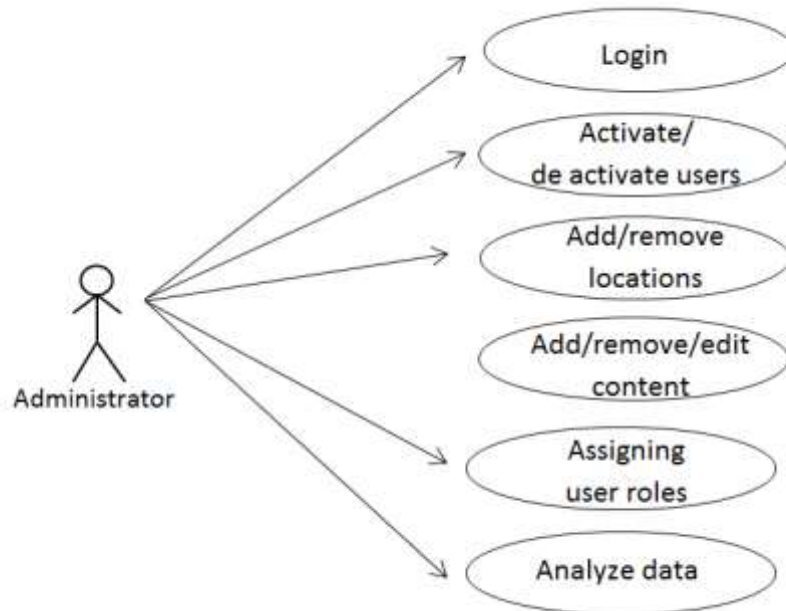


Figure 8: Use case diagram displaying administrator and roles

Use case descriptions for the administrative users were shown below.

Use case 1: Activate and deactivate users.

Primary actor: Administrator.

Pre-condition: User must be login to the system.

User must have administrative powers.

Main scenario:

Check whether the user has registered to the system correctly.

If details are correct provide the authorization to the user to access the system.

Alternate scenario: none.

Use case 2: Add locations.

Primary actor: Administrator.

Pre-condition: User must be login to the system.

User must have administrative powers.

Main scenario:

Identify a new location

Create relevant audio, image, video and other relevant materials.

Link those materials to the new location

Alternate scenario: none.

Use case 3: Data analysis.

Primary actor: Administrator.

Pre-condition: User must be login to the system.

User must have administrative powers.

Main scenario:

Open the data base and collect data

Statistical analysis.

Generate reports

Alternate scenario: none.

3.2.3 Activity diagram

Activity diagram to access the system and to access media were shown in the figures 9 and 10 respectively.

