Augmented Reality Application for Cultural and Historical Tourist Attraction Display (ARCH-TOUR)

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***Abstract*—ARCH-TOUR is a mobile application arching over tourist places by providing context-aware information drawn from Internet sites, such as the Wikipedia and WikiTravel via Augmented Reality technology. In this paper, the design process together with the technology and the test environment is presented. The application has been used to show the famous Buddhist temple Wat Phra Sri Rattana Mahathat, Phitsanulok, which exhibits one of the most beautiful Buddha images of Thailand. Augmented Reality technology leads to enhanced interaction with places of interest by visitors. Using audio and visual help to encourage visitors to get a deeper understanding of places of interest for tourists. Studies of visitors' behaviors using ARCH-TOUR show favorable results and will lead to improved versions of the application in the near future.**

***Index Terms*—Augmented Reality; Multimedia Application; Tourism Information; Information Management; Virtual Display, 3D.**

I. INTRODUCTION

Tourism is an industry that is vital to economic development in Thailand. Continuous publicity and promotion of tourism has been carried out, especially with the help of presentations. Presentation of attractions is an important factor which captures tourists' attention. There are other attractive promotions that come in various forms, such as the presentation of the media, travel guides and tourism websites. A large number of websites consisting details of tourist spots offer informational presentation in the forms of texts and pictures, in which a potential tourist needs technology supports to retrieve the tourism information. Various technologies are embedded in the presentations such as pictures, video, animation, 2-D and 3-D to make the presentations interesting so that they can attract travelers to the country. However, these presentations still lack of advanced technology that can attract potential tourists to be familiar with the places before visiting.

Augmented Reality (AR) is an emerging technology that blends the real world with the digital (virtual) world. It can display the image of a 3D object projected over the actual surface via cameras or webcams. AR is a suitable technology that can complement the presentation of tourist attractions to make it interesting. In addition, it allows tourists to really know the places which they plan to visit.

Augmented Reality technology has been applied to the global environment by Rekimoto and Nagao [1]. The objective is to create a real environment that users can recognize the situation they are facing by detecting the color of the bar codes on objects in the real environment. Users are able to see the real environment through this device and can get information and interaction with the actual environment. The prototype system called Navi Cam (NAVIgationCAMera) relies on detecting the color to be able to recognize the environmental situation. Vallino and Brown [2] conducted a research in virtual reality exposure called Haptics in Augmented Reality. This research allows users to be able to exert action with created virtual objects. It also built a strong feedback (Haptic Input) to the user, allowing users to feel the surface of the created virtual objects and the force with the virtual world, such as flowing water or land areas. In addition, users are able to move or lift a created virtual object.

Nowadays, many cities and regions offer AR applications that work like digital guides and draw information from such Internet sites as the Wikipedia and WikiTravel. An overview of the use of Augmented Reality on smartphones for tourism has been given by Yovcheva, Buhalis and Gatzidis [3]. One of their main complains about the current AR applications is that the displays will soon get cluttered and overloaded as more and more information is allowed to be displayed.

One of the main target locations for AR enhanced presentations is the group of World Heritage sites. Fino et al. [4] have designed an interactive tourist guide for San Cristobal de la Laguna that brings together Web 2.0, QR codes and AR. Tourists are guided by an interactive map of the city with augmented graphics, but without audio information. In-picture display of QR codes related to important buildings in the city lead interested visitors to the location via map routing. Keil et al. [5] used a 3D recognition approach to AR on a current generation smartphone. Resource intensive tasks are outsourced to the cloud, and the 3D recognition of buildings works even under difficult outdoor conditions. Snapshots superimposed by AR component allow users to view and read information in a relaxed position without the need of holding the smartphone towards the object of interest all the time.

Some studies have evaluated the relative advantage of destinations with AR services over destinations without these services. Haugstvedt and Krogstie [6] have applied the well-known Technology Acceptance Model (TAM) to study the acceptance of users (tourists) for augmented reality applications in tourism. They found that organizations can

benefit from providing applications that are both useful and fun.

Thus, we have applied AR technology to develop an application for tourist attraction displaying historical tourism in Thailand. Indeed, there is no existing work for presenting historical tourist information using AR technology in Thailand. Normally, tourist information is provided via Web sites and mobile applications including pictures, Google Maps, multimedia or information searching. The AR applications can enhance the attractiveness of tourist destinations, which constitutes a change in inheritance presenting the sights in a new fashion. Some cultural and historical places can even be made more interesting, which in turn will motivate visitors to study the background of tourist places even more and get an in-depth understanding.

