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FOREWORD

This proceedings volume presents the Bachelor Degree Project (PSM) papers from the Faculty of Computing at Universiti Teknologi Malaysia (UTM) for the academic year 2022/2023. The theme, “Innovation in Computer Technology and Applications,” aptly reflects the dynamic and evolving landscape of our field.

This compilation continues a tradition established in 2016, with prior editions published in 2017, 2018, 2021, and 2022. Each volume highlights the dedication of our students, providing them a platform to document and share their research findings and project outcomes in the academia.

Within these pages, readers will find a diverse array of papers from various programs, including Software Engineering, Graphics and Multimedia, Computer Networks and Security and Bioinformatics. The topics span a wide range of computing technologies, showcasing innovative solutions with practical applications.

This proceeding would not have been possible without the efforts of our editorial board, evaluators, and supervisors. We extend our gratitude to all the students for their hard work and commitment to excellence. We hope these insights will inspire further exploration in the field of computer science. We appreciate your continued support and participation in this academic endeavor.

Thank You

Aida Ali
Chief Editor

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Educational Animal Matching in Handheld Augmented Reality for Children

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Abstract— **Augmented reality (AR) is a type of technology that places the virtual object to the real-world environment to give an interactive experience for people nowadays. In this era, AR has become a popular technology that is useful for the education area. The handheld device has become more common for children and the children mostly get new knowledge of animals from the mobile educational application. However, the learning of animals with new technology and media in kindergarten is still less than optimal. Animal matching education application is one of the basic learning applications that can help the children classify and learn the information of the animals but still need to improve with new technology such as AR elements. Therefore, the aim of this project is to develop an educational animal matching in handheld augmented reality for children. The use of handheld AR for this application can enhance the learning interest and learning ability for children. There are three phases to be carried out in this project. The first phase is to analyse and study the educational animal matching in handheld AR for children to discover the better design and develop of handheld AR application for children. The second phase is to design and develop the educational animal matching application with handheld AR using ray casting technique and the last phase is to integrate educational animal matching application in handheld AR for children and evaluate the project outcome. The evaluation has been performed based on usability and user acceptance. The results show the application was well-received and met the expectations of the users, particularly in terms of attractiveness, user-friendliness, accurate animal matching, clear instructions, and overall satisfaction. Based on the result, the project success in enriching the learning process and delivering a fun and exciting experience for players in the educational animal matching in handheld augmented reality.**

Keywords—Augmented Reality, animal matching, handheld augmented reality

I. INTRODUCTION

Augmented reality (AR) is a technology that combines virtual objects with the real world to give an interactive experience for people nowadays. Every physical object or environment could become the target marker for the user to implement the AR technology. AR is now being used in a variety of industries, including education. In this era, the mobile device has become more common for everyone, including children. Most kindergarten teachers need the newest technology for the children to learn new things in some interactive ways.

Nowadays, children mostly get new knowledge from handheld devices. Most of the handheld devices have provided a variety of learning applications that help children learn different kinds of knowledge. For example, the animal matching education application is one of the basic learning applications that can help children classify and learn the information about the animals. The animal matching application with education feature can help children learn the knowledge of animals in more realistic way. Therefore, instead of learning in books, the advanced technology by combining the virtual and physical world with AR technology makes it more interesting for children to gain experience of learning new things from the handheld AR application.

This study will focus on educational animal matching application with handheld AR for children. The children can use the handheld devices to learn on the knowledge of different types of animals with the animal matching application. In this application, children will get immersive experiences on learning animal with the feature of AR technology.

II. LITERATURE REVIEW

A. Augmented Reality

AR technology mixes virtual information with the physical environment. Multimedia, three-dimensional (3D) modelling, real-time tracking and registration, intelligent interaction, sensing, and other technological tools are applied. [1] reported the main concept is to apply computer-generated virtual data to the surrounding world, such as text, photos, 3D models, music, video, and so on. In this way, the two types of knowledge support one another, leading to the development of the real world. Virtual Reality (VR) is connected to AR. Whereas VR refers to completely digitally manipulated virtual information,

AR refers to the mixing of the real world with a virtual environment [2]. AR includes different components such as AR tracking methods, AR display technologies, and AR interaction techniques. The tracking method consists of object tracking, image tracking, and world tracking.

