



User-Friendly Mobile Application to Analyse Archaeological Ruins in Anuradhapura Era

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ABSTRACT

Anuradhapura city in Sri Lanka has several well-preserved Archeological ruins. The lack of a proper mechanism to obtain reliable and accurate information about those archeological ruins is the most significant hurdle that visitors may confront when visiting and analyzing archeological sites. This mobile application may address that problem. Archeological ruins such as stupas, irrigation technology, and carvings are richly illustrated with images. As a result, when touring ancient ruins, visitors may want to quickly identify unknown ruins and learn more about them. There is currently no appropriate technique for resolving this issue. So as a solution for this case, the image detection component of Lak heritage android application detects images of ancient ruins and generates related information by using close features of the ruins. Also, as mentioned earlier, when visiting archeological sites for various reasons, sometimes visitors may need to clarify information without having images and may choose to obtain knowledge through communication rather than reading a large number of irrelevant articles. The Lak heritage user assistance chatbot has developed to fully fill above requirements as an interactive chatbot may answer user questions and facilitate user contact 24 hours a day, seven days a week. So on inscriptions, notes that had used to make people aware of something in the past, those notes were written on stones. There is no automated way for recognizing, analyzing, and translating inscriptions. The inscription reader component of Lak heritage Android application has provided that facility. Also, when it comes to irrigation systems, those systems did not have the technological strategies that exist today in the world; the technology that was used to develop the irrigation system, as well as the construction techniques used in the construction of stupas, are still unimaginable. Therefore, many archeological scientists are analyzing and studying that technology and attempting to impart that technological knowledge to the present. This application provides a detailed overview of ancient irrigation engineering and the technology used in the construction of stupas using 3D technology which may help to study the ancient technologies. Taking into account the aforementioned factors, we have created a more inventive and user-friendly Android application especially for university students, explorers and archaeologists who analyze archeological sites in Anuradhapura era. The Android application will be developed using deep learning, image processing, and augmented reality.

Introduction

In situations such as traveling, analysing the Anuradhapura era for educational purposes, touring with children for educational purposes, and so on, visitors are required to read a large number of unrelated articles to clarify such a minor point in some situations. As this is an obvious waste of time, it is preferable to provide accurate, effective, and efficient information in various ways when the visitor requires it.

Sometimes visitors may want to identify unknown archeological ruins that found suddenly. In such cases, visitors may prefer to identify those ruins instantly and get more details about the ruin quickly as it may make it easier to analyse those archeological places. From Lak heritage Image detection section, we have addressed that issue and provide the facility to users to identify any unknown archeological ruin instantly.

There is no any efficient way to find information in a short period of time without going through unnecessary articles. Sometimes the search engines may be useful but it is also unable to generate accurate information to most of the questions and mainly the search engine returns paragraph-style results. Both the archeological and tourism businesses have suffered as a result. The User assistance chatbot's main goal is to deliver the most relevant information about archeological sites based on the user's questions using Natural Language to aid comprehension. So instead of using search engines, the user can ask a certain question in the chatbot and receive an accurate and effective answer—no particular knowledge is required to use a chatbot. As a result, the User assistance chatbot can be used by any kind of person who has a different level of knowledge.

The ancient Sri Lankans used stone surfaces to scribble important information. "Inscriptions" refers to all ancient documents inscribed on stone surfaces. Inscriptions in Sri Lanka are divided into four categories: cave, rock, slab, and pillar inscriptions. These inscriptions are important because they are the most reliable sources of knowledge about ancient Sri Lanka. These inscriptions also provide useful information on the inscription's period, place, and situation, as well as the evolution of languages across centuries [4]. The content of these inscriptions will be extremely useful in researching ancient Sri Lankan history. Currently, the content of each of these inscriptions is painstakingly translated into modern Sinhala by an archaeology professional with

specialized knowledge of the old scripts [4]. The main goal of the application's inscriptions detection component is to recognize individual letters in these inscriptions and convert their meanings into English using a proper spelling recognition technique so that visitors can read and understand them.