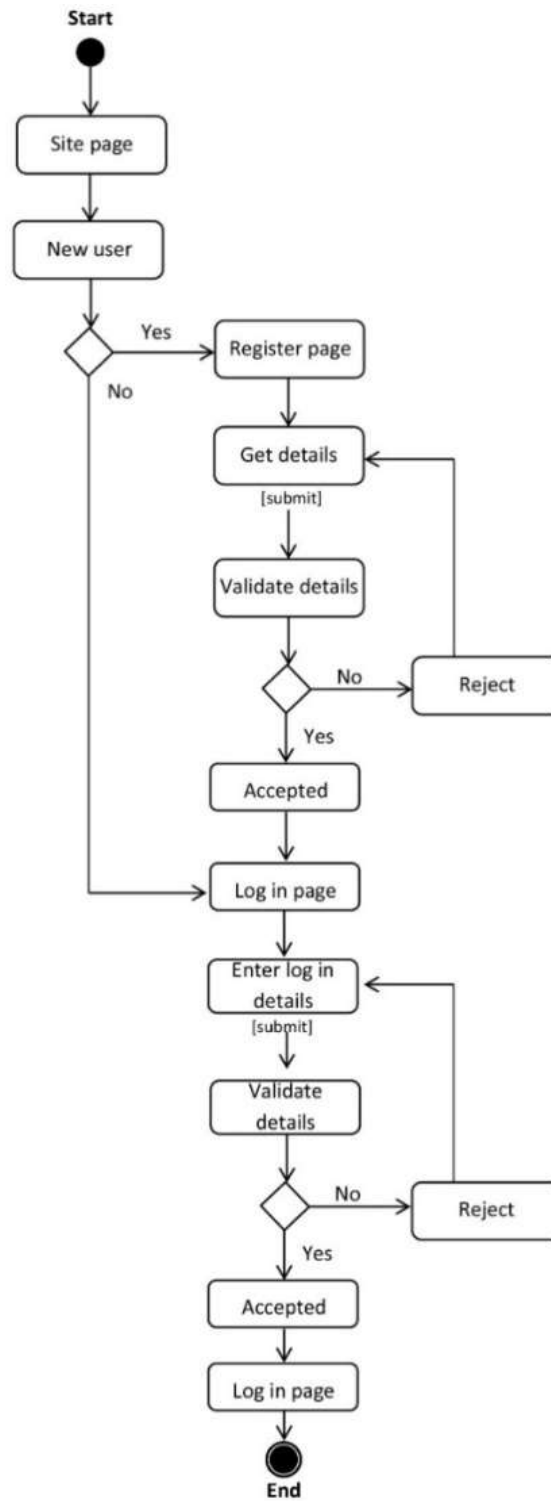


Figure 9: Activity diagram for the user login

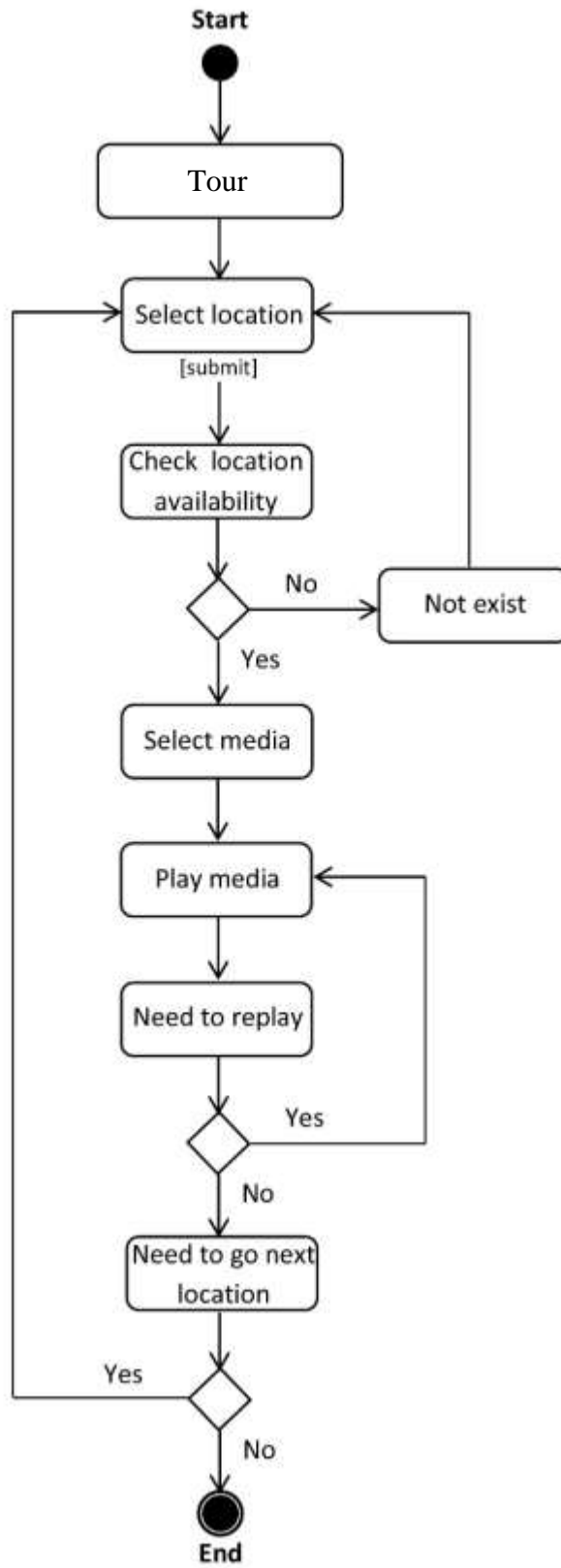


Figure 10: Activity diagram for accessing media

3.2.4 Class diagram for the application

Class diagram for the application was shown in the figure 11 below.

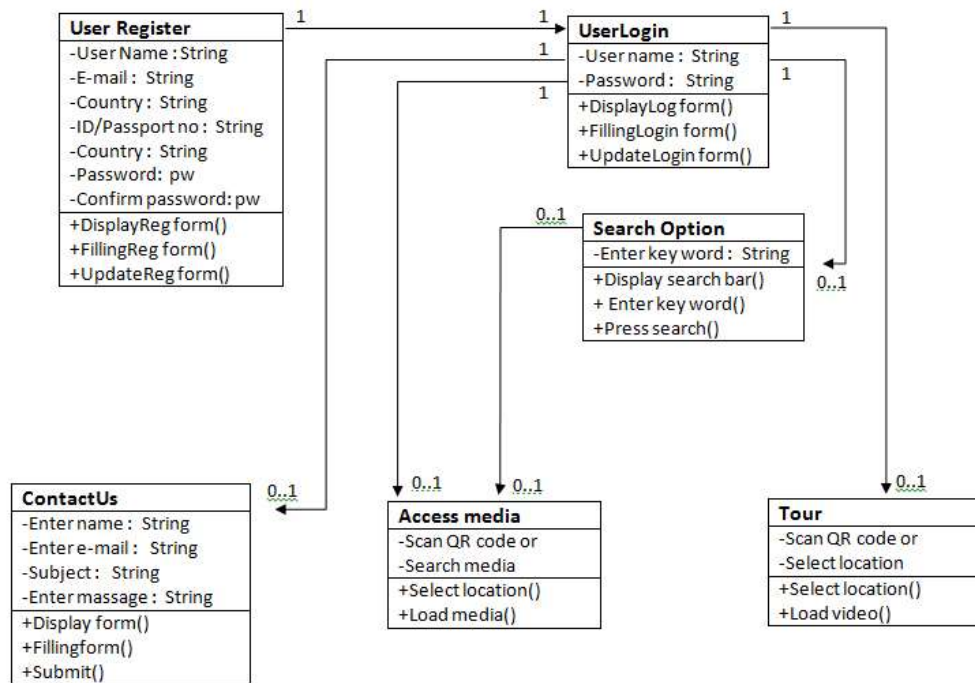


Figure 11: Class diagram for the application

3.4.5 Site navigation

Navigational options and pathways for the system were shown in the figure 12.

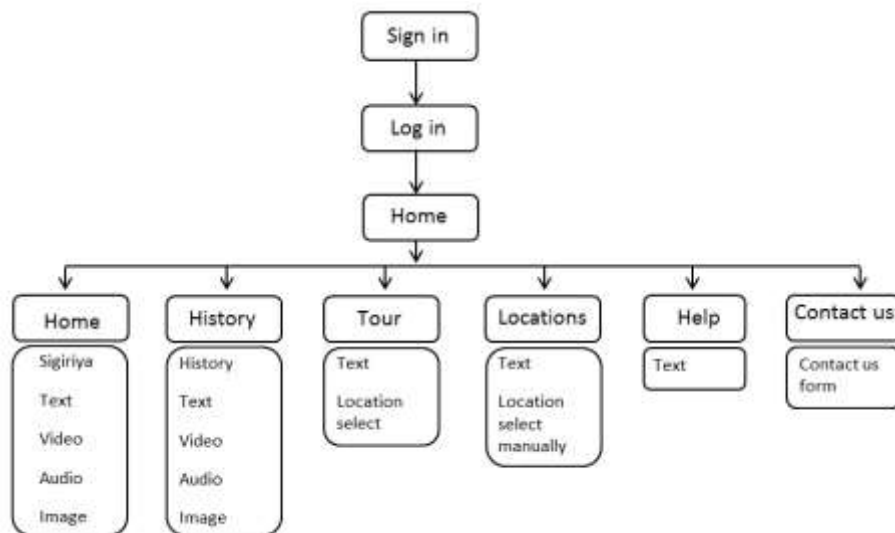


Figure 12: Diagrammatic view of navigational structure

3.4.6 System architecture

How the application communicates among clients, web service and database layers were shown in the figure 13 below.

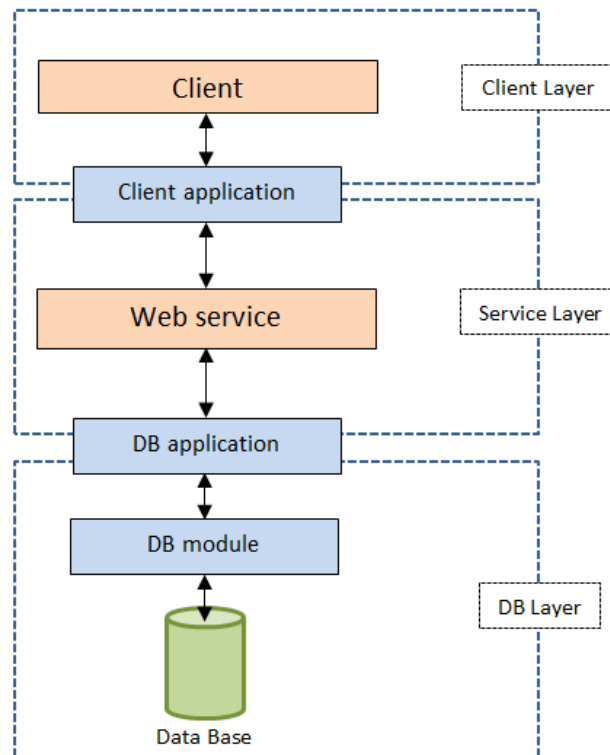


Figure 13: Layout of a system architecture

3.3 Development Methodology

3.3.1 Historical data collection

Most of the details such as picture material and descriptions for this reconstruction was obtained from the Department of Archaeology, Central Cultural Fund and from Sigiriya museum. Field visits were made to obtain ground and aerial photographs, interview archaeologists, determine layer structures, evaluate neighboring areas and to study geography. Site maps and plans, architectural drawings of important locations of Sigiriya were obtained from the library of the Department of Archaeology [26, 27, 28]. Some of the important figures were shown below (Figures 14 and 15).



