Android-Based Augmented Reality Application for Batak Musical Instrument Recognition

Rio Septian Hardinata, Taufik Al Fardoh , Zulham Sitorus

Abstract

Indonesia's vast archipelago has given rise to a rich diversity of ethnic groups and customs. This diversity is reflected in the country's many languages and cultural expressions—one of the most distinctive being music. Traditional music is typically performed with instruments that have been used for generations, although in some regions modern instruments are also employed to accompany traditional pieces. In North Sumatra, particularly within Batak Toba culture, several traditional instruments are commonly used to accompany dances and ceremonial events. These instruments are often considered indispensable for customary ceremonies. However, as time passes, public awareness and appreciation of traditional musical instruments have declined. Augmented Reality (AR) is a medium that blends images, video, audio, and text into the real-world environment, allowing users to feel as though they are directly experiencing what they see. The development of AR technology on smartphones can greatly help students learn about Batak Toba musical instruments. This study presents the design of an Android-based AR application for recognizing Batak Toba traditional instruments. The application features three-dimensional visuals that correspond to the actual instruments, concise textual descriptions, audio explanations, and samples of each instrument's sound. Overall, the "Android-Based Augmented Reality Application for Batak Toba Musical Instrument Recognition" was implemented effectively according to the proposed concept and design. The application was developed using the C# programming language, Unity 3D for application development, Blender for creating 3D objects, and Adobe Photoshop CS3 for logo design. This AR application offers a new and engaging way for students in Indonesia—especially in North Sumatra—to access concise information about Batak musical instruments.

***Keywords**:*Aplication,Android, Augmented Reality (AR); Blender; Musical Instruments; Batak.

Rio Septian Hardinata[1]
[1]Lecturer in the Computer Science Study Program, Universitas Pembangunan Panca Budi, Indonesia
e-mail: rioseptian@dosen.pancabudi.ac.id[1]

Taufik Al Fardoh[2], Zulham Sitorus[3]
[2]Computer Science Students, Universitas Pembangunan Panca Budi, Indonesia
[3]Head of the Master of Information Technology Study Program, Universitas Pembangunan Panca Budi, Indonesia
e-mail: zulhamsitorus@gmail.com[3]
2nd International Conference on Islamic Community Studies (ICICS)
Theme: History of Malay Civilisation and Islamic Human Capacity and Halal Hub in the Globalization Era
https://proceeding.pancabudi.ac.id/index.php/ICIE/index

Introduction

Indonesia's vast archipelago has given rise to a remarkable diversity of ethnic groups and traditions. This diversity is reflected in the country's many languages and cultural expressions—one of the most distinctive being music. Traditional music is typically performed with instruments that have been used for generations, though some regions also incorporate modern instruments to accompany traditional performances. In North Sumatra, Batak traditional music features several instruments commonly used to accompany dances and ceremonial events, and these instruments are often considered essential for customary rituals.

To ensure this cultural heritage is not lost over time, preservation efforts are needed so that knowledge of Batak history and traditions can be passed on to younger generations. The development of an augmented reality–based application for recognizing Batak musical instruments aims to introduce Batak culture to people across Indonesia. With this application, we hope to spark curiosity about Batak culture and foster a deeper appreciation for it.

Augmented Reality (AR) is a medium that integrates images, video, audio, and text into the real-world environment, enabling users to experience digital content as if it were present around them. Leveraging AR technology to present Batak traditional instruments can help users—especially students—learn in a more engaging, interactive way.

Education is a deliberate effort to cultivate and improve human well-being. It has a direct impact on quality of life. In today's era of rapid technological advancement, learning can take place actively and interactively. Teachers must not only teach but also be creative and innovative so students remain engaged and do not grow bored during lessons. In the learning process, methods and media are inseparable, and there are now many technologies that make teaching and learning more effective.

Human life is closely intertwined with rhythm—the pulse and heartbeat each have their own patterns. The right hemisphere of the brain becomes active when exposed to music, and the brain's response varies depending on the type of music. Music is widely believed to spark imagination and surface latent potential within individuals. It can also stimulate connections between neurons; when someone listens to music, specific neural pathways are encouraged to connect more frequently.