The irrigation system in Sri Lanka's dry zone, particularly during the Anuradhapura era, is the world's oldest historically documented irrigation system. Anuradhapura has a network of man-made tanks, known locally as Wewa, that are used to store, transfer, and use water for paddy farming [4]. Channels and spillways connect the small, medium, and large tanks, allowing water to flow close to the cascade and irrigate nearby agricultural areas. In comparison to modern approaches, some of the technologies employed to create these irrigation systems and numerous types of Buddhist stupas are unimaginably advanced. Analysing those procedures will allow to impart the historical technology in order to produce modern irrigation and construction systems for further improvement. Visitors will be able to learn and analyse further about irrigation systems and Buddhist stupas in the Anuradhapura era thanks to the 3D overview component of Lak heritage application.

Our prime aim of this research is to provide a platform to find accurate and effective information about the Anuradhapura period efficiently for studying and analysing purposes.

This research paper consist of 8 main sections. So as we have already discussed 3 of them earlier The next section in this research paper is Literature Review. That will provide background information of this research. such as overview information and range of same kind of component in related researches. Then the Methodology section in this research paper will provide information such as techniques that used for the development of the Lak heritage application, how has those techniques contributed to the process and the main implementing process. as there are four main component in this app. all the information of those four sections will be describe separately After the methodology section Results section will provide information about final view of the app, progress comparison with the initial requirement and may describe the accuracy of the final results. especially will provide information of the flow of the process of each component. Then in next section of Conclusion and Discussion will describe about the difficulties and the inconvenience that developing team had to face by developing this application. also the limitations and barriers that were there. and what kind of techniques and methods that used for overcome them. then finally will discuss about the way that can develop each of these component further. means a brief explanation of future plan to enhance this application in future. The next section is dedicated to acknowledge all the things and persons that have helped to develop this app by fulfilling all requirement details and techniques. Final section of this research paper, The Reference Section will Provide a list of all the information of sources that information has taken from.

2. Literature Review

Currently there is no proper system for the purposes of Lak heritage Android application. but when analysing researches that have similar kind of components there were few components that had similar characteristics. so analysing them to find strengths and weaknesses has helped to develop this application with better user friendly manner.

Ranun Gorai discussed how images and photos are defined in our daily lives, and he demonstrated three methods for sharpening edges, reducing noise, and removing motion blur from images[1]. Jangala Sasi Kiranet al. proposed an approach to improve the overall accuracy of the handwritten character in the pattern recognition field by using image processing techniques such as feature extraction and image enhancement [2]. Thamotharan et al. advocated that digital photos be processed using a variety of methods, including emphasized noise and edge detection algorithms. He also contrasted and compared two other radiographic image filtering concepts, such as mean and median filtering [3]. According to Shafiqua T.pathan and colleagues, this study focuses on security-based systems that leverage modern digital image processing, as well as a method for processing films from a variety of video devices. The features were retrieved using SUSAN after the continuous frames from the videos were set. Dipen Saini spoke about data clustering in the context of object clustering. A specific technique is used to detect groups from an image using distance measurements and linear features [5]. According to Mostafa Bayati Ed al, the important contribution of this research is plant phenotyping research or the automation of research in picture collecting to reduce data at geo-referencing errors, modular data visualizations, and fastest data gathering [6].