Figure 14: Full site plan of Sigiriya [27]

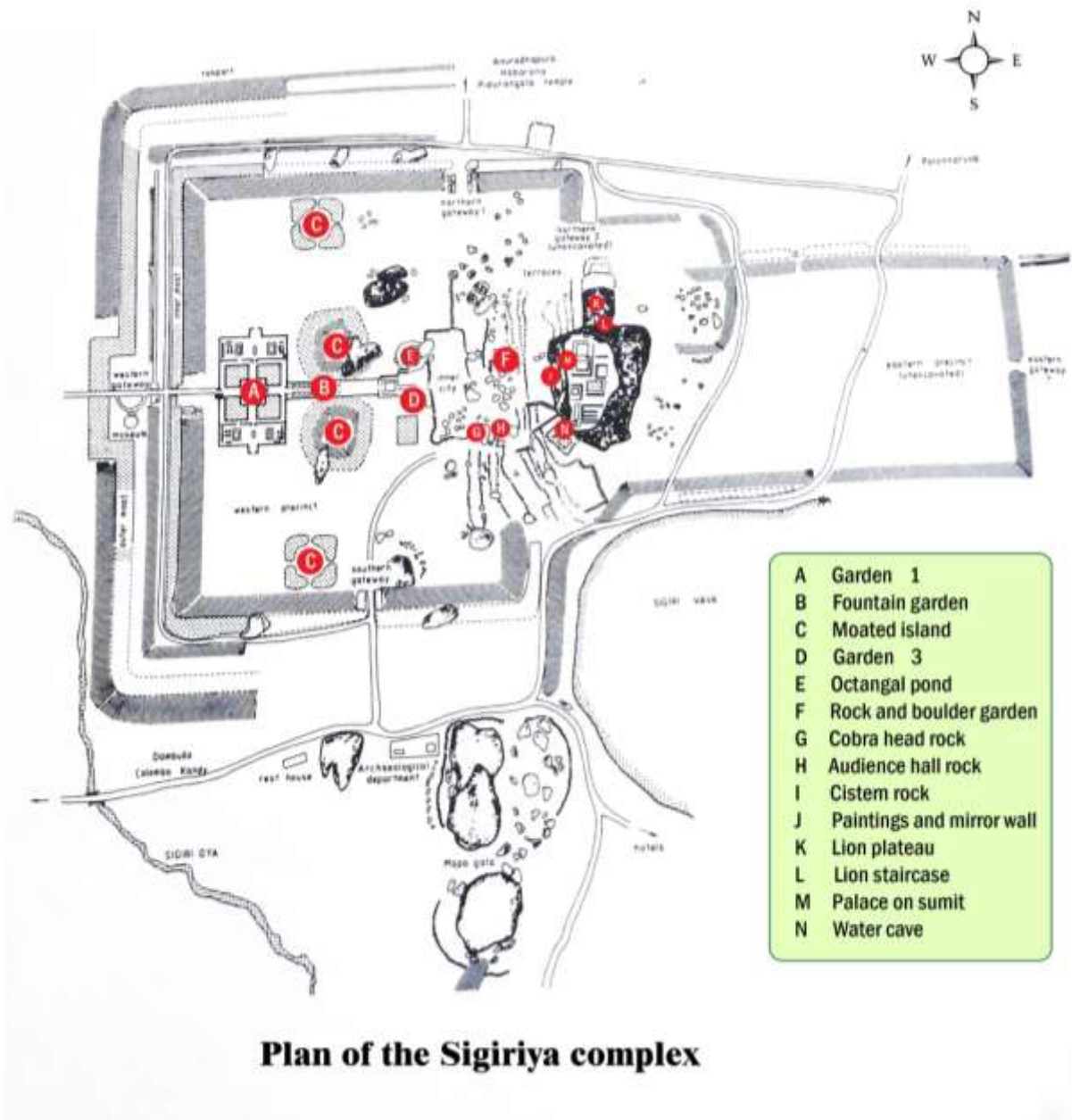


Figure 15: Identified main locations of Sigiriya [modified from 27]

Measurements of the interested locations were obtained from archaeological literature and during the site visits. Using these measurements, some of the important sites indicated in the Figure 7 were recreated for the application. Contents of the application were created using the information gathered from historical literature and interviews made with officers and archaeologists of the Central Cultural Fund.

3.3.2 Planning

Based on the findings of the requirement analysis, software shown in the table 1 were used in this project.

Table 1: List of software used for each task

Task	Software
1. Creating 3D objects and rendering	3D Studio Max ver. 2014 (64 bit)
2. Image processing and creating maps	Adobe Photoshop CS6
3. Video editing and composing	Adobe premier CS6
4. Visual effects and composing	Adobe After Effect
5. Color grading of videos	Darvinci Resolve
6. Sound editing	Adobe Audition
7. Creating application	Word press
8. Web coding	HTML ver. 5
9. Creating responsive display	Bootstrap
10. Data base handling	MySQL
11. To run all the above software	Microsoft windows 7 or above

For the application development, Intel core i5, 3.0 GHz processor, 8 GB RAM and 2 GB VGA were used. It was identified that for the smooth functioning of the application, Core 2duo 1 GHz or higher processor, 2GB RAM or higher, 1GB VGA or higher and 2 GB hard disk space, rear camera of the mobile device, QR code scanning software are required.

3.3.3 Storyboarding

A sketch of the story board for the application was shown below in Figure 16.

