Implementation of Augmented Reality Technology as a Learning Media for Solid Figures Formula

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ABSTRACT

The majority of people think that math is a difficult subject for students to understand and master. In the subject of mathematics, there is a material of solid figures which is one part of the field of geometry. Solid figures is a shape that has a volume and sides that limit it and is a three-dimensional shape. In this case, the opportunity for augmented reality technology is deemed appropriate to be a solution to student learning needs. Students can see objects with different learning experiences and are easier to understand. Therefore, the design of AR learning applications for solid figures is very important to be an interesting and effective learning solution. This system design is made using Unity and Vuforia, users can use the application by using a smartphone to scan 3D objects on the marker. The marker that has been made before will display 3D objects in the form of solid figures as a learning medium for students.

General Terms

Android, Unity 3D, Vuforia, Blender

Keywords

Augmented Reality, Solid Figures, Marker, Formula

1. INTRODUCTION

Mathematics is an important school subject because of its usefulness in our technologically-rich society and the value it has as a critical filter in educational and career opportunities [1]. As students progress through school, they are expected to develop their mathematical reading skills, which can include the development of general reading skills as well as skills specific to the subject [2]. In mathematics lessons, there is material about the building space which certainly requires visualization of 3D objects so that student learning becomes interesting and effective. With the help of AR technology, students will be more excited in learning the material.

Augmented Reality created by using qualitative method to collect and analyze the elementary students data and Marker Based Tracking method resulting an application that has a function as a [3] tool to display 3D objects as learning materials for elementary school students. A target is an object that the AR software recognizes and uses as an orientation to display virtual content [4]. Additionally, in participation, the technology offers a motivational solution and creates an overall higher acceptance and awareness of the plan, making the participants more engaged and represented in the planning process [5]. By using AR, additional information and graphics can be placed directly into the field of view of the user, either at a fixed location in their actual field of view or onto a fixed location at the crime scene [6].

This design is used for learning media for elementary school students so that they are not bored in learning math because it has many 3D objects that can be displayed and studied. The mobile AR application is to provide interactive visualization and real-time numerical simulation to promote students' active learning in the classroom [7]. The main purpose of this study is to design, develop and reveal the effect of an AR material to improve spatial ability in secondary school students using mobile devices [8]. The application was built using Unity 3D and Vuforia software. Unity 3D is a game engine that originated in Denmark and was developed by the developer Unity Technologies. It is not only easy to learn, but also cross-platform, which makes it popular among game developers at home and abroad [9]. The use of 3D attributes is an emerging field, but there is scant information on the range of 3D metrics that can describe the physical attributes of landscapes and which relate to the perception of landscape quality [10]. Vuforia AR Software Development kit utilizes technology to recognize and analyze camera input from the real world developed by Qualcomm and fully supported by the Unity game engine [11]. The software development tool (SDK) Vuforia was also used, which contains many libraries that facilitate the creation of augmented reality mobile applications and provides different types of options for viewing, taking video and for exploration of recurring events of the captured images, in order to calculate in real time the position of the camera and the location of the markers [12].

2. RESEARCH METHOD

The proposed system analysis in the design of the application system can be visualized in Figure 1 Architecture Model.
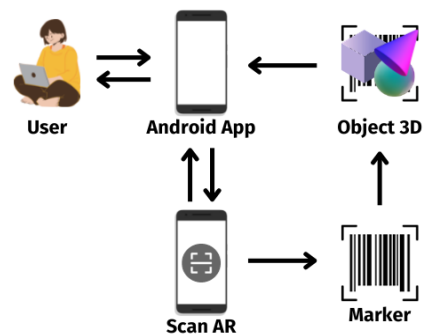

Fig 1: Architecture Model

Compared with 2D object detection, 3D object detection also needs to estimate the oriented 3D regression boxes from unstructured or heterogeneous data, which makes it more difficult [13]. AR Solid Figures application users can run the system by detecting markers provided to display objects through the camera sensor on a mobile device. Then the 3D object will appear on the smartphone screen and provide information and description of the scanned 3D object.

