Amazon Biology: An Augmented Reality-Based E-Book for Biology

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Abstract— **Biology is a difficult subject to learn for both high school and college students due to its complexity. Students are used to learning Biology from various methods such as reading textbooks, attending lectures, viewing images, etc. Biology is based on more practical and almost all the schools do not have proper lab facilities, anatomic structures, and resources to learn the module easily and perfectly. On the other hand, teachers who teach the module also faced a considerable number of issues when delivering the concepts. Some of them are unavailability of teaching aids, time-consuming, lack of lecture materials, etc. Apart from that, the nature of the topic and the teaching style are the main learning problems faced by the students. Therefore, students do not learn the concepts perfectly and interest in the module has been reduced day by day. To overcome these difficulties "Amazon Biology," mobile application has been proposed. The application consists of three major modules including image processing for the plant classification, augmented reality for human anatomy, and gamification. The proposed application has been used the techniques in augmented reality and game-based learning. More specifically, a book-based AR app is designed to allow each student to learn biology interestingly. The developed system delivers nearly 85% level of accuracy and provides more advantages for students. They are effective and efficient learning, teaching via visual materials, and practical.**

Keywords—Augment reality, image processing, gamification

I. INTRODUCTION

Education is one of the major factors in the modern community due to education is the most important fact in the economy of the developing country that should be considered. Although it seems to be there have been innovative new concepts for different sectors including the education sector, still there are difficulties and issues. It does not wonder in a developing country such as Sri Lanka, there have such problems among students and teachers such as social problems, education system problems, and more [1]. It makes a huge effect on society. Therefore, most educationists and innovators motivated to transforming within the educational world by cooperating with new technologies day by day. With that enthusiasm, they try to make solutions for common difficulties that are faced by students and teachers while learning and teaching process.

Although, technologies that can be seen within the appliances of science, more especially for biology, they are unable to give better solutions for difficulties that students and teachers face while learning and teaching process. Hence, team members conducted a questionnaire with participats from 50 randomly selected people who were related to biology [2] and biology teachers were interviewed to figure out those difficulties [3]. According to the statistics and previously conducted researches, stated problems as well [4]. They have included [5] the lack of lab resources and anatomic structures in rural areas school laboratories, have not suitable environment especially for topics of nature learning, [6] have not available sufficient textbook or reference materials, more time required for sketching biological structures, pieces of laboratory equipment are expensive, [7] more time required to prepare equipment for experiments, boring content of subject matter and more. It is a more student-centric module in the educational system and biology is a complex, conceptual, and more practical subject when considered subject matters such as plant and human [8]. Therefore, it is not enough students to refer to textbooks, attending classes, and lab practical. Therefore, it is required biological application with new effective educational methodologies and technologies.

In the 21st century, the usage of technology is considered the best solution for several common problems due that technology has a huge demand in the community and have a great relationship between education and technology. Among those technologies that can be used, Augmented Reality and Image processing have taken major places. Augmented reality and virtual reality or mixed reality are attractive and effective interactive learning methods that can be used in the education sector [9]. Augmented reality is the technology that combined the real world and the digital virtual world. Augmented reality makes 3D computer-generated objects on

the real-world environment that is existed[10]. Image processing is applied for detecting objects in the physical environment by using algorithms and deliver related meaningful details. To fulfill educational requirements, augmented reality and image processing can be used effectively.

Therefore, in this research, have introduced "Amazon Biology" is an e-learning mobile application on Android OS that a result of the combination of both image processing and augmented reality technologies for aid to the enhancement of biology learning. Image processing techniques are utilized for plant classification and augmented reality is utilized for the learning of human anatomy and gamification. Biology is a more natural related subject and most of the students unable to experience with plants and animals. Therefore, this application includes the learning of plants. Learning of plant-based on plant leaf classification, flower detection, and 3D plant life circle illustration. It aids to obtain better interaction and knowledge about plants without boring. While teaching biology, science teachers require more time to sketch human anatomy structure and make lab equipment, facilities to explain biological concepts, and more. Therefore, this application consists of human anatomy lessons in an interesting way. Human anatomy based on organ detection and organ illustration. Gamification based on different kinds of quizzes and puzzles. This e-learning appliance will make a positive attitude and interest in biology among students and teachers. It will make a positive transformation in the education world related to biology by introducing student-centric educational methods.

II. LITERATURE REVIEW

The majority of students and teachers are facing some issues with learning and teaching biology but cannot be seen proper digital application to experience with animals and plants in the real-world, share knowledge about biology in the proper way, and usage of resources. Although there have many mobile applications and researches related to biology e-learning, most of that appliances focused on question-based or paragraph based biological concepts delivery only, there have not delivered any natural learning and 3D animation experience. Researches are focused on image classification only. It can be rarely seen both plant classification techniques and augmented reality together in a unique platform.