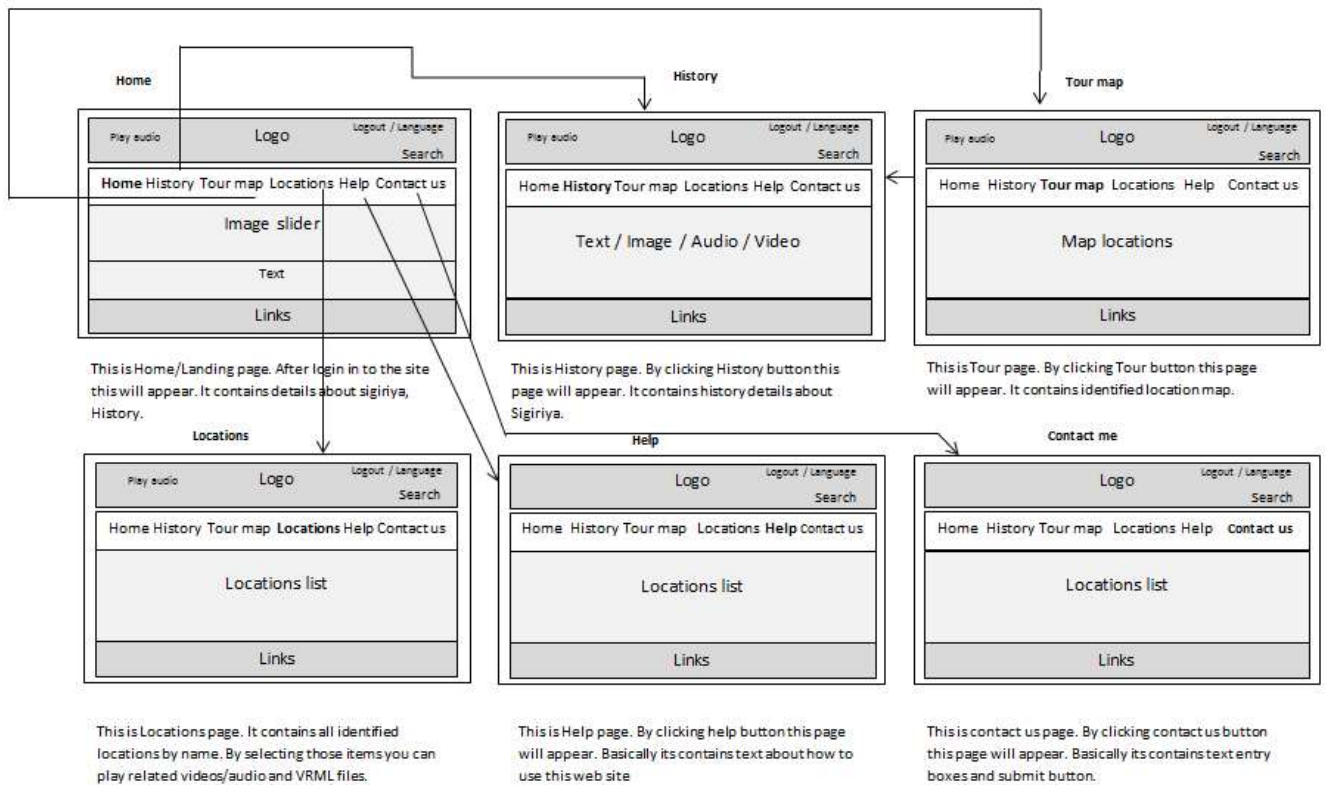


Figure 16: Story board for the application

3.3.4 Content production

Videos, audios, imagers and text were used as the contents of the application.

Video:

Based on the plans and maps obtained from the department of archaeology, 3D models of some of the previously identified locations were created. These locations included the garden (A), fountain garden (B), lion plateau (K) and lion staircase (L) as shown in the above figure 15.

Software used and the properties of the 3D animation were shown in the Table 2 below. Screen shots taken while modeling were shown below in the figure 17.

Table 2:Property, software and the specifications of the animation.

Property	Software/Specification
Software	3D Studio Max
Animation/image size	1280x720 pixels
Frame rate	25 fps
Output format	Taga 32 bit

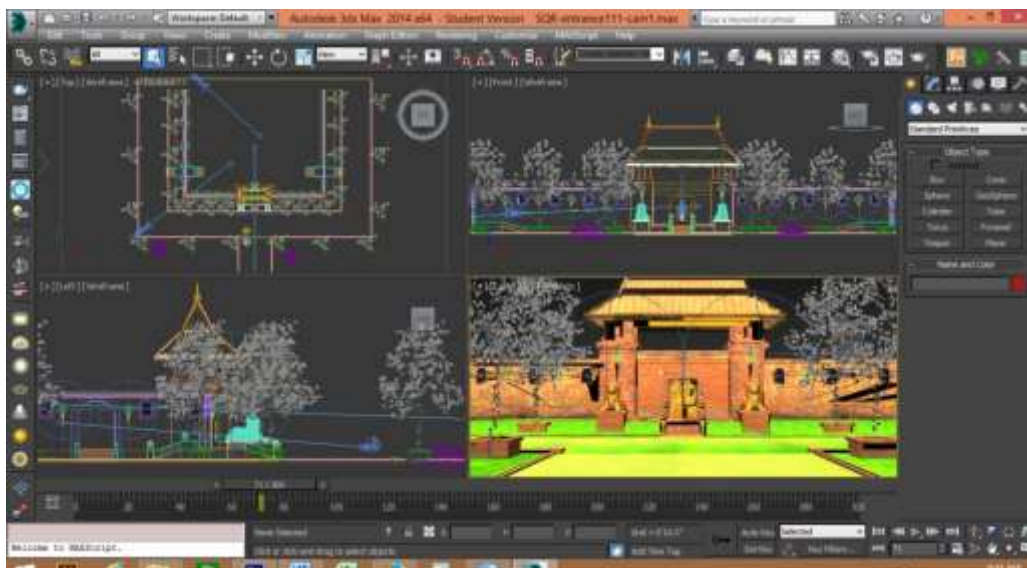
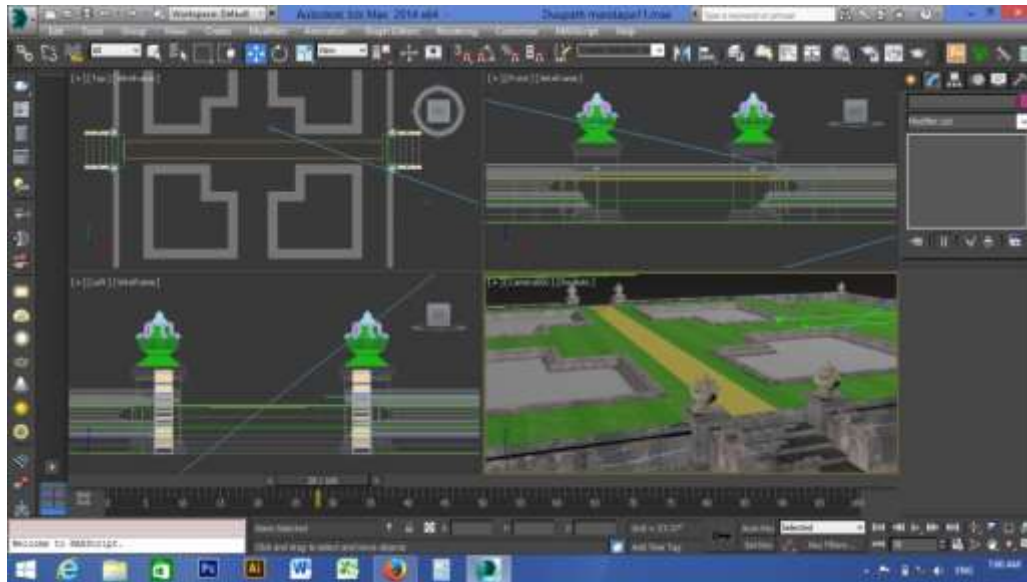


Figure 17:Creation of 3D models using 3D StudioMax

For the final video production, following properties, software and specifications were used as shown in the Table 3.

Table 3: Properties software and the specifications of the final video.

Property	Software/Specification
Software	Adobe premier CS6
Video size	1280x720 pixels
Frame rate	25 fps
Output format	MP4

Visual effects and color grading were done by using Adobe After Effect and Darvinci Resolve respectively to generate an ancient appearance.

Audio:

Music that enhance ancient heritage and proud was used with the following specifications shown in the Table 4. Narrations were recorded at a personal studio.

Table 4: Properties, software and the specifications of the audio

Property	Software/Specification
Software	Adobe Audition
Bit rate	44KHz
Output format	MP3

Image: Images taken while collecting historical data and site visits and newly created imagers were used. To generate ancient beauty, to resize image size, to change colors Adobe Photoshop was used. Table 4 shows the image properties.

