International Journal of Engineering & Technology, 7 (2.14) (2018) 85-88

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research Paper

An Experience in Establishing the Mangrove Reference Data Center (MRDC) and its Augmented Reality Based Application

Mohd Syafiq Alam Shah[1], Mohd Azam Osman[1]*, Abdullah Zawawi Talib[1], Siti Azizah Mohd Nor[2]

[1]School of Computer Sciences, Universiti Sains Malaysia, 11800 USM Pulau Pinang, Malaysia
[2]School of Biological Sciences, Universiti Sains Malaysia, 11800 USM Pulau Pinang, Malaysia
**Corresponding author E-mail: azam@usm.my*

Abstract

Mangrove forest is an ecosystem that is highly diverse not only in mangrove plants but also supports rich assemblages of fauna and other non-mangrove floral species. It provides numerous kinds of ecosystem services that are of great benefit to humankind. However, to the general public, knowledge on the importance of mangrove ecosystems is very limited. In this paper, we present our experience in establishing the Mangrove Reference Data Center (MRDC) and its augmented reality-based mobile application called Kilim Scouter which provides information details of mangrove plants and related information to the users. MRDC is a data center that stores information details of mangrove plants in Kilim Geoforest Park in Langkawi Island, Malaysia such as common and scientific names of species, as well as its distribution (GPS location). In addition, MRDC also stores other information for example other inhabitants of the ecosystem and non-living entities such as Karstic hills and caves found in the Mangrove ecosystem. MRDC comes with a web application that acts as an interface to MRDC for accessing, adding or modifying the information details of mangrove plants. Kilim Scouter is a mobile application which deploys Augmented Reality (AR) technology, a technology through which the view of the real world environment is augmented by adding computer-generated elements/objects. Kilim Scouter utilizes the AR technology to automatically track and identify the mangrove plants and its related information, and then provides the information by retrieving data from MRDC. MRDC and Kilim Scouter are capable of providing on-the-go accessibility of information details of mangrove plants and target users such as tourists and researchers. This application will create awareness on the importance of the mangrove ecosystems and thus, assist the effort in sustaining the mangrove ecosystem.

Keywords: *Augmented Reality; Data Centre; Mangroves,.*

1. Introduction

Mangroves are plants, e.g. shrubs, palms and ferns that grow within the inter-tidal region of coastal and estuarine environments throughout the tropical and sub-tropical areas of the world [1]. Beside plants, other living and non-*living* entities also form the mangrove ecosystems such as mangrove animals and abiotic factors [2].

In this paper, Kilim Geoforest Park in Langkawi Island, Malaysia is taken as our case study. Kilim Geoforest Park is located in the northern part of the island. The landscape consists of karstic hills with pinnacles of various shapes and sizes, elongated hills and islands with narrow valleys in between which becomes the home for mangrove forest. Tourists visit the park to experience its natural beauty especially the mangrove forest which is the habitat for many species of mangrove trees and animals.

Mangrove ecosystem has many benefits which are unknown to most people as there is no convenient and accessible data reference center for the mangrove ecosystem such as Kilim Geoforest Park. Until today, only the School of Environment and Natural Resource Sciences in the Faculty of Science and Technology, Universiti Kebangsaan Malaysia (UKM) has provided a resource for the mangrove information details. However, it only covers the mangrove plants information. Hence, in this paper, we present a centralized database Mangrove Reference Data Center (MRDC) that stores mangrove and its related information together with Kilim Scouter which is a mobile augmented reality application that provides on-the-go accessibility of the mangrove ecosystem information.

MRDC is a database which keeps information details on mangrove plants, inhabitants and non-living things in the Kilim Geoforest Park while Kilim Scouter is a mobile application that automatically recognizes the mangrove plant, its inhabitants and non-living things using Augmented Reality (AR) technology, a technology through which the view of the real world environment is augmented with computer-generated elements or objects [3]. Kilim Scouter retrieves the information details of the recognized object from MRDC. It utilizes the camera of the mobile device to view the real scene of the mangrove forest. In case of no Internet connection, Kilim Scouter supports offline database to retrieve the mangrove plants information details locally from the local storage of the mobile device.