This study aims to develop an Augmented Reality (AR) application for Batak Traditional Musical Instruments that can help introduce these instruments to users and serve as a learning medium for Cultural Arts classes in schools. The application is built using Unity 3D and the Vuforia SDK and runs on Android devices. It presents augmented content in the form of three-dimensional (3D) objects.

Literature Review

2.1 Music

Music is an integral part of life; therefore, it should also be an integral part of the school experience. Numerous studies have shown that music can be used to motivate learning in mathematics, social studies, language arts, science, history, and more. As a universal language, music can be integrated across all subject areas to enrich instruction. Because music helps make schools joyful places—and belongs to children collectively—teachers should leverage the motivation that music stimulates to enhance students' engagement and learning. (Benjamin, 1981)

2.2 Android

Android is a mobile operating system. It does not distinguish between core applications and third-party applications; the provided Application Programming Interfaces (APIs) offer access to device hardware, phone data, and even system data.

According to Murya (2014, p. 3), Android is a Linux-based operating system used for mobile devices such as smartphones and tablet computers (PDAs). Android provides an open

platform for developers to create applications for a wide variety of mobile devices. Today, Android has become the world's most popular mobile operating system. Its growth is inseparable from the role of Google. Android was originally founded by Andy Rubin, Rich Miner, Nick Sears, and Chris White in 2003 (Ceryna Dewi et al., 2018).

As technology advances, global digital communication has accelerated so rapidly that events in the Western hemisphere can be known in the East within seconds. This increasingly sophisticated communication is a hallmark of globalization and brings both positive and negative impacts across many areas of life. These developments must be matched by productive human resources. At the same time, people now often spend more time on mobile phones than with books, prompting literacy movements to rekindle a love of reading. In parallel, companies are competing to develop creative ideas that deliver value in this modern era, leading to a steady stream of increasingly advanced technological products.

Android is designed for touch-screen mobile devices such as smartphones and tablets. Interestingly, the platform's initial development was not intended for phones but to create an advanced operating system for digital cameras. When it became clear that the market for camera devices was not large enough, development shifted to smartphones. The primary function of the Android operating system is to act as a bridge between the device and the user's applications, enabling users to interact with their device and run apps that simplify digital activities. As Supardi (2014, p. 2) notes, Android is a Linux-based operating system for mobile devices that encompasses the operating system, middleware, and applications.

2.3 Augmented Reality (AR) Media

Augmented Reality (AR) is a medium that blends images, video, audio, and text into the real-world environment, allowing learners to feel as though they are directly experiencing the content they see. Dewi & Sahrina (2021, p. 1081) note that AR media can attract and motivate students. Masri & Lasmi (2018, p. 40) further explain that AR can make previously two-dimensional objects appear realistic and seamlessly integrated with their surroundings in real time and in three dimensions. An illustrative AR diagram (see Figure 1) shows how AR merges the physical and the virtual (Haryani & Triyono, 2017).

Ronald T. Azuma (2008) defines augmented reality as the combination of real and virtual objects in a real environment, running interactively in real time, with accurate three-dimensional registration (i.e., virtual objects are properly aligned with the real world). This merging of real and virtual content is enabled by appropriate display technologies; interactivity is achieved through specific input devices; and high-quality integration requires effective tracking.

Similarly, Stephen Cawood and Mark Fiala, in their book *Augmented Reality: A Practical Guide*, describe AR as a natural way to explore 3D objects and data—a concept that fuses virtual reality with the real world. As a result, 2D or 3D virtual objects can appear lifelike and integrated into the physical environment. With AR, users observe the real world around them enhanced by computer-generated virtual objects (Nugroho & Pramono, 2017).

From these points, it can be concluded that AR media has been used by various researchers; however, in this study AR will be employed to examine its effectiveness in learning, particularly its impact on students' cognitive outcomes (Qorimah & Sutama, 2022). AR is considered a subset of the Virtual Environment (VE) domain—commonly associated with Virtual Reality (VR)—but differs in that AR overlays virtual elements onto the real world as viewed from the same place. AR generally exhibits three core characteristics: it is interactive, operates in real time, and supports accurate 3D registration/integration of virtual and real objects, thereby enhancing user interaction and perception of the environment.