2.1 Data Collection Procedure

This system design has gone through 3 stages of data collection as material used in making augmented reality learning applications.

2.1.1 Literature Study

Reference data collection as an understanding of the theory and basic concepts of the application is obtained through scientific journals and books found on Google Scholar. The data obtained is then researched as a first step in designing the application.

2.1.2 Interview

We conducted interviews directly at the location of the elementary school, namely SD Negeri Ngemplak Nganti. Activities carried out include interviews with teaching staff and students at the school, we also conduct questionnaires to students at the school. These activities are carried out in order to obtain accurate data needed to build AR Solid Figures applications.

2.1.3 Data Collection Time

The data collection time required is 6 months from December to May. Data collection that requires a short time is certainly aimed at building an optimal application according to the needs of the school.

2.2 System Design Logic

System logic design is a clear and complete description of a system regarding the system to be built. In this case we use Flowchart as a system workflow and UML (Unified Modeling Language) as a visual modeling method used to design and model software systems. Flowcharts provide an alternative approach to teaching complex content, which allows students to organize and summarize information that promotes meaningful learning [14]. Unified Modeling Language (UML) has become a de facto standard for design, specification and modeling of object oriented software systems [15]. UML uses visual modeling tools to enable developers to obtain an accurate and complete understanding of the target system through the integrated engineering definition, analysis, design, production, testing and maintenance process of the structural and behavioral characteristics of system requirements [16]. In this research we use Use Case Diagrams and Activity Diagrams as a visual modeling method from UML for designing AR Solid Figures.

2.2.1 Flowchart

In Figure 2 Flowchart below explains the workflow of the system that has been created. The user starts the application then enters the Main Page, then there are several menu options that have their respective functions. The first option is Marker which functions to display 3D objects, the second option is Display Guide which functions to display application guides, the third option is Information about the application addressed to the user, and the last fourth option is Quiz Show which can be used by the user.
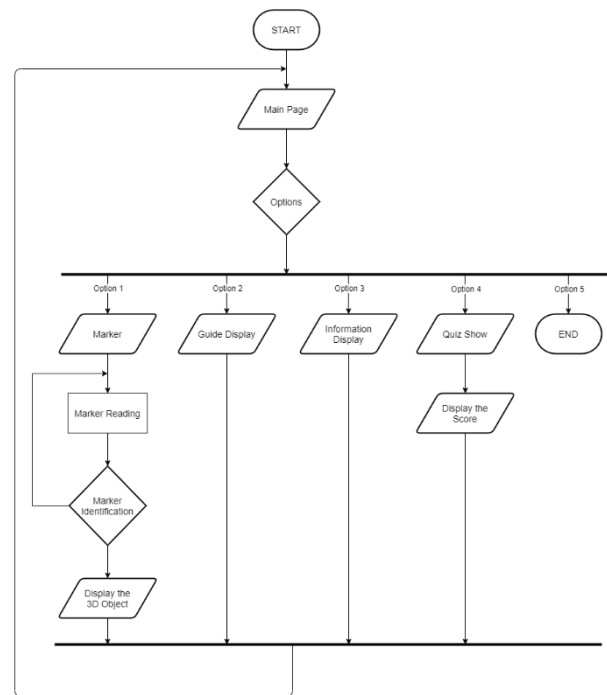