Mangrove ecosystem consists of various kinds of mangrove plant and wildlife, including the landscape formation which is the limestone karst. Each of these entities has their own information details such as a common name, species name, family, habitat and others. However, visitors in Kilim Geoforest Park are not able to get comprehensive information on the nature and life in the park. Therefore, the purpose of MRDC and Kilim Scouter is to address this problem.

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2. Background study

The idea of providing information details of the mangrove ecosystem is still in infancy as there are only a few such existing systems. In this section, a study of some of the existing systems is presented.

Langkawi Mangrove Biodiversity Database [4] is a website that provides the information details of mangrove plants. This website is based in Malaysia and it is a collaborative project involving Universiti Kebangsaan Malaysia, Universiti Teknologi Malaysia - Bioinformatics Research Group (BIRG) and Iwana Solution. The website presents the information details of the mangrove plants by listing all the mangrove plants' name in a table arranged according to the alphabetical order of their scientific name. The table also provides the common names and family for each of the mangrove plants. Each of the scientific names of the mangrove plants is presented as a clickable link. If it is clicked, it jumps to the page that shows the information details of the clicked mangrove plant including its real photo. Examples of the information details of the mangrove plant provided by the websites are common name, family, distribution, habitat, leaf, petiole, flower and fruit.

Mangroves and Their World [5] is a website that provides an online identification program of some mangrove species based on the GLOMIS database. GLOMIS is an acronym for Global Mangrove Database and Information System. The aim of GLOMIS is to ensure that the mangrove ecosystems are managed and utilised judiciously for forest products such as timber and fuelwood as well as the sustainable management of fisheries and the maintenance of coastal water quality and stability. Both websites are owned by the International Society for Mangrove Ecosystems (ISME), an international non-profit and non-governmental scientific society which plays a role in collecting any information details related to the mangrove ecosystem. Mangroves and Their World website serves as an illustrated reference book of several mangrove species, and also shows some small animals living in mangroves such as mudskipper, crab and shellfishes. Basically, this website mainly uses a hyperlink to jump to the webpage that shows the information on the mangrove plants. On the homepage, it provides a few hyperlinks such as a hyperlink that jumps to the webpage of mangrove plants classified based on the shape of the root, stem, leaf, flower and fruit. Another hyperlink jumps to the webpage of the mangrove plants classified based on the name. Currently, this website only provides information on the mangrove plants in Okinawa, Japan.

iMangroves (MangroveiD) [6] is a mobile application that functions as a botanical guide that provides more than 800 select images, 100 world distribution records and authoritative botanical descriptions of all 85 mangrove plant species, hybrids and varieties occurring worldwide. The information details about the mangrove plants is based on a project called Mangrove Flora Project conducted by Dr Norman C. Duke, a long time mangrove ecologist and marine science specialist. The function of this mobile app is to show the diversity and distribution of the mangrove plants and improve our knowledge on the mangrove plants. The information details of each of the mangrove plants can be accessed by clicking on the name of the mangrove plants which are arranged in a list consisting of a scrollable page of the app. Besides, the app also features a capturing tool where it allows any user to capture images of the mangrove plants and other related entities that are newly discovered and register them into the database. Currently, this app supports iOS and Android mobile operating systems.

3. MDRC system and Kilim scouter

The Mangrove Reference Data Centre (MRDC) is a database system to store the mangrove plants information and other related entities such as living things (crabs, eagles and many more) and non-living things (lime stones) in Kilim Geoforest Park. Kilim Scouter is a mobile application that uses AR tracking technique to detect and analyze the mangrove plants and then display the information details retrieved from MRDC as a virtual object on the video feed of the mobile device. MRDC and Kilim Scouter comprise two main modules which are the MRDC module and the Kilim Scouter module. The MRDC module includes the database and web application sub-modules while the Kilim Scouter module includes the sub-modules of location identifying, tracking objects, visual rendering, retrieving information, and storing and updating data.