II. Methodology

The application of AR technology to present the sights can be divided into two main principles.

A. 3D Architectural Design

3D modeling [7] is the process of applying geometrical software to show the surface area of three-dimensional objects either animated or not. 3D models can display a two-dimensional image through a process called 3D rendering or be used in a computer simulation of physical phenomena. Models may be created automatically or manually. 3D is similar to plastic arts, such as sculpting the 3D model to display the object in three dimensions using a collection of points in 3D, Welding with geometric shapes, such as triangles, lines, curved surfaces, and other sets of data.

In this research, we used the following tools to design 3D model of attractions.

- Autodesk 3ds-Max [8] is a program used to design and build three-dimensional model, which was developed by Autodesk Inc. The effect of 3D-Max is an easy to use and designed a more realistic model which can also control the movement of the model. This program is commonly used in applications such as video games, commercials, movies and so on.
- Autodesk Maya [9] is a program used to create photo-realistic visualization and natural effect simulation. Maya is a program with high physical flexibility, high performance and ease of use.
- Google Sketchup8 [10] is a software used in designing the 3-D Model which is a freeware program and can create a drawing or image quickly and easily.

B. Augmented Reality

Augmented Reality (AR) is a technology that blends the world of reality and virtual reality together via software and connected devices such as webcams or other device related to the virtual reality display screen through the computer screen or other display devices. The processes of AR technology consists of two main processes as follows:

1. Image Analysis or Marker Detection is a marker detecting process by using images to be searched from the marker database with the size and layout of the marker data to analyze patterns of the marker. In this process, necessary information of the marker such as the size of the marker (in centimeters) and the format of the marker are stored in database. Typically, the form of a marker is black and must be a square with a black border and white background.

2. Visual Tracking:
   - Pose Estimation is a process of determining the three-dimensional position (3D Pose) of the marker compared with the video camera, which is shown in the matrix size 4x4 to identify the relationship between the camera coordinated frame and marker coordinated frame. The camera coordinated frame is coordinated frame of reference to any video camera and marker coordinated frame is used to refer to any marker.
   - 3D Rendering is a process of creating a two-dimensional image from three dimensional models modeled to describe the object or the environment. In this research, we selected 3D rendering technique using the scene graph.

BuildAR program [11] is a connection program between the marker code and models to display the virtual model. The program is easy to use and suitable for AR application.

III. System Implementation

In this research, we have chosen Wat Phra Sri Rattana Mahathat with its rich cultural and historical attractions representing a famous archaeological site in the province of Phitsanulok, Thailand. The content and the history of the temple is presented in an audio format. A pattern of ancient temple within Wat Phra Sri Rattana Mahathat and a map has been created with a three-dimensional model and can be presented using ARCH-TOUR. The work process can be divided into five steps as follows:

1. The collection of data regarding Wat Phra Sri Rattana Mahathat consists of the history of the temple and temple architecture and style within the temple. The information of the temple was collected from documents such as books, flyers, photographs and some Information on the Internet (Figure 1).

Figure 1: Wat Phra Si Rattana Mahathat and a Buddha

2. The design of Wat Phra Sri Rattana Mahathat in 3D format is shown in Figure 2 and 3.

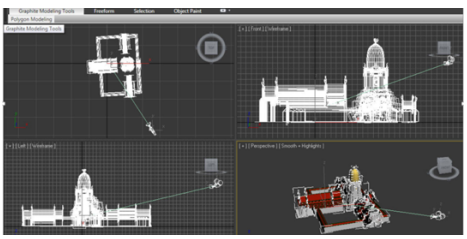

Figure 2: Constructing 3D Models using 3ds Max

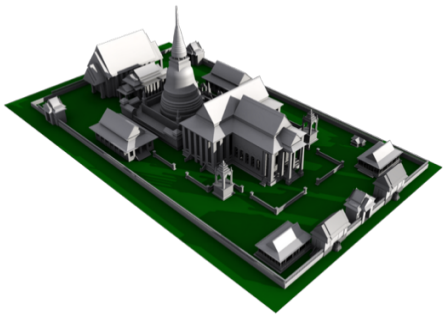

Figure 3: Examples of 3D models of historic Wat Phra Si Rattana Mahathat

3. The construct of modeling and tools to be connected with AR technology can be divided into four-step process as follows:
   - Construct 3D Modeling of temple architecture with Maya and 3Ds-Max program.
   - Prepare a video presentation of Wat Phra Sri Rattana Mahathat with Adobe Premiere Pro.
   - Convert video files to into MP4 file format and connect with AR.
   - Design and create marker with Photoshop cs4 and buildAR Pro.