Table 5: Image properties

Property	Software/Specification
Image format	JPEG
Resolution	300 dpi
Color depth	24 bits
Color format	RGB

VRML content production:

Sketchfab was used to publish 3D models in VRML format. Settings were customized based on the requirement.

Website development:

The content management system (CMS), WordPress, was used in the website development. Page builder by site origin, Press apps login and access, Site origin widget bundle, Slider revolution, Tinny MCE advance, WP Google map and WP visual composer were used as plugins to customize content and the website.

Chapter 4

4. Implementation and Evaluation

4.1. Implementation

The system was developed using structured multimedia development model and waterfall model. Therefore, benefits of both systems; structured approach and prototype model, were able to implement. Screen shot of the home page of the software was shown below in the Figure 18.

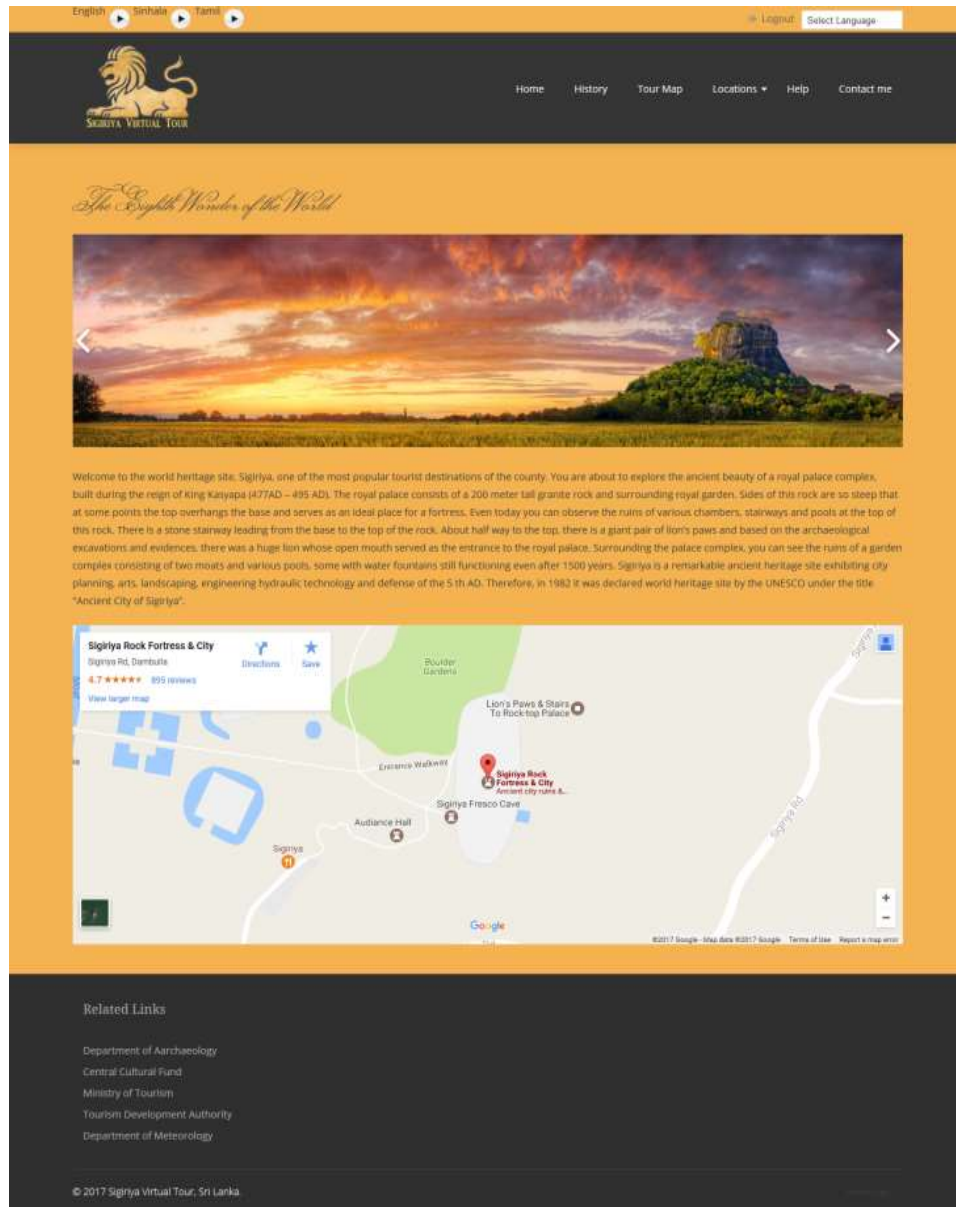


Figure 18: Home page of the application

Core functionalities:

Register: User should register to the application by providing his personal details at the registration page as shown below (Figure 19).

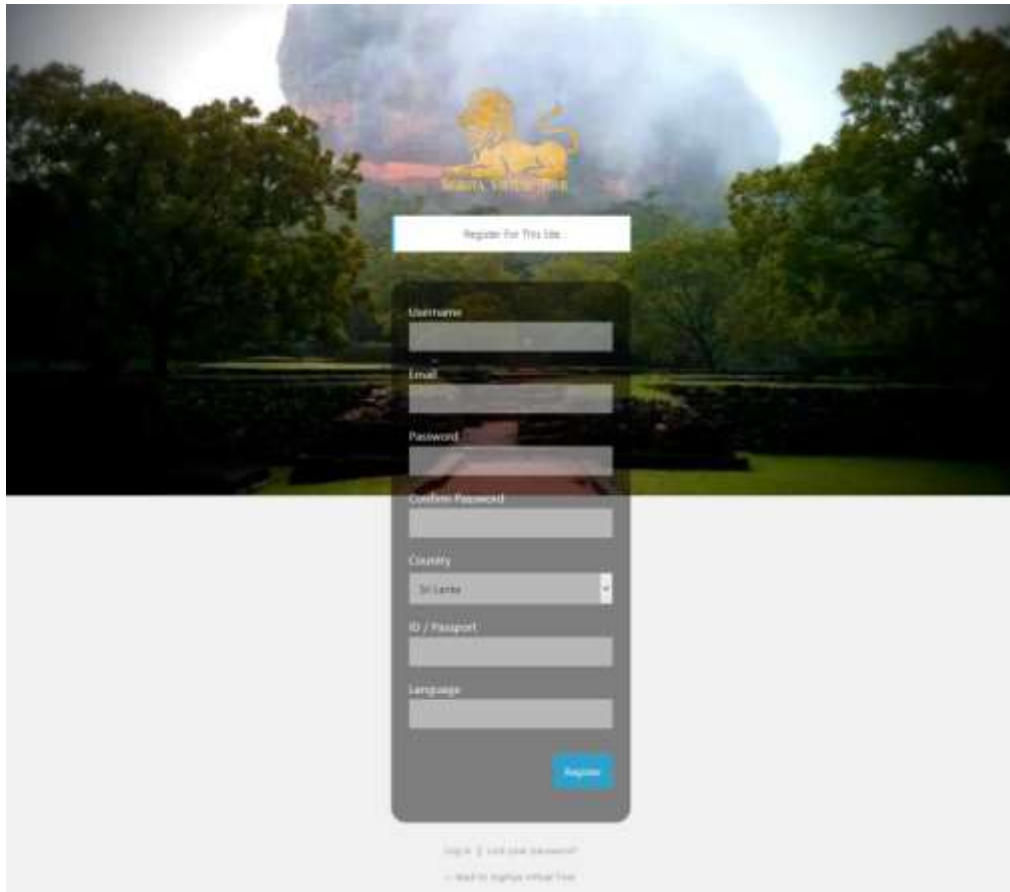


Figure 19: Registration page for the application

Login: User should login to the application using user name and password. Login page was shown below in the figure 20.