Research Methodology

The development model used to build the AR application is the waterfall model. The waterfall method, introduced by Winston W. Royce in 1970 to describe software product practices, consists of five phases: analysis, design, implementation, testing, and maintenance. Each phase of the waterfall model is shown in the figure.

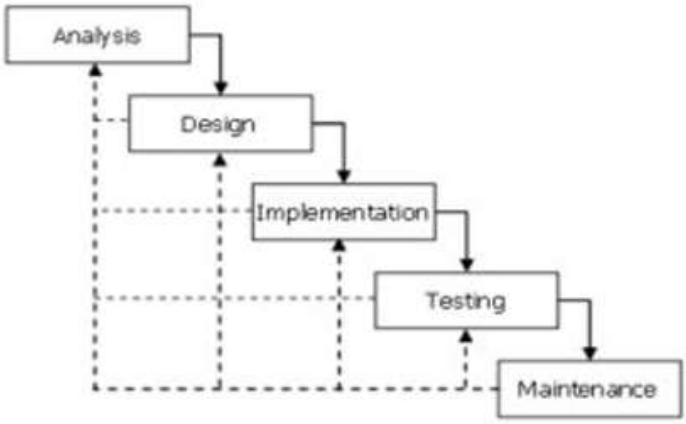

Figure 1. Phases of the Waterfall Model

a) **Analysis**
In this phase, data are collected to obtain information about the software to be developed, aligned with user needs. Data collection techniques may include observation, interviews, and questionnaires.

b) **Design**
This phase translates the requirements gathered during analysis into a software design. The deliverables include application sketches and models, often using UML.

c) **Implementation**
After the design is completed, the software application is built and developed—in this case, an application that utilizes Augmented Reality technology.

d) **Testing**
During testing, the software is verified and validated. This phase aims to identify and fix errors (debugging). The overall testing process includes unit testing, integration testing, system testing, and acceptance testing.

e) **Maintenance**
The final phase involves product installation and ongoing maintenance. Activities include deploying the application, fixing issues that arise in production, and performing updates or enhancements as needed.

To support the preparation of this study, a well-defined framework with explicit stages is required. This framework outlines the steps to be taken in addressing the research problem. The research stages describe the sequence of activities the researcher will carry out. The knowledge base embedded in the application design will serve as an instructional medium to introduce traditional musical instruments of North Sumatra, particularly those of the Batak Toba. The knowledge base is drawn from relevant literature.

The stages of the research are as follows: data collection, application design, application development, application testing, and report writing. The flow of these research stages is illustrated in the figure below.