4. Design tools and methods for presenting information via AR which can be described as follows.
   - Adopt the AR technology to connect with created 3D models (Figure 4).
   - Present tourist attractions in 3D virtual reality using AR (Figure 5).
   - Add Narration Animation and sound presentation.

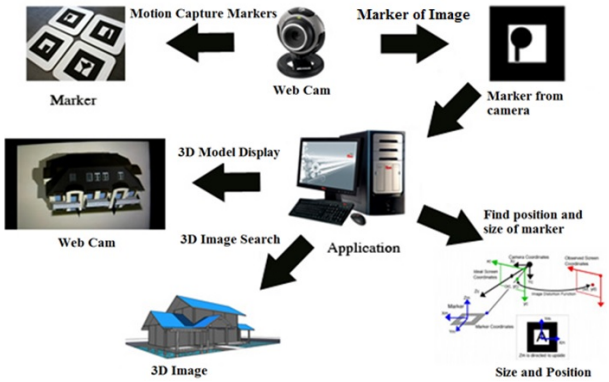

Figure 4: The application of Augmented Reality in connection with the model 3D

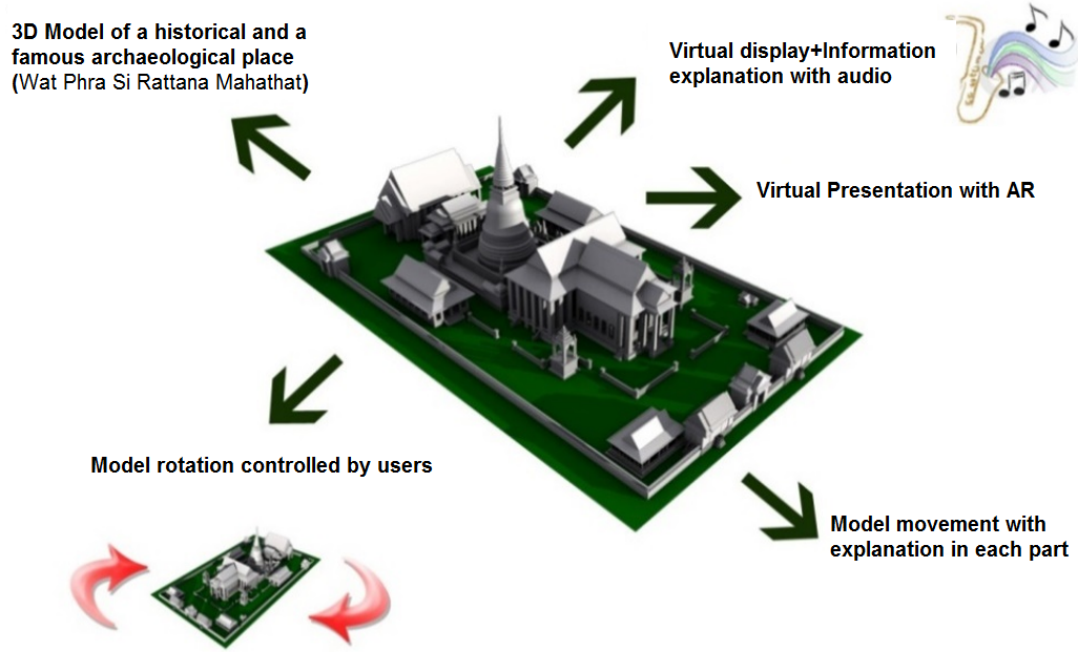

Figure 5: Tourist attractions in 3D presentation with AR

5. Design a travel guide with Wat Phra Sri Rattana Mahathat using the information from 1-4 and test a virtual presentation via a travel guide tour with AR (Figure 6).