Contact us:

For a user to send feedback, contact us page was designed as shown in the figure 21



Figure 20: Login page of the application

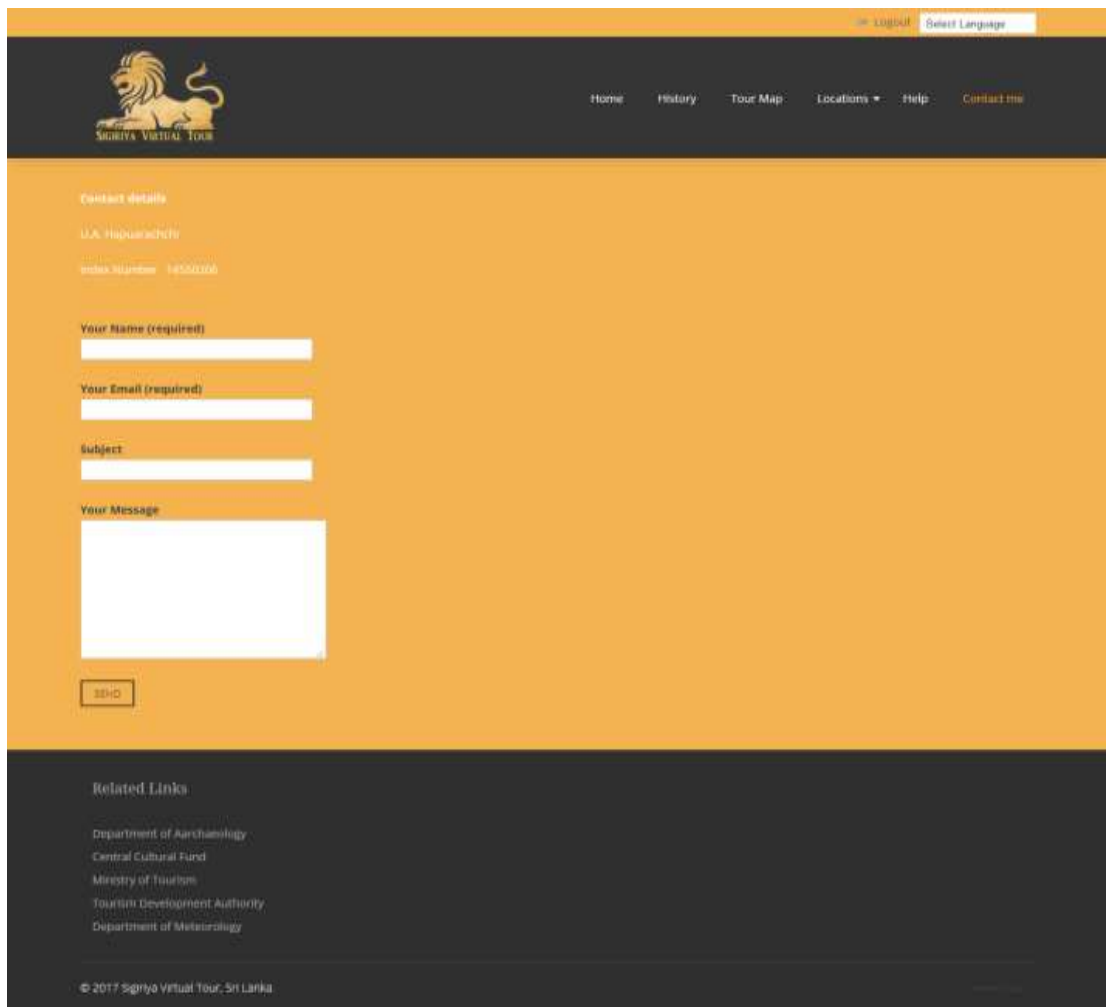


Figure 21: Contact us page for the application

Virtual tour:

When the user selects virtual tour option, following map will be shown (Figure 22). Selection of the desired location on a map can be done through QR code scanning, obtaining GPS coordination or using key words. Once the desired location is selected, user has three options to choose; videos, imagers or audios.