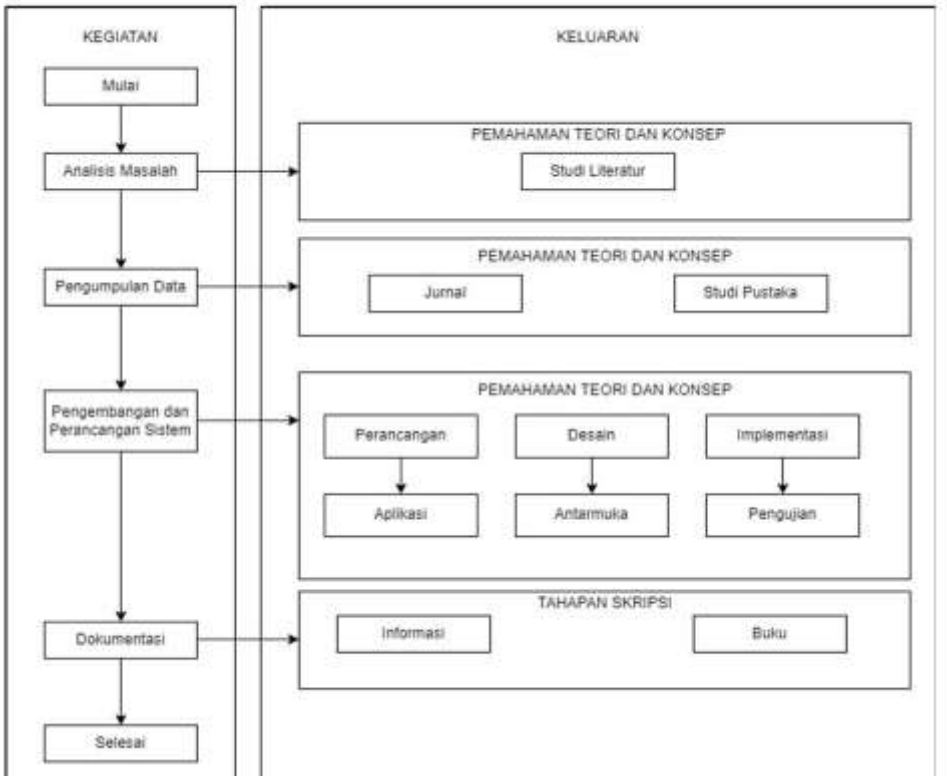

Figure 2. Research Workflow Architecture

3.1 Use Case Diagram

A use case diagram depicts the interactions between users (actors) and a system. It describes typical scenarios of how users engage with the system through narratives that illustrate system usage. The ordered sequence of steps that explains the exchange between the user and the system is called a *scenario*.

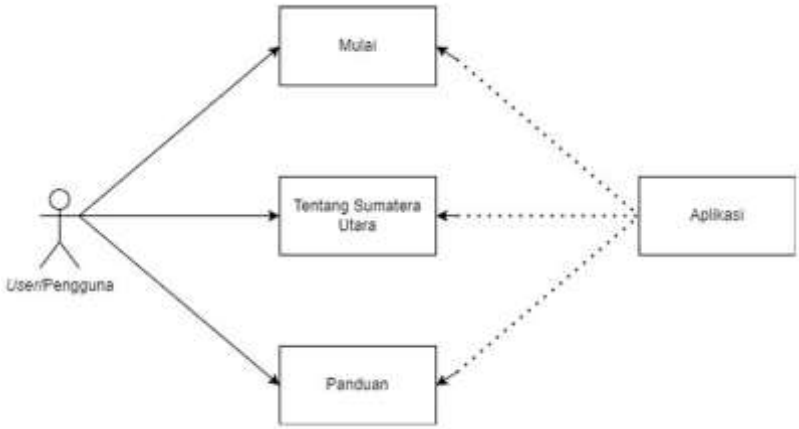

Figure 3. Use Case Diagram Design

3.2 Activity Diagram

An activity diagram depicts activities, objects, states, state transitions, and events. In other words, it models the workflow of a process and illustrates the system's behavior for a given activity, including control flow (start/end nodes, decisions/merges, forks/joins) and, when needed, responsibilities via swimlanes.