There are a literature review of related works and existing application below.

A. Related works

In several times augmented reality is used such as mathematics, physics, and chemistry subjects. They focus on the students' learning system. But rare to use the biology subject due to the complexity of the syllabus. So that amazon biology mobile app we target the main biology concepts to attract the attention of the student and also teachers [11].

In various ways, augmented reality is used to increase the attention of the students. AR always support to away the traditional learning system and simulate the teaching experiences. Some research studies prove using augmented reality reduces the wasted time to learn subjects in traditional classes. They mainly target to develop an AR literacy system for students [12].

This study aims to determine, 3D visualization of breast tumors is shown too effective by previous studies. This research mainly introduces the AR application that can help doctors and surgeons to have a more accurate visualization of breast tumors [13].

This research regarding the education base digital game using virtual reality for aim to train autonomous innovative supportive young generation. Game-based augmented reality is now a very trending learning way. Increase the attention of the complex concepts using augmented reality experience very useful to learning. Students are boring to learn these concepts because of their complexity and content. So, using an augmented reality game based application can solve these all problems [14].

B. Existing Applications

There are myriad of mobile application related to biology. There have figured out features of those applications and this application comparison mentioned below.

Table I: Existing application comparison

Product	Complete Biology	3D biology	Biology eBook and Quiz	AR 3D Science	Our app
AR animation	x	√	x	x	√
Labeled pictures	x	x	√	x	√
Marker based AR	x	x	x	x	√
3D answers	x	x	x	x	√
Tutorials	√	√	√	√	√
Easy to use	x	√	x	x	√
Gathering plant-related information	√	√	x	x	√
Plant life circle illustration	x	x	x	x	√
Audio object description	x	√	√	√	√
Game session	x	x	x	x	√
Illustrate Flower recognition.	x	x	x	x	√
User friendly	x	x	√	x	√

AR-3D is an augmented reality educational app to learning science. It is a mobile application with some human anatomy 3D structures. The features of the application allow students to touch, rotate, and zoom in and out. The only description illustrates for each element. It's only the 3D object in the 3D view application [15].

3D Biology+ application provides visual 3D human anatomy models. It helps to visualize the information of each 3D model. This application has an online library to download human anatomy structures. Then students can rotate, scale, and control the biology model. Internet connection is essential for download models [16].

Biology eBook and Quiz application support for both human and plant kingdoms. Descriptions of each partition consist of 2D images. But bit complex interfaces have to display details. This application focused on deliver biological concepts of plants, animals, and human kingdoms from questions as well [17].

Amazon Biology application has more features rather than other biology applications. For the first component, students can identify the real-world plant by using image classification. Some student does not have any practical idea of the plant leaf and flowers related to biology syllabus. So that using this component students can identify the plant, flower and can visualize the 3D life cycle of the plant. It can be learned about complex botany concepts easily. The second component is about the augmented reality map with real-world experiences. This application should capture the textbook images related to human anatomy then visualized the image using augmented reality space. This helps to get the laboratory experiences. Some school doesn't exit the real-world anatomy structures in the labs. And, in rural areas students don't even see the real anatomy structures. So, this app helps them to get real-world experience. The third component will be making users entertained using this platform and it is augmented reality technology for gamification. It increases the interest of learning biology concepts and memorizations. Blender with augmented reality with games can learn complex biology concepts easily. Finally using all these techniques, this platform provides very productive services to the education system.

III. METHODOLOGY

First and foremost, team members conducted a questionnaire, interviews, and literature review to collect important facts to build a mobile application with effective image processing and augmented reality experience. After that, team members began the implementation of the mobile application by setting up initial requirements for work on the Android OS platform. At attend to the application, the user should register in the system to obtain more advantages from the application. After registration, the user able to log into the system. Then users have three options to choose. They are "Scan & Learn", "Amazing Augmented", and "Augmented Quiz". They are considered under three components in our research. They are,

1. Object illustration with image processing for plant classification.
2. Object illustration with augmented reality for human anatomy.
3. Gamification.

Figure 1. System Diagram

A. Plant classification

In the first component of the application, related to the plant due to it is the foundation of nature learning topic in botany. Subject matters of botany are typically complex and less preference among students. Hence, object illustrations with image processing have used plant classification and flower recognition for increase interactivity and preference toward nature learning.