Fig 2: Flowchart

2.2.2 Use Case Diagram

In the Use Case Diagram scenario, it is used as an interaction between users and the functions of the system being built.
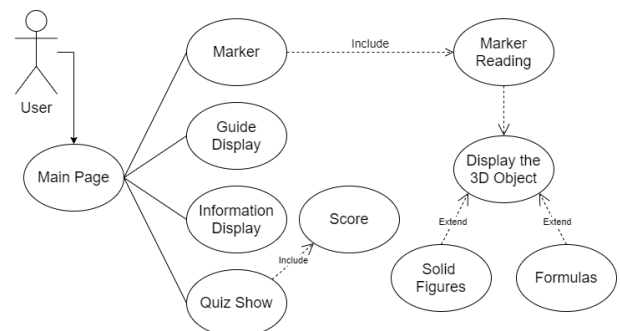

Fig 3: Use Case Diagram

3D object detection algorithms have become increasingly important in the industrial and academic communities in recent years [17]. In the diagram above, it can be seen that users can interact with the system. Users perform activities on each menu in the application, especially in scanning markers and then displaying 3D objects.

2.2.3 Activity Diagram

Activity diagrams are used to model workflow systems, service oriented systems and business processes [18]. This diagram illustrates a user performing actions on the app and running the app to display 3D objects. Thereby automatic generating test case from UML activity diagram became systemic, feasible and effective [19].
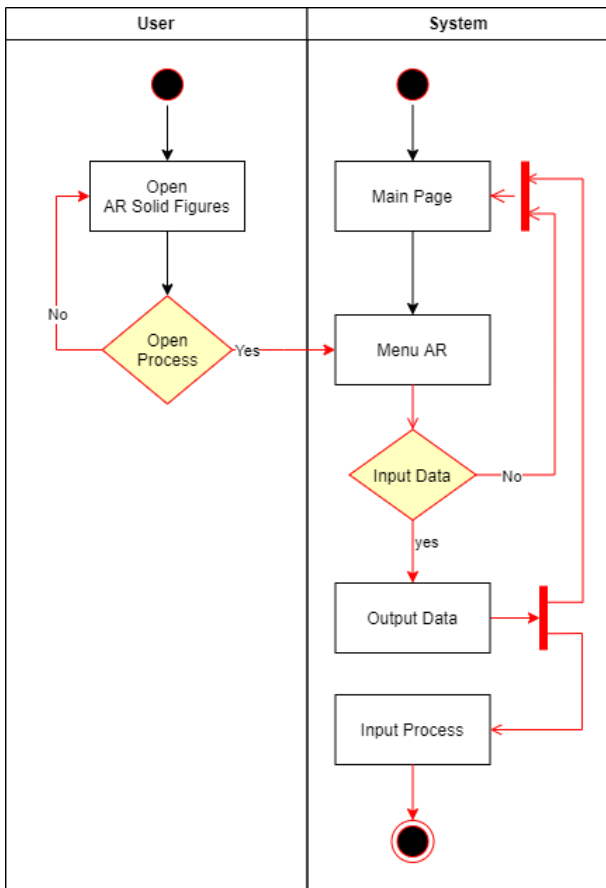
Fig 4: Activity Diagram

2.3 Physical Design

Entity relationship model (ERD) is used to explain the relationship between the database system and the basic objects that have relationships between these objects. Entity relationship diagram (ERD) is one of the main diagrammatic representations of a conceptual data model that reflects users' data requirements in a database system [20].
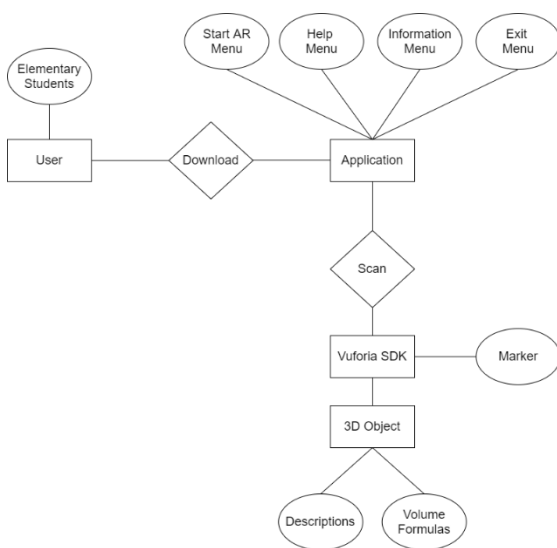

Fig 5: Entity Relationship Diagram

2.4 Interface Design

Interface design is the implementation process of the application wireframe design using Whimsical. The wireframe display includes the menu structure contained in the AR Solid Figures application as a learning media for students. Wireframes are nevertheless among the most influential and most important prototype methods because the most innovative ideas tend to arise from them [21].