The capabilities of MRDC and Kilim Scouter include ability to: 1) detect and recognise the mangrove plants or other related entities, 2) display the information details of the recognised mangrove plants or other related plants as a virtual object on the video feed, and 3) store the information details of the mangrove plants and other related plant information including photos, GPS coordinate and the use of mangrove plant.

All of the above capabilities allow MRDC and Kilim Scouter to provide the information details on the mangrove ecosystem to the public such as tourists and researchers. MRDC and Kilim Scouter can trigger the awareness of the public on the mangrove ecosystem.

Kilim Scouter which utilizes AR technology is capable of tracking real objects viewed on live video feed or camera viewfinder of a mobile device, and then registers or renders the computer-generated objects (virtual objects) on the live video feed [7-9]. Thus, Kilim Scouter has a feature that identifies the object of real scene such as mangrove plants, wildlife and limestone structures. It identifies or tracks the object viewed on the camera of a mobile device. In AR technology, there are a few tracking techniques for tracking real object. Table 1 shows the comparison of the different techniques of AR tracking.

Table 1: Comparison between Augmented Reality (AR) Tracking Techniques

Technique	Sensor-based tracking [10]	Vision-based tracking [11]	Hybrid tracking [12]
Description	Tracks using active sensor such as optical, magnetic, inertial, acoustic or ultrasonic	Tracks using computer vision methods for calculating the camera pose relative to the real world objects	A combination of sensor-based tracking and vision-based tracking
Advantage	Varied based on the sensor used; optical – better accuracy; magnetic – cheaper to implement; inertial – lightweight and no reference; acoustic – no distortion.	Requires less computation with robust output	Robust output, better accuracy
Disadvantage	Easily distorted by natural factors such as light	Less accurate	Requires high computation

4. System design and implementation

Figure 1 shows the overall modules of the proposed system. Figure 2 shows the architecture diagram of MRDC and Kilim Scouter. By using the mobile device camera, the real scene of the mangrove forest is viewed in real time on the live video feed of the mobile device. Kilim Scouter will track or identify any mangrove plants or other related plants using the AR tracking technique. In addition, the current GPS coordinate of the mangrove plants is also recorded to enhance the accuracy of the tracking processes. If objects (mangrove plants etc.) are successfully identified, Kilim Scouter will retrieve the information details of the identified mangrove plants from the MRDC database. If there is no network coverage, Kilim Scouter will retrieve the information details from the local database and these information have to be downloaded beforehand. Finally, all of the retrieved information details will be

augmented or superimposed as a virtual object on the live video feed using the AR registration process. Hence, users can read the information such as detail of the mangrove plants and other related plants as well as a superimposed virtual object on the live video feed on their mobile devices.