Railbot is a telegram-based chatbot that lets users get train information by typing in the train's id [10]. This chatbot function is focused on the Indian railway system. This chatbot is utilized in the railway API to receive train information when a train PNR id is entered, and the chatbot returns train data and delay time [10]. This chatbot can only provide information about trains that have a PNR number and is only available to Telegram subscribers. RailwayBot is a chatbot research project focused on railways. This chatbot gives useful railway information such as seat availability, ticket purchase, and cancellation [11]. For Facebook Messenger, this is a chatbot. Users will be able to use this system in conjunction with Facebook as a result of this. When a user asks a question, the chatbot will respond with a link to help them address the problem. Providing detailed information rather than a link is preferable. It's a fantastic concept for a chatbot [12]. Flow.ai is a chatbot that can assist us in locating our current location. The chatbot locates the nearest store location when we tell it where we are [12]. The focus of the study is mostly on the service-providing firm. Customers can use a chatbot to find the nearest branch of the organization. This chatbot is mostly for WhatsApp or Facebook Messenger. The chatbot will detect the user's location and send them to the nearest store if they type in the address or share their location with it.

Creating the correct alphabet of the original Brahmi script from the photographic data of ancient Sri Lankan inscriptions. In this research paper, they have prepared the alphabet for Brahmi scripts. They created this alphabet by analysing the original Brahmi scripts in Sri Lanka and tried to suggest a systematic solution. The sample image was digitized using an image scanner and saved in JPG format [3]. Pattern recognition, image processing, and mathematics are used to develop a novel method for determining the author of an ancient inscription. The proposed method entails a) matching all realizations of an alphabet symbol on two inscriptions pairwise. This matching is done to account for systematic differences in the size, orientation, and position of the various letters in the documents; b) a new criterion for quantifying the goodness of fit is given; c) the statistical distribution of quantities associated with this criterion is estimated; and d) novel statistical criteria for determining whether two inscriptions were written by the same person have been developed. The method has been applied to 32 Classical and Hellenistic inscriptions, which have been completely classified into nine writers [5].

Because the language has evolved with distinct character sets, epigraphers face a difficult problem in recognizing old Tamil characters. This project's main goal is to employ OCR and NLP techniques to recognize distinct Tamil scripts from the 9th to 12th century. Using threshold values, the colour images were converted to a gray image and a binary image throughout the segmentation phase. To identify the specific character, picture attributes such as the amount of lines, curves, loops, and dots were retrieved using Scale Invariant Feature Transform (SIFT) techniques from segmented images. The Support Vector Machine (SVM) classifier will be used to classify and create characters based on the extracted vectors. The character's patterns will be compared to those of other characters and predictions will be made. The corresponding Unicode value will be assigned to each recognized character. It will be updated in the image corpus to improve character recognition and make the system more successful at identifying characters. As a result, the suggested method is capable of resolving the major issues with interpreting inscription images [7].

This section creating a 3D program that can recognize antique tank technologies and stupas. The AR modulator is the focus here. This has a 3D animation feature. While technology improvements have made it possible for users to build and interact with items in 3D virtual space, little has been done to improve or increase engagement with the viewpoint. When we begin to think about this topic, we notice that it effectively covers a large problem area with a variety of unique scenarios. It covers a wide range of topics, including being inside vs. outside an object, how close the viewpoint is to the object, what the user is looking at and interested in, egocentric vs. exocentric thinking, parallel vs. perspective viewing projections, multiscale and level-of-detail issues, what kind of data is being examined (abstract, incomplete, photoreal, engineering, CAD, entertainment, medical, simulation, and so on), and what is being examined (abstract (authoring, inspecting, etc.) [1].

One of the tools used is Sygic, a 3D GPS navigation software. It's a car navigation system for mobile phones. For a variety of mobile devices, Sygic produces voice-guided GPS navigation with turn-by-turn directions. Sygic collaborates with the world's leading PND and phone manufacturers to bring cutting-edge innovations to market. Sygic maps, on the other hand, are only available in a few locations and languages. In addition, I can't see the actual view. Navigon is a different GPS navigation method. Navigon delivers a realistic map display when it is required. There are no audible or visual red-light camera warnings, though. The GPS reception and POI quality in Navigon are the worst [2].

3. Methodology

This Lak heritage Android application consist of four main components. so each component have implemented by using different methods and techniques.