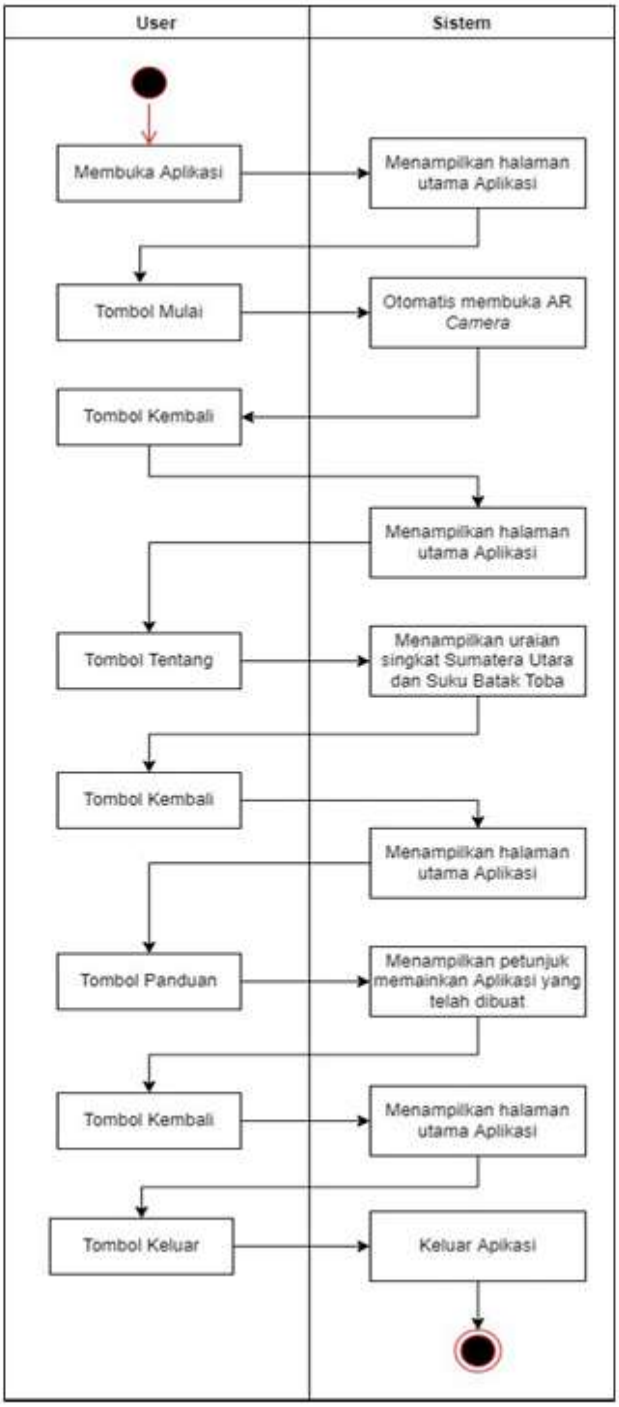

Figure 4 Activity Diagram

Results

4.1 Main Components in System Implementation

To determine whether the developed interface operates properly, the system must be tested. Accordingly, several components are required, covering both hardware and software.

The table title is at the top, while the image title is written below. If tables and figures can be included in a single column, then the writing example is as follows:

4.2 Hardware Used

The hardware employed in this study is as follows:

1. Laptop used for application design:

- CPU: Intel Core i5-4210U
- RAM: 12 GB
- SSD: 512 GB

4.3 Software Used

The software utilized in this study includes:

1. Operating System: Microsoft Windows 10
2. Code Editor/IDE: Visual Studio Code
3. 3D Modeling: Blender 3.1
4. Game Engine / AR Platform: Unity 3D
5. AR SDK: Vuforia
6. Graphic Design: Adobe Photoshop CS3

4.4 Application Interface

This subsection presents the user interface and design of the Android-based Augmented Reality (AR) application for introducing Batak Toba traditional musical instruments. It showcases the layout, navigation flow, and key screens to illustrate how users interact with the application.

4.5 Main Menu Interface

The following figure shows the application's main menu screen.



Figure 5. Main Menu Interface

The system interface is designed to be simple, consistent, and easy to learn. On the splash screen, users are greeted with the app logo and a brief title that reflects its purpose—an AR-based introduction to Batak Toba traditional musical instruments. From there, users land on the Main Menu, which presents primary actions: "Start AR/Scan," "Instrument Catalog," "Help," and "Settings." Clear visual hierarchy, readable typography, and intuitive icons guide users smoothly, including first-time users.

When "Start AR/Scan" is selected, the interface switches to the camera view with a scanning guide frame and concise instructions, such as "Point the camera at the marker." A stability indicator (e.g., focus icon or distance hint) helps users achieve optimal detection. Once the marker is recognized, the 3D instrument model appears as if anchored in the real environment. Persistent "Help" and "Back" buttons on the top bar ensure quick access to guidance or a return to the previous screen.

In AR mode, interaction controls are ergonomically arranged: rotate, zoom, and pan controls are placed within thumb reach. Multi-touch gestures are enabled to enrich the experience (pinch to zoom, drag to rotate/pan). A floating "Info" button in the lower right opens

a description panel showing the instrument's name, origin, role in ceremonies, and basic playing techniques. This appears as a bottom sheet card that can be swiped up for full details or dismissed to refocus on the 3D object.

Audio features are integrated via a "Play Sound" button that triggers a short sample characteristic of each instrument. Users can pause or replay audio and adjust volume without leaving AR mode. For classroom use, a "Favorite" (or "Bookmark") action lets teachers and students save instruments for quick access in lessons. Smooth transitions and tasteful micro-interactions maintain immersion and prevent disorientation during navigation.