B. Handheld AR

With the evolution of intelligent display devices, AR has become a potential, which is driven to greater heights by the various types of display devices developed with intelligent display technology. There are three major groups of display technologies that play an essential role in the area of AR technology nowadays. Handheld devices have been considered the most promising AR tools [3][4]. Handheld device display, relying on AR technology. Handheld device display is extremely light and compact, especially with the popularity of smart phones, using video aspect to represent the use of AR technology. Smartphones and tablets are small and include all the technology needed for AR, such as a display, camera, graphics, Global Positioning System (GPS), compass, and accelerometer [5]. [6] reported handheld AR has significant uses in gaming, interactive marketing and advertising, education, and navigation. Handheld devices have grown in popularity as an AR alternative. Today's smartphones and tablets are highly portable. All the hardware required for AR is contained in a single device. Through its fast Central Processing Unit (CPU) and many built-in sensors, the handheld device provides a video-perceived AR experience [6].

C. Marker-Based Tracking

In marker-based tracking, the marker to be identified has been saved in a database. The marker might be a picture or a descriptor of an image. A camera and AR software are used to recognise AR markers as the position of virtual objects. These markers provide a recognition library that analyses the marker's rotation and translation relative to the device's camera in real time. The design presented having thousands of different codes, thus enabling uninterrupted tracking through the database at a very reasonable cost.

D. AR in Animal Education for Children

Early exposure to the animal's shape and size will aid kids in making good knowledge of the species [7]. Based on this principle, it is necessary to produce media that may be used in schools to educate children about animals. AR is the technology used for this aim [7]. AR Animal Recognition provides kids with knowledge about the animal's shape, habitat, and the animal's original sound. Learning about animals is like learning letters or alphabets in that toddlers must first learn the pattern of the letters [7]. Children will learn not just from the books, posters, or paintings hanging on the classroom wall, but also from AR-based learning material that helps the children learn about animals more clearly [7]. Furthermore, AR aided learning is engaging and interesting to kids. AR technology was employed to develop an animal-recognition magic book for kindergarteners [7].

AR-based learning implementation Learning media is not affordable since it is produced using open-source software [7]. The system needs just a PC or a smartphone. The objective of developing AR-based learning materials is to provide students with a variety of learning opportunities while using existing technology. Children's learning will be more engaging and realistic [7].

E. Previous Work

TABLE I. COMPARISON BETWEEN EXISTING SYSTEMS

Application Project	Animal Recognition AR Learning	AR-based Animal Recognition application	AR Book App
Type	Educational game	Educational game	Educational
Types of Animals used	Water and Land animals	Herbivore and Carnivore animals	All types of animals
Development software used	● Unity 3D Engine ● Vuforia	● Unity 3D Engine ● Vuforia ● 3D Blender ● Photoshop Cs6	● Unity 3D Engine ● Vuforia
AR Interaction Used	Touch screen interaction	Touch screen interaction	Touch screen interaction
Tracking Method	Markerless	Image Marker	Marker-based
Display device used	Handheld Device	Handheld Device	Handheld Device
Target User	Kindergarten Children	Children	5-6 years old kindergarten children

III. METHODOLOGY

Figure 1 showed the methodology of the three main phases and the details were further described in the following sections.