A. Archaeological Ruins Detection And Find proper information

It's a method for manipulating images, obtaining enhanced images, and extracting important data from them. It's a type of signal processing in which a picture serves as the input and the output is either an image or the image's distinguishing features: the creation of images, Enhancement, Restoration.

Synthesis is the process of creating new images from an existing dataset. The term "unconditional generation" refers to the process of producing samples from a dataset without regard for their condition. In computer vision, picture production has been extensively studied, with one of the main research challenges being to generate images from arbitrarily complicated distributions with minimum supervision.

Enhancement: Image enhancement is highlighting certain information in an image while weakening or deleting any unneeded information to meet specific objectives, such as reducing noise, revealing fuzzy details, and altering levels to highlight specific features of an image.

Restoration: From a corrupted/noisy image, this approach estimates the clean, original image. Corruption can be seen in the form of motion blur, noise, and camera misfocus.

B. User-Friendly User Assistance Find Information About Archaeological ruins.

Users will use this component to connect with the User Assistance chatbot to ask and clarify questions concerning the Anuradhapura era. Users can ask any questions they want in Natural Language, and User Assistance will provide them with reliable replies. Natural Language Processing (NLP) techniques and Deep Learning algorithms were employed to develop user support.

There were three significant stages in the evolution of user assistance: Train the model, Create training data , and then load it.

To begin, I spoke with a few final-year Archaeological students to have a better understanding of the areas we should include in this system. Then we gathered facts and data from Wikipedia and historical websites, as well as archaeological publications produced by a variety of archaeologists. We discovered information such as the locations of archaeological ruins, their essential differences comparing to the same type of ruins in other kingdoms (if any exist), information about the creators and their purpose, and so on.

Following the gathering of data and information, a prototype Q&A template for archaeological site information was created. A JSON file with sample questions and their solutions. was created when the prior stage was completed. In this file, there was a lot of intent. Every intent has tags, question templates, and response templates. After generating the JSON file, I used NLP techniques to pre-process the data. Some of the NLP methodologies used for data pre-processing include tokenization [6], stemming [7], and bag of words [8].

Finally, the trained model should load to receive the output for the inputs that user entered. User inputs were sent via the Feed-Forward network in this process, and the percentage of inputs that matched each purpose was analysed. If the intent matches more than 75% of the user inputs, the model returns a response with related information.

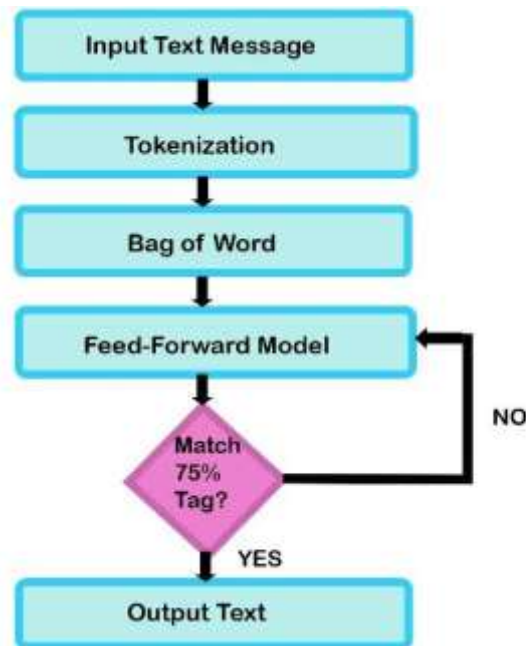


Figure 1: User Assistance Chatbot diagram

C. Detect and Read Inscriptions.

The Brahmi script identification system is a smartphone application aimed mostly at ancient history students. The strategies and mechanisms for recognizing the ancient Brahmi script are described in this section. Project implementation, materials and data to be used, data obtained, and realistic needs for meeting project objectives are all covered in the explanation. It also includes a list of the study topics we've identified

Image Scanning and Noise Removing

We must first take a video of the rock surface, which will then be uploaded by the user. The image is saved in the database once it is posted. The machine will next scan the video frames one by one. It needs to be a clear video of the rock surface. To scan the image, we employ several image processing techniques. After that, the scanned image is saved in the database. The sample characters are then separated from the scanned image.