2.4.1 Main Page

This Main Page directly displays the main menu of the AR Solid Figures application. The available menus include Start AR, Quiz, Help, Information, and Exit.

Fig 6: Main Page

2.4.2 Scan Marker Page

On the Scan Marker Page, it shows how the camera scans the marker. A successfully scanned marker will display a 3D object along with its description.

Fig 7: Scan Marker Page

2.4.3 Help Page

The Help page displays information about using the app. Users can follow the app usage guide if they are confused about starting the app.
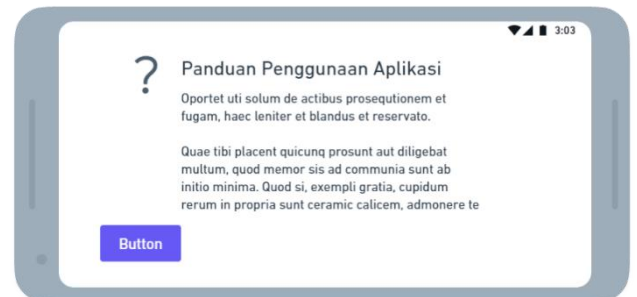

Fig 8: Help Page

2.4.4 Information Page

The Application Information page displays a brief overview of the application and the developer's bio. This information aims to make users aware of the application and get closer to the developer.

Fig 9: Information Page

3. RESULT AND DISCUSSION

3.1 Assumptions

The assumption in the Solid Figures AR Application is that users can use this application to scan markers and display 3D objects along with their descriptions. Users can also perform activities on other menus provided.

3.2 Hypothesis

This hypothesis is based on assumptions obtained and proven in the research stage. The hypothesis of this research is "Mobile Augmented Reality Application as a learning media for solid figures can increase enthusiasm and new experiences for students".

3.3 Run an Experiment

This software was created using the Unity 3D tool with the C# programming language. This software uses markers to display 3D animations or buildings, the markers are stored in Vuforia tools as a database. In addition, it also uses the blender tool to create 3D objects. It is expected that each function on the system can run well and optimally.

3.3.1 Main Page

The Main Page contains the main menu including Start AR as the main feature of scanning markers to display 3D objects, Quiz for knowledge training to users, Help as an application usage guide for users, and Info as information about the application and developer.
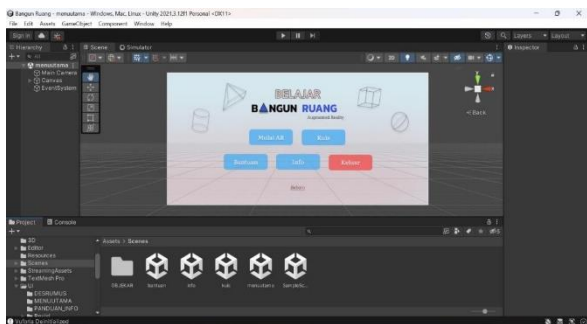

Fig 10: Implementation Main Page in Unity

Fig 11: Main Page

3.3.2 Scan Marker Page

Scan Marker page when the camera is ready to scan the marker. The user can point the camera at the provided marker and wait for the process until the 3D object is displayed along with its description and formula.