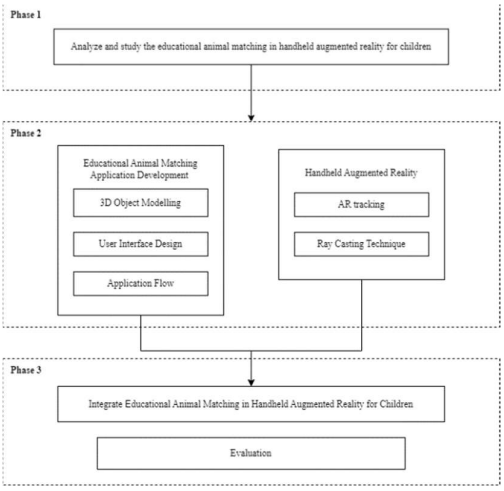

Figure 1. Project Methodology

A. Phase 1: Analyse and study the educational animal matching in handheld augmented reality for children

The first phase of this project methodology described the Augmented Reality (AR) technology, handheld AR, and the approaches of educational animal matching in handheld AR. In handheld AR, AR interaction, touch screen interaction, and AR tracking were studied to design and develop a suitable handheld AR application for children. Further analysis and study of the handheld AR application was discussed in the literature review of Chapter 2.

B. Phase 2: Design and develop the educational animal matching application with handheld augmented reality

In the design and development phase, the application development in handheld AR was described based on the research information gathered in the first phase. The animal three-dimensional (3D) object modelling and user interface were designed to develop the animal matching application. Besides, the flow of the animal matching application, which included the ray casting technique of handheld AR, was designed and developed to ensure the application could be integrated in the next phase. The AR tracking process was also developed in this phase, which included the image marker created from the Vuforia Software Development Kit (SDK) and further integrated in Unity game engine.

C. Phase 3: Integrate the educational animal matching application in handheld augmented reality for children and evaluate the project outcome.

After the design and development were completed, the educational animal matching application in handheld AR started to be integrated. The animal object model, the interface of the application, AR marker tracking, and the ray casting technique were integrated to complete the project prototype. The animal matching application was designed for children to learn about the sound and the name of the animal through touch interaction. Additionally, the handheld device was required to integrate this application. After integrating this simple AR animal matching application into the handheld device, the testing and evaluation of the project prototype were carried out to collect feedback for further improvement.

IV. APPLICATION DEVELOPMENT DESIGN

This section explains the development design of the Educational Animal Matching Application. It includes the animal matching application flow, randomized animal design and AR tracking and interaction. There are as follows:

A. AR Tracking and Display

In handheld AR interaction, this application used AR tracking with Vuforia Software Development Kit (SDK) and ray casting technique interaction. Figure 2 defined the process of AR marker-based tracking with ray casting technique interaction. For the AR tracking, the AR camera searched for the input image marker, and the user had to hover the handheld device's camera over the image marker saved in the Vuforia database. By using the Vuforia SDK, the marker pattern of the input image marker was identified and had to match the image marker uploaded in the Vuforia database. Then, the viewpoint of the marker was calculated with position and orientation to recognize the marker and allow the display of the virtual object on the image marker. Additionally, the ray casting technique interaction was implemented during the display of the virtual object while playing the animal matching application. For the ray casting technique interaction, the user could ray cast the virtual animal to hear the sound of the animal and select the animal to match the parent and baby animal.

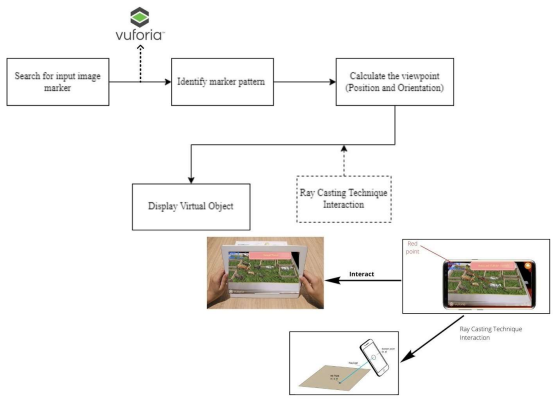

Figure 2. AR Marker based Tracking Process with Ray Casting Technique Interaction

B. Animal Matching Application Flow

The educational animal matching application was an application designed for children to learn about and recognize a variety of animals by playing the animal matching game. Figure 3 depicted the flow of the application. According to Figure 3, the user had to enter a username to play the application. After entering the username, the user could choose to view a guide that explained how to play the AR application. Once the user was ready, the user could start playing the application. The next step was to open the camera and scan the AR image marker, which would allow the virtual object to be placed in the real-world environment. Once the virtual object appeared, the user could begin playing the animal matching game by using the ray casting technique to interact with the objects and match the parent animals with their respective baby animals. When a virtual animal object was selected for matching, the sound of that animal would play, and the name of the animal would be displayed at the top. The matched animal would then be released into a fenced area. Once the user finished matching all the animals, the results of the animal matching game would be displayed. At this point, the user had the option to repeat the animal matching game by returning to the main menu, view their score for the matching game, or go back to the home screen.