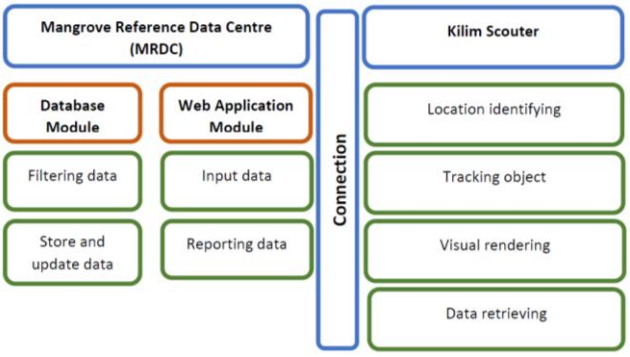

Fig.1: Module Diagram of MRDC and Kilim Scouter

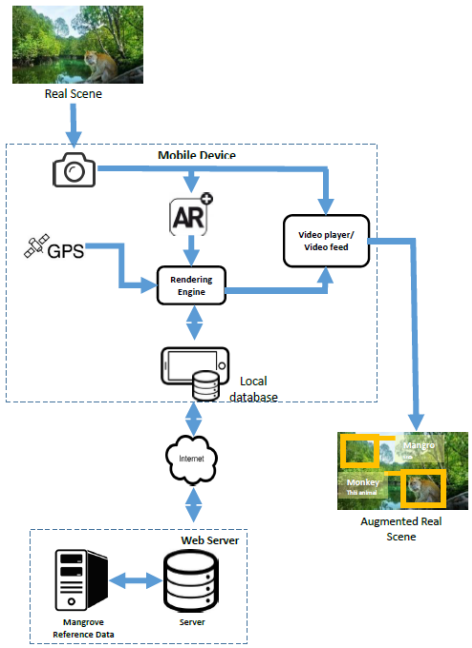

Fig. 2: Architecture of MRDC and Kilim Scouter

Figure 3 shows the architecture for the web application of MRDC. The MRDC web app acts as an interface for the user to access the information details of mangrove stored in MRDC. It is a cross-platform application as it can be deployed on any devices such as laptop, tablet, or smartphone, as long as all the devices have a web browser. When a user accesses the web application, the web server will respond and send the code of CSS, HTML and other related items to the user's web browser where it will be displayed in a user interface which allows interaction with the users. The MRDC web app will retrieve the information, details of the mangrove plants and other related entities from MRDC.

5. Comparison between proposed solution and existing systems

Existing systems such as the Langkawi Mangrove Biodiversity Database[4] website only provides the information details of the mangrove plants, but not on the animals and non-living things such as limestone structures. On the other hand, Mangrove and Their World [5] website provides almost comprehensive information on a mangrove ecosystem including animals. However, accessing the website during a visit to Kilim Geoforest Park is not possible without an Internet connection. Accessing a website requires a number of interactions and sometimes, it is time consuming especially in accessing a website with a poor user interface. Unlike the website, mobile app is easy and simple to use as little interaction is required. Furthermore, currently, there are no mobile apps that can be used by visitors of a mangrove ecosystem and thus, they are not able to get on-the-go accessibility of information details of the mangrove ecosystems.

The only way of getting information details of the mangrove ecosystem is through the tour guides. However, they can only give brief information pertaining to the mangrove plants and related information. Sometimes, they may provide inaccurate information. It may be due to the lack of knowledge on the mangrove ecosystem compared to more accurate information collected by researchers.

All of the existing systems have limitations and also weaknesses. Table 2 presents a comparison of the features of the existing systems with our proposed solution, MRDC and Kilim Scouter. One of the weaknesses of the existing solutions is that they do not support offline mode. Offline mode is one of the most important functions for everyone, as a mangrove ecosystem such as Kilim Geoforest Park has a weak cellular or network coverage. It is fairly difficult to download the data from MRDC to local storage of a mobile device if the network connection is weak. Therefore, MRDC and Kilim Scouter which supports an offline mode is proposed. MRDC and Kilim Scouter are also able to retrieve the data from the online database (MRDC). Besides, Kilim Scouter utilizes the AR technology in presenting the mangrove information details. Using this technology, it allows user to identify the mangrove entities in a more interactive way, where a user can locate the mangrove entities based on real location through the camera viewfinder of an Android device and then interact with it such as by clicking URL that will redirect the user to the main web application of MRDC.

Table 2: Comparison of Features between Existing Systems and, MRDC and Kilim Scouter

Criteria	Langkawi Mangrove Biodiversity Database [4]	Mangroves and Their World [5]	iMangroves [6]	MRDC and Kilim Scouter
Category	Web Application + Online database	Web Application + Online database	Android-based mobile application	Android-based mobile application + Web application + Online database
Hardware	Any device that can open the website	Any device that can open the website	Android-based mobile devices	Android-based mobile devices (for Kilim Scouter) and any device that can open a website (MRDC web app)
Augmented Reality-based	No	No	No	Yes
Internet-dependency	Yes	Yes	Not always	Not always
Offline mode	No	No	Yes	Yes
Advantages	-	Simple and easy to understand the contents	Simple and easy to be used	Simple and easy to be used, utilizes AR

One of the constraints of this system is the accuracy of location/GPS tracking. However, the constraint can still be solved

by doing some calibration on the Android device before starting to locate the mangrove entities. Calibration can be done by turning on the GPS function and then rotating the device in a few directions. The device needs to be rotated for a few seconds until it retrieves the current GPS coordinate. In addition, the calibration process can be enhanced by using GPS calibration app such as GPS Status & Toolbox [13].