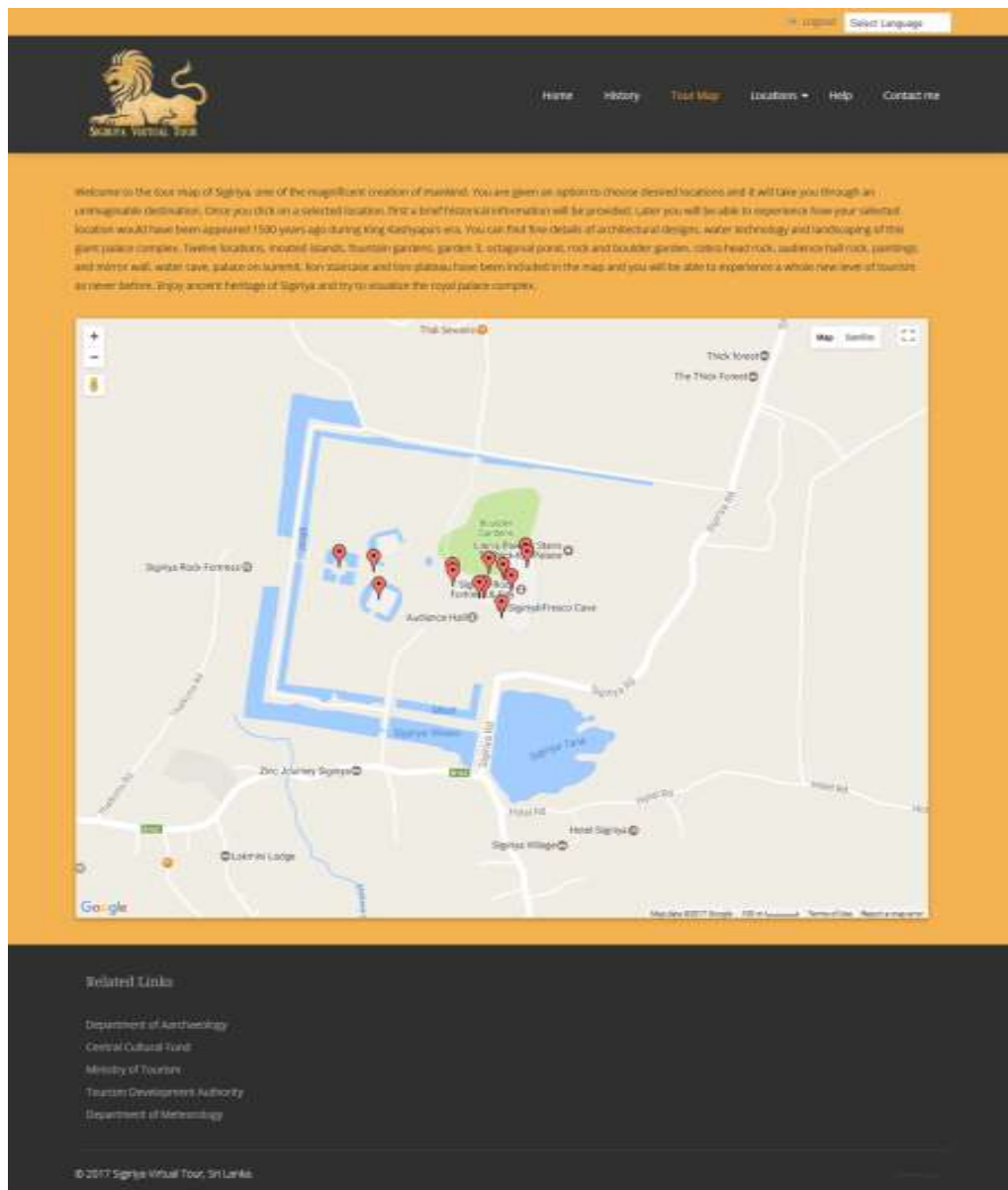


Figure 22: Map showing points of interest of Sigiriya in this application

Panoramic view will give user to play 3D images in as 360 angle.

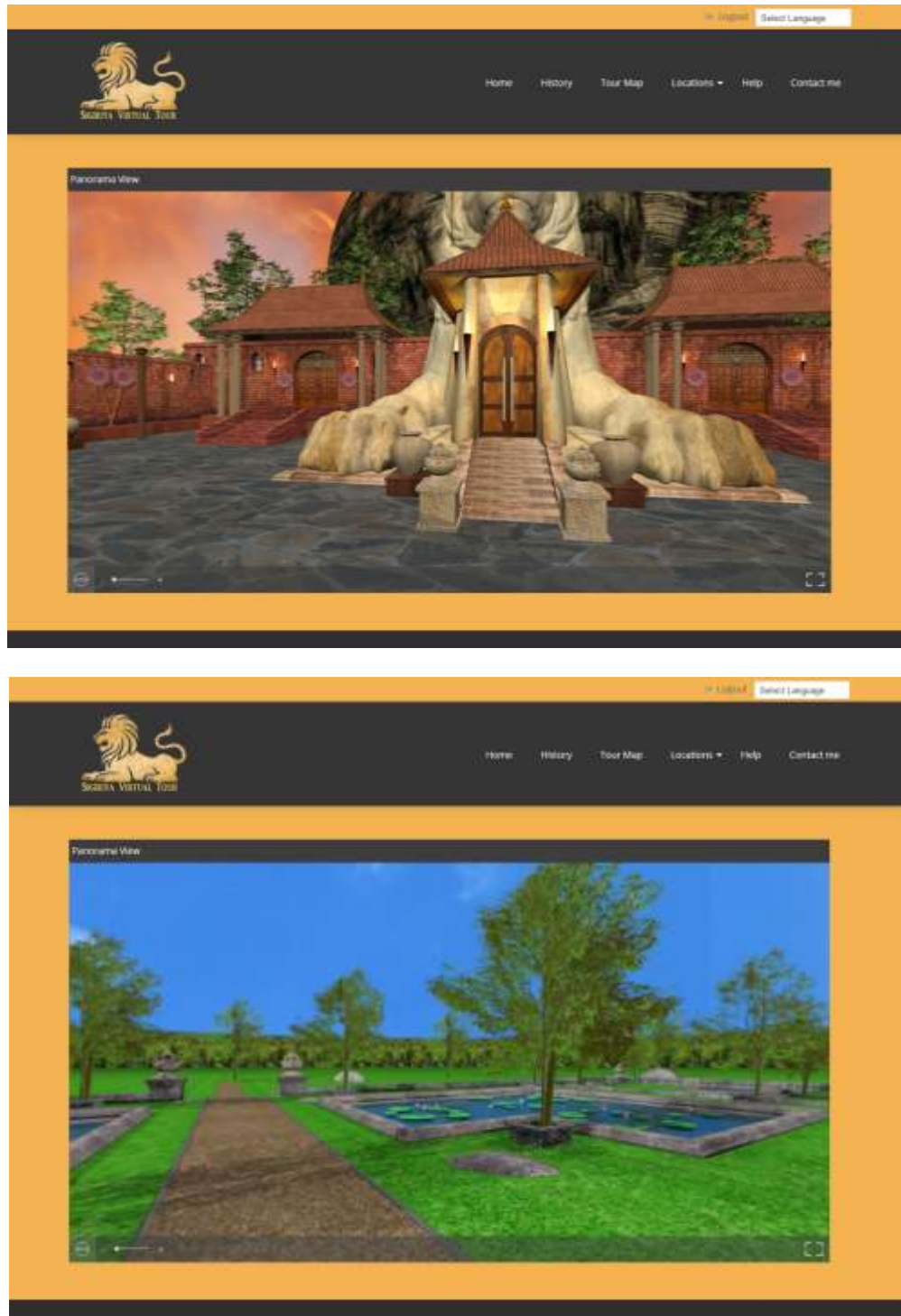


Figure 23: Embedded 3D image to panoramic player

3D Recreation:

For a selected locations 3D recreations were created. Current views and recreated views were compared below (Figure 24).



Figure 24: Current views and recreated views of selected locations

4.2 Evaluation

Evaluation of the system was done in order to make sure that the application meets the client's requirements. System testing as well as user acceptance was tested. Lessons learned and problem encountered during the project was identified.

4.3 Testing

Alpha and beta testing done by my university friends and they gave me valuable feedback within short period .

Questionnaire was developed using SurveyMonkey application [29] as shown in the figure below (Figure 24)

1. How visually appealing is our website with color combination ?

- Extremely appealing
- Very appealing
- Somewhat appealing
- Not so appealing
- Not at all appealing

2. Does the website appear easy to navigate?

- Extremely easy
- Very easy
- Somewhat easy
- Not so easy
- Not at all easy

3. How satisfied are you with the look and feel of this website?

- Extremely satisfied
- Very satisfied
- Somewhat satisfied
- Not so satisfied
- Not at all satisfied

4. How visually appealing is our website?

- Extremely appealing
- Very appealing
- Somewhat appealing
- Not so appealing
- Not at all appealing

5. Are icons that are used to assist navigation (e.g. back to the homepage, exit) clear and intelligible?

- Extremely appealing
- Very appealing
- Somewhat appealing
- Not so appealing
- Not at all appealing

6. Included videos, pictures are they (a) relevant, (b) an aid to understanding?

- Extremely appealing
- Very appealing
- Somewhat appealing
- Not so appealing
- Not at all appealing

7. Included video sequences, are they of an adequate quality?

- Extremely appealing
- Very appealing
- Somewhat appealing
- Not so appealing
- Not at all appealing

8. Included sound recordings, are they of an adequate quality?

- Extremely appealing
- Very appealing
- Somewhat appealing
- Not so appealing
- Not at all appealing

9. Website offer anything extra that cannot be done in more traditional ways ?

- Extremely appealing
- Very appealing
- Somewhat appealing
- Not so appealing
- Not at all appealing

10. Is the user interface easy to understand? (For example, is the screen layout clear and easy to interpret?)

- Extremely appealing
- Very appealing
- Somewhat appealing
- Not so appealing
- Not at all appealing

Figure 25: Questionnaire developed for the application

Twelve test cases were identified as shown below.