In this phase implementing, image processing methods are used with a 3D virtual environment for plants and flowers. Compared with different types of plant classification, plant leaf-based classification is an effective way and initial choice. The initial step, plant leaf in a solid clear background is used for recognition easily. After the user captures and uploads the image of the plant leaf to the system by smart mobile device, they are sent to the server for the classification phase. In the server by applying to pre-process techniques of image processing, to build the image with the extracted feature. Then images are classified by using a frequently used image classification algorithm based on neural networks. The system displays the result of plant classification. They are included plant name and biological descriptions about the identified plant to proper subject matters. To more user interactivity, the system displays a 3D plant life circle with animation techniques such as zooming, rotation, flowing features. There has an option to flower identification to cooperate with Hibiscus flower to improve awareness of flower anatomy. When the user captures the image of the flower and system display the 3D flower model of the identified flower with animation features. Users allow making motions of 3D objects.
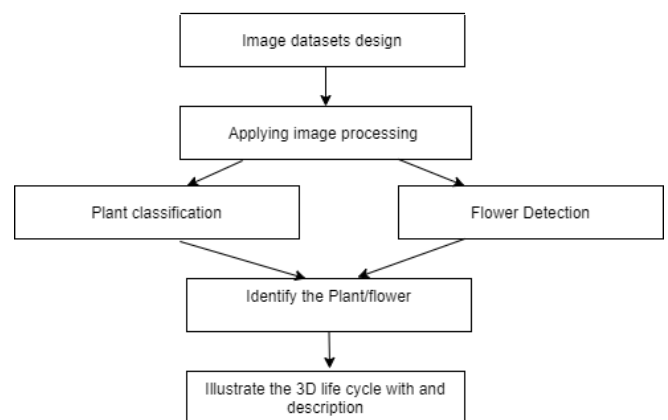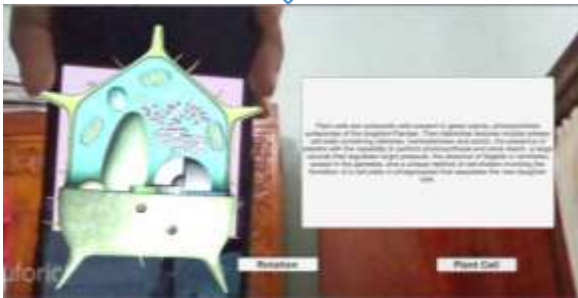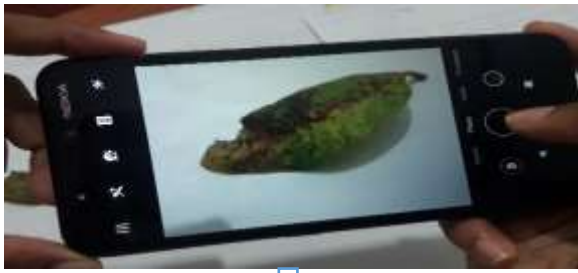

Figure 2. Functional flowchart

Figure 3. Plant Demonstration

B. Human anatomy classification with image processing and augmented reality.

Augmented reality technology is a new trend all over the world. In this study, an augmented reality map with the real-world. The application is used image processing-based methods, augmented reality to recognize the human anatomy textbook images, and illustrates the labeled 3D module to give augmented reality experiences to the users. When the user points out the mobile device to the textbook image and the 3D model with labels is appeared on the augmented reality space. Users can do rotation, zooming the 3D model, and can get real-world experiences.

When the user captures the image and the system classified by using an image classification algorithm which is based on deep learning neural network. Then the system begins to recognize the image. By applying deep learning module for image recognition and filter the pixels one by one and identify the feature points. Then the system identifies the target image by using image processing. After use augmented reality to tracking image. Then the target image is converted to the tracking format by using the image detection and tracking module. In 3D space, the trackable base class used to identify the object in the real world. This AR scenario development by using unity and android studio. Target images are trained using the feature points and crated target database. When the user scans the real object, using augmented reality recognition and create target virtual objects. It helps the system to the recognition of the textbook image. After all these processes completed, illustrate the labeled 3D model in augmented reality space. This platform gives the learner to learning complex biology concepts easily and interestingly.
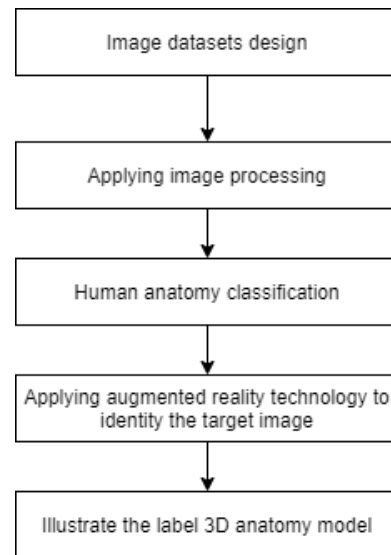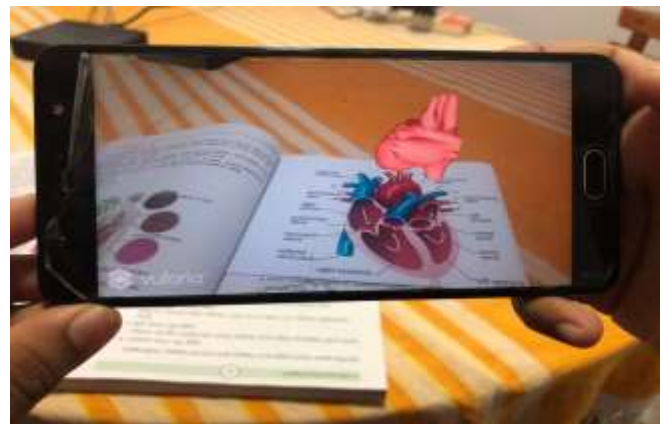