Fig 12: Scan Marker Page

3.3.3 Quiz Page

The Quiz page is used by users as an exercise or game that aims to motivate and increase students' enthusiasm for learning.
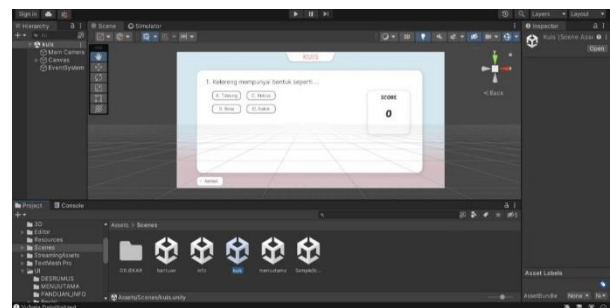

Fig 13: Implementation Quiz Page in Unity

Fig 14: Quiz Page

3.3.4 Help Page

The Help page aims to provide detailed application usage guidelines to users.

Fig 15: Implementation Help Page in Unity

Fig 16: Help Page

3.3.5 Information Page

This page displays information about the application as knowledge about the purpose of the application and also displays the developer's bio to get closer to the user.
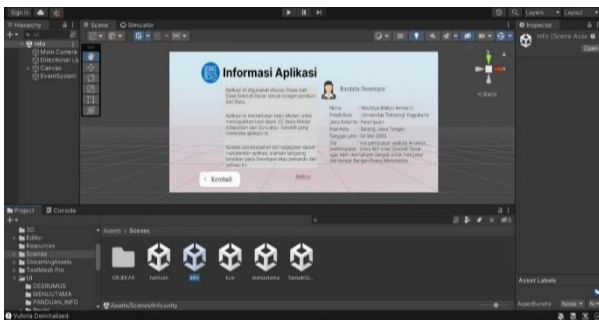

Fig 17: Implementation Information Page in Unity

Fig 18: Information Page

3.3.6 Markers in Vuforia

The markers created as a database were loaded into the Vuforia SDK along with Unity 3D. The markers are various shapes of solid figures that will be used in the application.
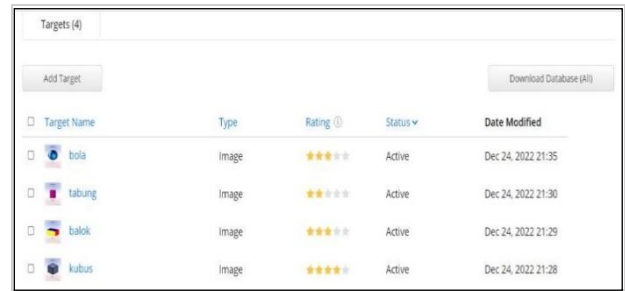

Fig 19: Markers in Vuforia

3.4 Discussion of Result

The implementation of the application has been completed and the next is to conduct testing which aims to find out whether there are errors in the program or not. In testing this application we use black-box which focuses on the functional specifications of the software. The tester, in black box testing only knows about the input (process by a system) and required output, or in the other word tester need not know the internal working of the system [22].

Table 1. Black-box Testing

Testing Activity	Expected Results	Testing Results	Conclusion
Main Menu	Menu functions can be executed	Menu buttons can function properly	Accepted
Scan AR Page	Can scan markers	The camera function is running and can scan markers to display 3D objects.	Accepted
Help Page	Display the app guide clearly	Clear and complete application guidelines	Accepted
Information Page	Information is well displayed	The page functions properly and displays complete information	Accepted
Quiz Page	Quiz can run	Display quiz questions and score results	Accepted

4. CONCLUSION

Based on the results of research on learning applications and formulas of building space using augmented reality, it can be concluded that the design of the application can attract the learning interest of fifth grade students of SD Negeri Ngemplak Nganti. The objective of this investigation is better understanding of the dominance of leading mobile apps and the future trend of mobile apps designed for the global market [23]. Application development by utilizing smartphones as optimal learning media can motivate students in learning mathematics. Attractive interface design and many application functions make the application easy to run.

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