The following step is to remove the image's sounds. The image's primary flaw is the noise, which obscures the original image's fundamental elements. The presence of noise can degrade the system's performance. Scratches, fissures, voids, and other sounds are frequently heard on stone surfaces [1].

To reduce the noise, we first extract data from the database, then apply image processing methods/filters such as central processing filters, Wiener filters, and other similar techniques. Broken or deleted characters may cause images in inscriptions to be removed. In the inscriptions, there is an unneeded space between the lines and the letters. The Wiener filter is a Gaussian noise removal tool found in inscriptions [1], while the Median Filter is a technology used to reduce "salt and pepper" noise.

The sample letters are then separated from the scanned and noise-removed image.

Identify the Broken or Erased Parts of The Brahmi Letters

The majority of the time, this function is used to recognize Brahmi letters. Some of the lettering on the stone's surface may have been obliterated, while others may have fractured due to a variety of factors. This work compares the broken letters to the letters of the word to identify the broken parts of the letters by analysing the patterns of previously identified letters.

Images from a database with roughly 1000 Brahmi characters that were discovered specifically for damaged letters are essential.

The Department of Archaeology of Sri Lanka provided sample data on Brahmi inscriptions. Many photos of distinct Brahmi alphabet letters can be found in the database (about 1000 images for each Brahmi letter). For each Brahmi letter, around 1000 photos are developed for format training and approximately 200 images are designed to be formatted and tested for processing in its data folders. It analyses the previously identified letters to find the actual letter. To detect Brahmi characters, we use a variety of algorithms, with the optimal approach chosen based on output accuracy.

Identify the Letters Features

The goal of this activity is to determine the characteristics of the letters. The same pattern may be seen in some of the letters in the inscriptions. The main goal of this work is to find those patterns and analyse and distinguish between them. To determine the letter shape, we study sample letters from that time period and generate them using algorithms based on their correctness

Processing and Translating

We are primarily concerned with processing and translation in this project. We'll convert Brahmi characters to English letters during the editing and translation process. The other main goal is to combine previously identified letters to find the correct English word.

We then use the Brahmi script to create a coherent English statement. To accomplish so, we'll need to use high-precision machine learning to design or alter algorithms. The final product will be in the form of a text file. The provided text file can be translated into another language if the user desires.

A. 3D Overview Based on Augmented Reality

Topology in 3D. In contrast to placement, virtual object visualization does not necessitate any details other than the exact shape and alignment of the actual items. Because the virtual object is "blended" with the real environment, a tangible object will almost certainly appear between the virtual object and the user. The real object is an occlude of the virtual object in this scenario. The obscured areas of the virtual item should not be visible to the user.

The system is built around previously gathered data. The system's first design phase is architectural design, followed by interface design using integrated modelling.

- **Texturing**

- **Unwrapping**

This entails unfolding a three-dimensional mesh. When the texture artists receive the finished models from the 3D modelling department, they will produce a UV map for each 3D object. UVs are, in fact, two-dimensional representations of three-dimensional models. By directly linking a 2D image (texture) to vertices on a polygon, UV mapping can help wrap a 2D image (texture) around a 3D object. The finished map will be utilized for texturing and shading. [30]

- **Texture painting and shading**

The general appearance of an object, as well as its interaction with light, are critical to its realism and attractiveness. This encapsulates the general goal of the texturing and shading processes, which work in tandem.

- **Texture mapping**

"Text mapping" is defined as "a way of defining high-frequency features, surface texture, or colour information in a computer-generated image or 3D model," according to Wikipedia. We intend to employ this strategy in the development of our software as well. The default colour for final 3D models is flat grey. Adding colours to a 3D model, as well as surface and material qualities, necessitates another step in the 3D animation pipeline: 3D texturing. In the rendering step of the 3D animation, textured models will be used.