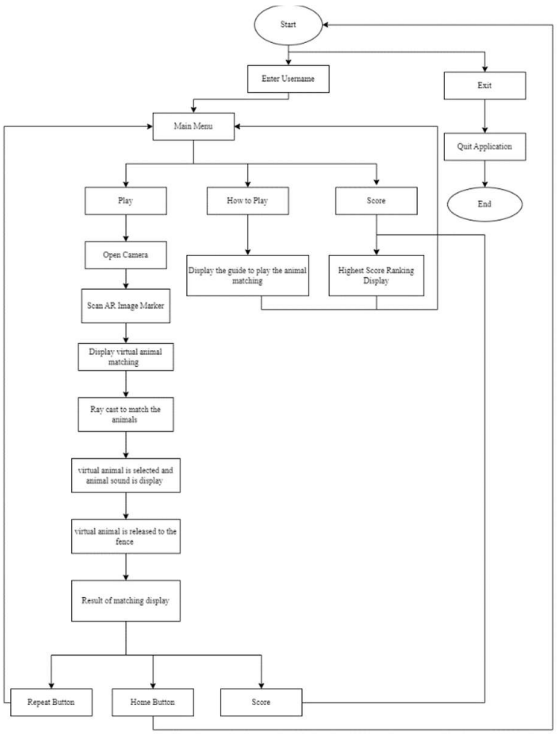

Figure 3. Flow of Application

C. *Randomized Animal Design*

The randomized animal was designed to generate a random set of animal pairs and place them on an image target. When the algorithm started, the algorithm shuffled an array of animal pairs using the Fisher-Yates algorithm. Then, a subset of animal pairs was randomly selected from the shuffled array. The algorithm also shuffled an array of positions where the animals would be placed.

Each selected animal pair, a mother and baby animal, was instantiated. Random positions were generated within a confined space on the image target. The mother and baby animals were then placed in random positions. The shuffled positions array ensured that each animal pair was placed at a different random position on the image target. The algorithm randomly selected animal pairs shuffled the positions, and instantiated the animals on an image target, ensuring a varied and randomized arrangement of mother and baby animals. Figure 4 presented the design algorithm of randomized animal and position.

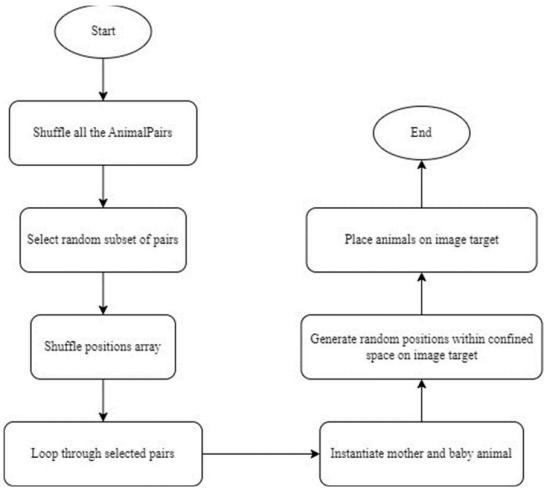

Figure 4. Randomized animal and position design diagram

V. IMPLEMENTATION

A. *Random Animals*

For the AR animal matching, each matching uses 5 sets of farm animals. In each matching, the 5 sets of farm animals will randomly place on the field on the AR animal matching scene as shown in Figure 5. There is a list of 9 sets of farm animals used and 5 sets of animals will be randomly selected and randomly placed in random positions in the scene.