Table 6: Identified test cases

Requirement No	Functional Requirement	Criticality
1	As a new user I want register to web site	High
2	As a user I want login to the system to access all the functions	High
3	Every data point entered will be authenticated by the system	High
4	As a user I want play video from the content media	High
5	As a user I want play audio from the content media	High
6	As a user I want play VRML from the content media	High
7	As a user I want to search interested items within web site.	Medium
8	As a user I want to send feedback	Medium
9	As a system administrator I want to activate or deactivate user accounts	High
10	As a system administrator I want to add content to the system	High
11	As a system administrator I want to edit content in the system	Medium
12	As a system administrator I want to get statistical analysis and viewing logs of the system	Medium

Performance of the application was evaluated by providing the following test cases.

Table 7: Test cases used for evaluation

		User feed back (0 to 5)
Test Case ID	01	
Title	Register to the web site	
Pre-Condition	Launch the web application	
Test Steps	1. Click on sign in link	
	2. Enter details in relevant field	
	3. Press submit button	
Expected Results	Register user to the system	

		User feed back (0 to 5)
Test Case ID	02	
Title	Login to the web site	
Pre-Condition	1. Launch the web application	
	2. Registered user	
Test Steps	1. Enter user name	
	2. Enter password	
Expected Results	Login to the system	

		User feed back (0 to 5)
Test Case ID	03	
Title	Authenticate sign up details	
Pre-Condition	1. Launch the web application	
	2. Open sign up page	
Test Steps	1. Enter user name (char only)	
	2. Enter e-mail (should contain @)	
	3. Enter country (char only)	
	4. Enter ID/passport no (num/char only)	
	5. Enter date of birth (date)	
	6. Enter user name (num/char only)	
	7. Enter password (any character)	
	8. Re-enter password (match with	

	password)	
	9. Click on submit	
Expected Results	Login to the system	
		User feed back (0 to 5)
Test Case ID	04	
Title	Play video	
Pre-Condition	1. Launch the web application	
	2. Registered user	
	3. Login to the system	
Test Steps	1. Open the tour page or location page	
	2. Select video	
	3. Play video	
Expected Results	Play video smoothly	

		User feed back (0 to 5)
Test Case ID	05	
Title	Play audio	
Pre-Condition	4. Launch the web application	
	5. Registered user	
	6. Login to the system	
Test Steps	4. Open the tour page or location page	
	5. Select audio	
	6. Play audio	
Expected Results	Play audio smoothly	

		User feed back (0 to 5)
Test Case ID	06	
Title	Play VRML	
Pre-Condition	1. Launch the web application	
	2. Registered user	
	3. Login to the system	
Test Steps	1. Open the tour page or location page	
	2. Select VRML	
	3. Play VRLM	
Expected Results	Play VRML smoothly	
		User feed back (0 to 5)
Test Case ID	07	
Title	Search	
Pre-Condition	1. Launch the web application	
	2. Registered user	
	3. Login to the system	
Test Steps	1. Select search option	
	2. Enter desired word and search	
Expected Results	If match search word with content show it	

		User feed back (0 to 5)
Test Case ID	08	
Title	Send feedback	
Pre-Condition	1. Launch the web application	
Test Steps	1. Select contact us page	
	2. Enter the message	
	3. Submit	
Expected Results	Message should recorded in data base	

		User feed back (0 to 5)
Test Case ID	09	
Title	Send feedback	
Pre-Condition	2. Launch the web application	
	3. Registered user	
	4. Login to the system	
Test Steps	4. Select contact us page	
	5. Enter the message	
	6. Submit	
Expected Results	Message should be recorded in data base	

		User feed back (0 to 5)
Test Case ID	10	
Title	Activate/de activate users	
Pre-Condition	1. Launch the web application	
	2. Login as admin user	
Test Steps	1. Get entered data	
	2. Authenticate entered data	
	3. If valid registered as user	
Expected Results	Create new user account	

		User feed back (0 to 5)
Test Case ID	11	
Title	Add content to the system	
Pre-Condition	1. Launch the web application	
	2. Login as admin user	
Test Steps	1. Select location to add content	
	2. Add content	
	3. Save changes	
Expected Results	Should appear newly added content in web	

		User feed back (0 to 5)
Test Case ID	12	
Title	Get reports	
Pre-Condition	1. Launch the web application	
	2. Login as admin user	
Test Steps	1. Open the data base	
	2. Select required data for report	
	3. Create report	
Expected Results	System will create report	

4.4 Lesson learned during the project

This project provided different learning opportunities. Some of them were stated below.

To use google maps, navigations, markers and their limitations for the online web application,

To create, incorporate VRML models to an online web application,

It was later realized that such an application would be more effective if used as a mobile application(Android version) instead of a web application with rapidly developing technologies.

I learned important of project plan and how to plan project within limited time period.

Chapter 5

5.1 Conclusion and future work

Sigiriya is one of the main tourist attractions among other ancient heritage sites in Sri Lanka and has remnants of glorious ancient cities, water parks, recreational sites, temples, hospitals, castles and many more. Each year it attracts many local and foreign visitors. From the preliminary discussions held with relevant officials and visitors, a requirement of a virtual tour guide was recognized. It was found that majority of foreign tourists have no idea of the scale of beauty and ancient glory of this eighth wonder of Sri Lanka. With the huge potential of today's tourist industry Sri Lankan Cultural Fund hopes that in future tourists will come to the country just to see this Lion Rock mountain or "Sigiriya" similarly that they would go to visit other places like Great wall in China and Pyramids in Egypt. In achieving such a target, technology should merge effectively with the ancient history and make it popularize in the world. In achieving such a long term goal, the proposed application was developed specially targeting the foreign visitors.

The application will help locating the current location of the tourist visiting Sigiriya and will open up more options and locations to view. Logged users can experience every aspect of the app whereas the unlogged users can interact with the app to a certain extent. Once the location is found, the visitor can find nearby locations, distances, time taken to reach and detailed descriptions of each site. This will give the visitor an option to choose, ignore or add to favorite list. This application will let the visitor/tourist stand at a specific location to experience most memorable and important moments and events that had occurred in a particular location via VR videos. All the sites and locations in Sigiriya were not selected since this was only done as a concept development project. Therefore, at this stage of the system, the application is not having full details and historical views for the visitor to enjoy. Devise limitations such as screen resolution, signal strength and memory would hinder the full functionality of the software.

Several future developments were recognized as described below. At the moment it does not have the facility to recognize the locations via GPS. Therefore, in future developments, the mobile app can be synchronized with this web application to smart detection of the locations of the visitor. Depending on the feedback received during the evaluation, the application will be further improved. It can also be further improved to collect details of visitors, most visited locations,

their favorite routes and time spend in each location, which can be useful in future statistical analysis and promotional activities of the tourist industry.

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