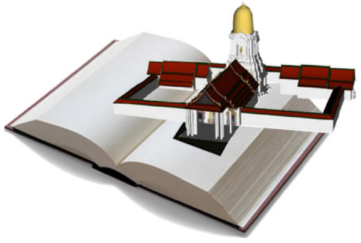

Figure 6: Example of a travel guide design and virtual presentation with AR

IV. TESTING AND RESULT

To test the presentation of the 3D models with AR, the following tools are required:

- The marker (called Markup).
- The web camera, video camera or smart phone camera.
- The display may be a monitor or computer screen, smart phone or others.
- A piece of software or a processing unit is used to create three-dimensional images or objects.

The testing was divided into two parts: 1) virtual presentation with AR and 2) explanation with audio which is indicated in Figure 7, 8 and 9. These figures show that the

virtual presentation works properly with AR. The audio of tourism information is recorded and played when the objects are shown.

Figure 7: Examples of virtual presentation with AR

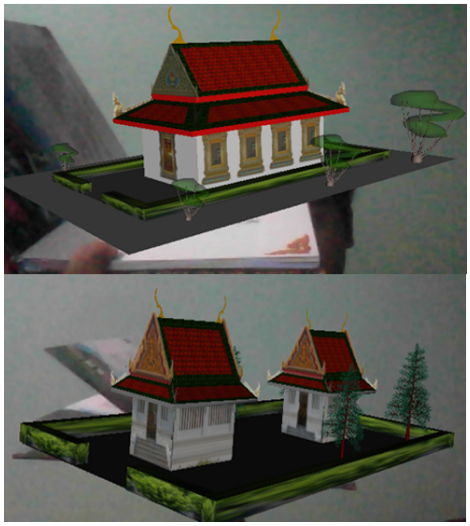

Figure 8: Examples of virtual presentation with AR

Figure 9: Examples of virtual presentation of a traveling book with AR and audio

Addressing the potential usability problems, we followed the HARUS approach by Santos et al. [12]. HARUS consists of 16 questions focusing on comprehensibility and the user's capability of manipulating the AR system. Due to limited space, we can only present a concise overview of the results achieved so far.

In Table 1, data gained by testing ARCH-TOUR are summarized. All in all, we collected data from 18 participants who responded to 16 statements using a five-point Likert scale questionnaire during the experiments. The statements read as follows:

1. I think that interacting with this application requires a lot of mental effort.
2. I thought the amount of information displayed on screen was appropriate.
3. I thought that the information displayed on screen was difficult to read.
4. I felt that the information display was responding fast enough.
5. I thought that the information displayed on screen was confusing.
6. I thought the words and symbols on screen were easy to read.
7. I felt that the display was flickering too much.
8. I thought that the information displayed on screen was consistent.
9. I think that interacting with this application requires a lot of body muscle effort.
10. I felt that using the application was comfortable for my arms and hands.
11. I found the device difficult to hold while operating the application.
12. I found it easy to input information through the application.
13. I felt that my arm or hand became tired after using the application.
14. I think the application is easy to control.
15. I felt that I was losing grip and dropping the device at some point.
16. I think the operation of this application is simple and uncomplicated.

Table 1
Test results

Statement	No. of responses	Mean	SD
1	18	4.1	0.8
2	16	3.8	0.7
3	17	4.5	1.6
4	16	4.4	2.2
5	18	4.0	0.9
6	18	3.8	0.5
7	16	4.5	0.2
8	15	4.0	1.7
9	17	4.6	1.9
10	18	4.2	1.0
11	18	3.9	0.1
12	16	4.4	0.6
13	16	3.9	0.6
14	17	4.5	0.5
15	18	4.4	0.9
16	15	4.4	1.8

ARCH-TOUR has been tested and evaluated with 18 participants for usability with a five-point Likert scale. The results show overall satisfaction with the comprehensibility and the way of manipulating the system in everyday situations.

V. CONCLUSION AND FUTURE WORK

This research presents an application of augmented reality for cultural and historical tourist attraction display by using a sample of "Wat Phra Sri Rattana Mahathat, Phitsanulok, Thailand, for testing. A travel guide has been designed and presented with AR to tourists at Phitsanulok province, Thailand. The feedback from users was very satisfying, and it shows that they were motivated to get more information on exhibits and buildings inside the temple. Regarding the presentation, tourists found the information was useful and attractive when they experienced with the system. However, the use of low quality cameras sometimes hampered the capture and visualization of 3D models. The program could not read and show results of virtual objects, if there was too much glare or if it was too dark during the marker reading process. Further work is to use Augmented Reality technology in virtual tourism presentations at other places via Web or mobile devices to get more attention by and convenience for the users.

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