Within "Settings" and "Help," users can calibrate the camera, choose language, adjust text size (accessibility), and review best practices for lighting and scanning distance. If marker detection fails, the interface provides clear feedback and step-by-step suggestions (e.g., "Improve lighting or move the camera closer to the marker"). All screens are tested for responsiveness across Android device sizes, with attention to performance: 3D models are optimized for load time, and a loading indicator reduces perceived wait. Overall, the interface is informative, engaging, and supportive of an effective, inclusive learning experience.



Figure 6. Screen Display Once the AR Camera Recognizes a Marker/Barcode

Conclusion

This study successfully designed and implemented an Android-based Augmented Reality (AR) application to introduce Batak Toba traditional musical instruments. By integrating 3D visuals, descriptive information, and audio samples, the application provides an engaging, interactive learning experience that can enhance students' curiosity and understanding of local cultural heritage. Built with Unity 3D, Vuforia, Blender, and C#, the system demonstrated reliable marker detection and smooth interaction (rotate, zoom, pan), making it suitable as a complementary learning medium in Cultural Arts classes and informal cultural literacy programs.

Nevertheless, several areas warrant improvement and further research. Performance can be optimized for lower-end devices, and content breadth can be expanded to include more instruments, playing techniques, and contextual narratives (e.g., ceremonial uses). Future work may also incorporate markerless AR, multilingual support, learning analytics, and assessment features to measure cognitive gains. With these enhancements, the application has strong potential to scale as a sustainable digital platform for preserving and promoting Indonesia's traditional music—especially that of the Batak.

References

[1] Ariska, K. (2020). Penggunaan Alat Musik Tradisional Sebagai Media. 4(2), 276–286.

[2] Benjamin, W. (1981). No Title هبی بسطس اط بسبفارط بی :تررم نسخ و بسری نسخ بیی بلی رایطر 3, بارلیبم. فصلنامه پژوهشهاي اقلمادي بررسی(September), 675–687.

[3] Ceryna Dewi, N. K., Anandita, I. B. G., Atmaja, K. J., & Aditama, P. W. (2018). RANCANGBANGUNAPLIKASIMOBILESISKABERBASISANDROID. SINTECH (Science and Information Technology) Journal, 1(2), 100–107. https://doi.org/10.31598/sintechjournal.v2i1.291

[4] Gayatri. (2018). A. ANDROID a. Sejarah Android Android adalah sebuah sistem operasi untuk perangkat. Android Adalah Sebuah Sistem Operasi Untuk Perangkat Mobile Berbasis Linux Yang Mencakup Sistem Operasi; Middleware Dan Aplikasi. Andorid Menyediakan Platform Terbuka Bagi Para Pengembang Untuk Menciptakan Aplikasi Mereka. Awalnya; Google Inc. Membeli And. http://repository.ump.ac.id/2748/3/BAB II_AFRIDA NUR FAUZY_TI%2714.pdf

[5] Haryani, P., & Triyono, J. (2017). Augmented Reality (Ar) Sebagai Teknologi Interaktif. Jurnal SIMETRIS, 8(2), 807–812.

[6] Nugroho, A., & Pramono, B. A. (2017). APLIKASI MOBILE AUGMENTED REALITY BERBASIS VUFORIA DAN UNITY PADA PENGENALANOBJEK3D DENGANSTUDIKASUSGEDUNGMUNIVERSITASSEMARANG.14,86–91.

[7] Qorimah, E. N., & Sutama, S. (2022). Studi Literatur: Media Augmented Reality (AR) Terhadap Hasil Belajar Kognitif. Jurnal Basicedu, 6(2), 2055–2060. https://doi.org/10.31004/basicedu.v6i2.2348

[8] Rahma, A., Ashari, & Habib, M. (2021). Android Dan Masa Depan : Analisis Dampak Terhadap Pengguna. Jurnal Pendidikan Dan Pengabdian Masyarakat, 1(1), 1–10. Studi, P., Komputer,

[9] I., & Mulawarman, F. U. (2011). Memahami Penggunaan UML (Unified Modelling Language). 6(1), 1–15. Zebua, T., Nadeak, B., & Sinaga, S. B. (2020). Pengenalan Dasar Aplikasi Blender 3D dalam Pembuatan Animasi 3D. 1(1), 18–21.