- **Rendering**

Following the modelling phase, the 3D artist begins work on bringing the scene to life. "The easiest approach to understand 3D is to compare 3D objects to real-world items," Rubye says. A consultation and a vision are the first steps in the 3D rendering process. After that, there's analysis and design, which serves as the foundation for modelling. After that, 3D rendering and refinement operations take place. The render is given once it has been approved [8].

4. Results

The Android Application was designed with the goal of making it as user-friendly as possible. Machine Learning and Deep Learning concepts are used to improve user-friendliness in that system. Android Studio, Java, and Python were used to construct the system.

A. Archaeological Ruins Detection and Find Proper Information

With the advent of fast and cheap machines, digital image processing has become a very highly demanded field of study and practice. It provides solutions to various real-life applications in an economical way.

Using image processing techniques, can sharpen the images, contrast to make a graphic display more useful for display, reduce the amount of memory requirement for storing image in for motion, etc.

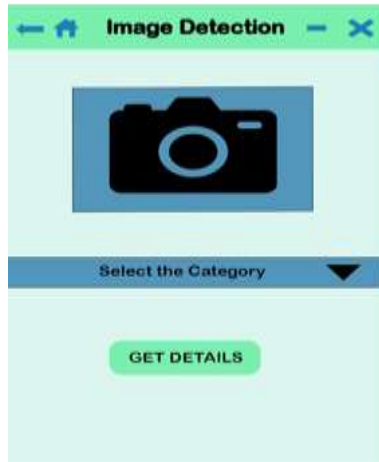


Figure 2:Image Detection Component Side 1



Figure3:Image Detection Component Side 2

B. User-Friendly User Assistance Chatbot To Find Information About Archeological Ruins.

Users can ask whatever inquiry they want about the Anuradhapura era's archeological ruins. The system will then load the model to select the most appropriate question based on the user's input. The model responded with related information if the user's input matched more than 75% of the sample questions (Figure 6).

Because Sri Lanka has a more than 2500-year history, there are numerous archeological sites around the country. However, as a first step, also considering the limited resources with covid protocol we have just developed this Android app for the Anuradhapura era. so this app will cover all the information regarding Anuradhapura archeological ruins. In the future, I hope to expand this by adding information on more important places and cities in Sri Lanka. And also will be able to add Tour plan facility based on the users most prefer areas according to the user's input. so the Lak heritage user assistance chatbot might generate a tour plan by asking few questions after the conversation. so as that develop this further.,

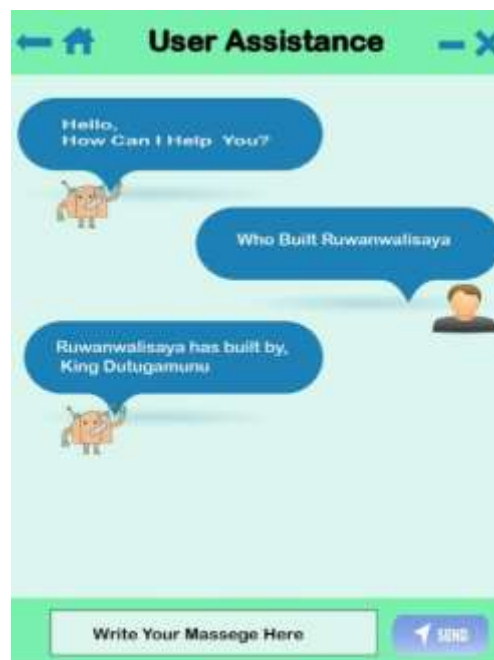


Figure 4:User Assistance Chatbot Component

C. Detect and Read Inscriptions.

This study introduces an automated system for inscription image processing, analysis of ancient Brahmi script, inscription recognition, and translation. It removes noise, recognizes character properties, and locates letters that have been broken or erased. Finally, the inscription's letters are translated into English. As a result, I was able to develop the best pre-trained models for classifying and identifying difficult-to-identify inscriptions.