Based on an analysis of the system, there are a few limitations of MRDC and Kilim Scouter due to technological constraints. The limitations are as follows:

- The accuracy of the AR tracking of mangrove is less accurate. This is due to the constraint of the AR tracking technique itself as currently, there is no existing technique that can track accurately real objects visually (such as mangrove plants).

Kilim Scouter faces difficulty in retrieving information details of mangrove plants from MRDC due to poor network coverage in Kilim Geoforest Park. Therefore, Kilim Scouter provides offline-mode function which can pre-download the information details and stores them in the local database of mobile device.

5. Sample Screenshots

Figure 4 shows some sample screenshots of the mobile application. Figure 4(a) shows an interface where the red mark indicates the superimposed object representing an entity. Figure 4(b) shows the red mark which indicates an entity as a superimposed object while the yellow mark indicates the real object of the entity.

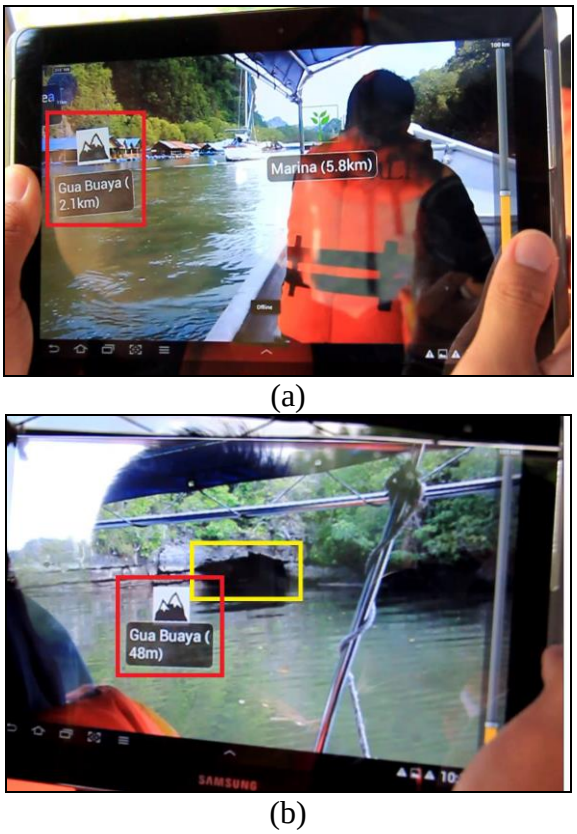

Fig. 4: Screenshots of the Mobile Application (a) Indication of the Superimposed Object that Represents an Entity (b) Indication of the Superimposed Object and the Real Object of the Entity

6. Conclusion and future work

MRDC and Kilim Scouter are proposed in order to solve the problems encountered by the relevant authority and visitors in Kilim Geoforest Park. It is believed that this proposed solution will sustain the mangrove ecosystem in the park by triggering the awareness of people on the importance of mangrove ecosystems. MRDC and Kilim Scouter utilize the AR technology, which involves the process of tracking, sensing, displaying and interaction in detecting the mangrove plants and other related entities, and then displaying the information details of the mangrove as a virtual object on the video feed of the mobile device. Thus, the proposed solution provides a database for storing information details of Mangrove entities and accessing it with on-the-go accessibility through mobile devices.

The development process of MRDC and Kilim Scouter has encountered many challenges such as the accuracy of the GPS sensor. Many technologies were used in this proposed solution such as SQL which is the basis of MRDC, and Java which is for coding Kilim Scouter.

Both MRDC and Kilim Scouter can be further improved as both utilize technologies that are rapidly evolving. For example, in the future a more sophisticated AR tracking technology can be used which does not rely on GPS coordinate and can work in offline mode. Using this technology, it can give a better result and accuracy in tracking the mangrove entities. As a result, the user, such as visitors can enjoy a greater experience in the journey through the mangrove ecosystem.

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