Figure 5. Random animal place on the field in the AR animal matching scene

B. *Ray Casting Technique Interaction*

The ray casting technique interaction is used on selecting the animal. The mother animal is having the mother tag while the baby animal is having the baby tag. Figure 6 shows that the ray is based on the center point on the screen. When the ray cast hits the collider of animal that has mother or baby tag, the hit will trigger the selection of animal and the selection needs the user to hold for three seconds to continue to next step.

Figure 6. Animal selection scene

C. Animal Matching

For the animal matching, after the user scans the AR image marker, the scene will show the 5 sets of farm animals randomly placed on the field in the AR animal matching scene and the timer will start to countdown. Then, the user can select the mother or baby animal by using ray casting technique and hold for 3 seconds to trigger the selection. After the selection of animal, the user can select the respective fence to place the animal by using ray casting technique and hold for 3 seconds to trigger the selection. After the selection, the mother or baby animal will move and release to the respective fence waiting for matching their mother or baby animals. After that, the user can select the match mother or baby animals by using the same method of selection and the match mother or baby animal will then move and release to the respective fence for checking whether the mother animal is match with their baby animal as shown in Figure 7.

Figure 7. Check matching animal scene

VI. Result and Evaluation

A. Result

The result of the project is a prototype of educational animal matching in handheld augmented reality with Vuforia augmented reality (AR) software development kit (SDK). The prototype is using touch-based interaction and ray casting technique to display the three-dimensional (3D) animal model on the AR image marker in handheld devices. The user can start the application and interact with the animal matching by placing the AR image marker in front of the device to allow the AR tracking. The 3D animal models of the animal matching are rendered and displayed on the device's screen. The animal will be placed at a random place on the field and the user can select the animal to match the animal before time's up. Figure 8 shows the scene after the 3D animal models display on the AR image marker and the user interacts with animal matching.

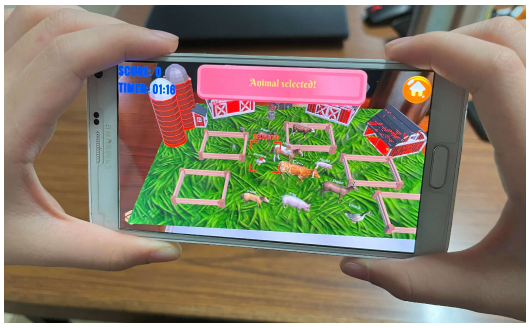

Figure 8. Scene after the 3D animal models display on the AR image marker

B. Evaluation Result

The evaluation results based on the questionnaires provide a comprehensive understanding of the respondents' backgrounds, as well as their experiences, feedback, and satisfaction with the prototype. The positive ratings and agreement on various aspects of the prototype indicate that it was well-received and met the expectations of the users, particularly in terms of attractiveness, user-friendliness, accurate animal matching, clear instructions, and overall satisfaction. However, the mixed responses on certain statements suggest that there may be areas for improvement, such as the effectiveness of AR tracking and the ease of controlling virtual objects. Taking these findings into account, further refinements to the prototype could enhance the user experience and overcome any shortcomings.

VII. Conclusion

The project is developed with the educational animal matching application with handheld augmented reality using ray casting technique. The animal matching and types of animals is being studied for developing the suitable educational animal matching application for children. The flow of animal matching application in handheld AR and the educational of animal for children is evaluated to ensure that this application can give better interactive and realistic animal learning experiences for children.

The project limitation is the lack of other types of animals for the users to play the application and learn the animals such as wild animals, reptile's animal and so on. The application's purpose is to help users learn about animals. By offering a limited range of animals, specifically excluding categories such as wild animals and reptiles, the educational value may be diminished. Users might miss out on the opportunity to explore and learn about a wider variety of animal species and their characteristics.

In the future work, the prototype can enhance the educational value and engagement of the application by expanding the range of animals. Incorporating wild animals, reptiles, and other lesser-known species will allow users to explore and learn about a broader variety of animals and their characteristics. The enhancement can be achieved by conducting thorough research and incorporating accurate information and interactive content

for each new animal species. Regular updates can introduce new animal additions, ensuring the application remains dynamic and encourages users to continue exploring and learning.

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