The inscription reading technology will be enhanced in the future to provide a more precise result, and the data set's data capacity will be increased. Other existing pre-training algorithms are also being used to schedule training. The method is then tweaked to fit all times by including sample data from previous inscription periods (transitional, medieval Sinhala period, modern Sinhala time period). Currently, only an Android application is being built; however, this program will be produced for iOS and Windows platforms in the future.

TABLE 1: Results Of Pre-Trained Based Models of Inscription Datasets.

Pre-trained model	Accuracy	Loss
MobileNet	86.00%	1.3594288839942607
VGG16	74.00%	0.7748644793852365
VGG19	77.00%	1.3158677473068258
InceptionV3	73.00%	1.1445882079029459

Table 2 : Results Of Pre-Trained Based Models of Inscription letters.



Figure 5: Inscription Reading Component side1

D. 3D Overview Based on Augmented Reality

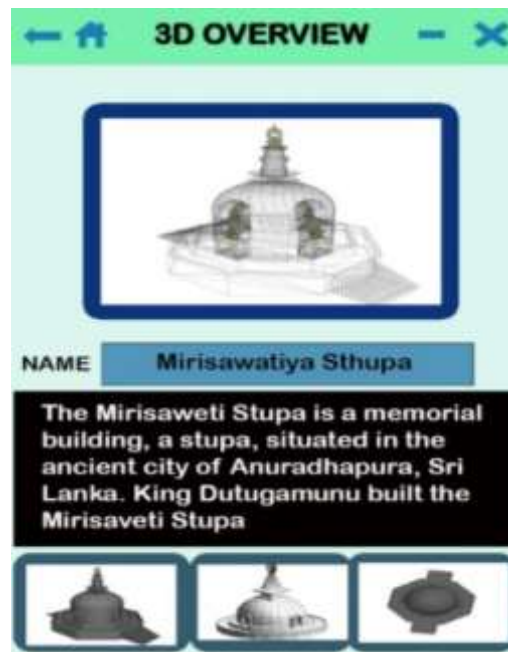


Figure 6: 3D Overview Based on Augmented Reality Component

Anyone, whether in the tourism industry or not, will be able to watch the order in which they pray at Adamantane if you utilize this mobile app in the future. As a result, this software will be updated in the future to allow you to view a map of your current location utilizing GPS technology. Furthermore, touching an old site allows you to see its past nature or how it was developed. The animation program was updated to make 3d images as a result of a difficulty with this creation, and the animation became a problem [1].

5. Conclusion and Discussion

There were various limitations in creating this application. During the collecting data and taking photographs, there was not any opportunity to go to Anuradhapura with the covid protocols. With the lockdown situation, also the former archaeology professor that we were planned to appoint as the external Supervisor had to went abroad suddenly. Therefor we could not be able to contact him much as we need. As a result, we encountered a number of problems in creating the database. But met the requirements by using alternatives. Finally, under 4 functions, this application has been created by doing research on the Archaeological ruins, irrigation technology, stupa buildings, inscriptions and carvings of the Anuradhapura period and finding the exact historical data of them.

using this application Anyone who visit Anuradhapura can find information to solve any problem especially when visit alone. Introducing this application to the tourists in the tourism industry will enable them to use the application to obtain information about archaeological ruins in effective way, spreading accurate information about ruins among people of their native countries when they returning to their home countries will help to boost the tourism industry in the country as well as the inflow of foreign investment.

In the end, the project was successful as pre expected. But this application can be further developed by providing information about the ancient antiquities of the kingdoms of Polonnaruwa, Dambadeniya, Kurunegala, Kotte and Kandy etc. and also supporting to the different languages, so that even a users who don't know English also can get reliable and effective information about archaeological ruins through this application.

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