Figure 4. Functional flowchart

Figure 5. Learning human anatomy- heart

C. Gamification

The gamification function in the proposed Amazon Biology application has used to increase the interactivity with the user. Have given the proper augmented reality gaming experience for those who learn biology. The literature study and the questionnaire gave the difference between the used technologies in this application.

In the building, the phase has used a unity game engine to build the game. To reduce the complexity and to give a smooth experience for those who use the application, the application has used augmented reality technology. Used 3D objects placed in the image target which use as a marker for the game. To add value for used game objects has transformed into correct positions through the inspector and scripts that the application has used. The application used scripts for click events for touchpoints. Using those scripts, the system can move the 3D objects to point that relevant places. The application has used drag and drop functions to move the elements. The application going to implement the complex cells as 3d objects and used for the game it will work as a memory game. In the building, the phase has used gamification concepts. The application has used a scoring

system for each trial as a reward for the game. In the progression going to implement the levels and personal base game for those who play the game. To fulfill the users' expectations have used replay and infinite play modes for the game. Further levels have to implement according to the biology syllabus which students are following.
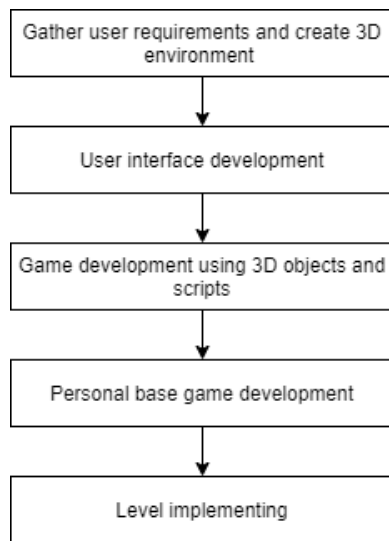

Figure 6: Functional flowchart

Figure 7: Game for Students – Level 1

IV. RESULTS

When considering plant classification, for identifying the plant have used neural network algorithm. There have successfully trained six kinds of plant models using neural network algorithm. In each kind of plant has above 100 images with different side's angles for training and testing. The average value of accuracy is 90.57%. Team members hope to increase accuracy by extending the quantity of trained image due to inaccurate feature extraction and classification in some conditions.

The application is used image processing-based methods with augmented reality to recognize the human anatomy textbook images. After doing some tests, image processing the accuracy value is above 95%. Furthermore, increase the target images dataset in augmented reality information space also can increase the accuracy level. The system has been used a mobile phone to capture the image target and augmented reality information display the module to verify its accuracy and effectiveness. But are some cases, the effect is not good. Because some target images feature points can't be recognized. The reason for that textbook images features point's leads to lower accuracy of feature matching. So that it better to train various images with more feature points had better recognition.

Also, this research currently testing augmented reality games with a marker that the application has made in gamification. Also, team members hope to test the completed application among randomly selected a few numbers of students and teachers in high schools to evaluate the "Amazon Biology" mobile application.

V. CONCLUSION AND FUTURE DIRECTIONS

Students and teachers face difficulties to learn biology due to different kinds of reasons to fulfill educational requirements. Although the majority of the population are using mobile phones and tablets, as a developing country, there can be considered the lacking of a suitable digital platform for biology learning in Sri Lanka. Therefore, in this study, team members have been introduced the "Amazon Biology" mobile application that is used image processing and augmented reality to overcome difficulties of biology. This paper introduced a neural network approach for plant classification and flower detection. For increase interest of biology, have introduced human anatomy and biological game with augmented reality. This application helps those who can't get real-world experience to get augmented reality-based experience which same as real.

Future direction aims to implement a virtual biology laboratory, update the application with the Sinhala language, and implement an application with more capability for new biological information. Furthermore, it is possible to improve the gamification session with advanced game levels.

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