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Review JoMTRA

Augmented Reality Based 3D Drawing from the 2D

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Abstract

Students benefit from this approach since it offers an alternative viewpoint on content production and teaching and learning techniques. Managing global projects necessitates the use of techniques and resources to aid in content communication. The development of augmented reality (AR)/virtual reality (VR) content requires a significant amount of time if efficient design and visualization techniques are not employed. The use of highly detailed 3D games that may have required a large financial commitment for commercial enterprises is more common among students. Though many educational institutions have fast and free internet available, its use may be limited by big file sizes, which would require high internet rates to download the animation content that may be put on a website. Low-polygon modeling techniques have traditionally been essential for AR and VR development. However, in multidisciplinary projects, teams often use their standard software to create 3D content, which can limit interactivity. This is because optimizing the software for performance tends to increase the file size of the developed media.

Keywords: Augmented reality (AR), virtual reality (VR), visualization, CAD drawings, QR scanning

INTRODUCTION

Higher education (HE) institutions and industries are worried about the declining quality of technical drawings (TD) due to an insufficient understanding of the fundamental principles and conventions that support best practices. Increasing evidence suggests that simulations, animations, and augmented reality and virtual reality (AR/VR) technologies can enhance learners' engagement, competence, and skills, particularly compared to traditional teaching methods.

This study aims to develop and evaluate the overall effects and impact of virtual and augmented reality based methods and tools on teaching and learning technical drawing principles within higher education. The development of these tools and methods was informed by the results of a previous international study that explored three key areas: perceptions of technical drawing education, assessment of technical drawing knowledge and skills, and expectations for technical drawing education.

Technical drawing has consistently been a crucial element in the training of new product designers and engineers. It is vital to convey technical product specifications (TPS), such as material, size, shape, and tolerance, during the new product development process. The decline in standards, caused by insufficient understanding of fundamental principles and drafting of conventions, poses a challenge for higher education institutions and traditional teaching methods.

Although engineering and product design students generally favor visual, sensory, inductive,

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and active learning styles, most engineering education, particularly teaching technical drawing skills, has traditionally depended on auditory, abstract, deductive, passive, and sequential teaching methods. This application seeks to bridge the gap between theoretical 2D engineering drawings and practical 3D visualizations, thereby fostering a profound comprehension of engineering principles. It caters to a diverse spectrum of engineering disciplines, spanning from mechanical and civil engineering to architecture, and beyond. The user-friendly interface, comprehensive suite of features, and integration of AR technology collectively position this application as an invaluable tool for engineering education, professional development, and creative exploration.

RELATED WORKS

Several researchers have examined the literature on AR and its use in architecture, engineering, and construction education. Researchers have recognized new opportunities to use AR in educational settings. Behzadan [1] reported a project aimed at enhancing the current learning environment in construction by creating and implementing an interactive AR tool.

This tool was developed to significantly enhance students' comprehension of the construction process, equipment, and safety protocols [1]. The AR book was assembled by integrating the pages with tracker images. The ARToolKit serves as the platform, allowing augmented information to be overlaid on markers using head-mounted displays (HMDs).

The paper concluded that when effectively implemented, AR significantly enhanced student achievement, boosted interaction between teachers and students, and improved students' problem-solving skills. In a separate study, Behzadan and Shirazi [2] created an AR tool, known as CAM-ART. This Context-aware Mobile Augmented Reality Tool (CAM-ART) was designed for education in the civil engineering and construction sectors [2]. The AR tool was implemented in an undergraduate course to assess its impact and advantages on student learning. The students were instructed to use their handheld devices (such as iPads, iPhones, tablets, or smartphones [8]) to access context-sensitive virtual information from the course textbook related to the material presented conventionally. They organized the students into groups to make the tasks more interactive and collaborative. The results indicate that AR enhances the learning experience and helps bridge the gap between technology and students in education. CAM-ART also created an engaging environment that fostered interaction and collaboration among students and their coursework by involving participants in a multi-media-rich learning experience. Similarly, David Fonseca [3] investigated the feasibility of AR on mobile devices for architecture education [4]. This study concentrated on the usability of the tool, its impact on student performance, and the increase in student engagement. This research was conducted with third-year Architecture and Building Engineering students during the 2011–2012 academic year, with a course designed for classroom instruction and evaluated at the end of the term. The results suggest that AR is effective for visualizing simple models but would be less practical for more complex models.

Students were motivated by their experience with AR technology and expressed an interest in similar technologies if they enhanced their academic performance. They were more engaged in the classroom and found that the 3D virtual content helped them understand and communicate more effectively. Consequently, AR significantly enhanced the learning process. Chen et al. conducted related research on using AR to improve students' spatial skills [5]. The experiment employed AR and tangible 3D models to develop teaching methods aimed at enhancing students' spatial abilities in learning engineering graphics concepts more effectively.

The research found that AR generated increased interest among students and demonstrated that combining AR with tangible models could yield better outcomes. In 2015, a similar study aimed to evaluate AR's effectiveness of AR as a pedagogical tool for student learning [6]. This study utilized Junaio, an open-source web-based programming environment, to create a model building from basic blocks. The experiment involved two groups: Group 1 used the traditional paper-based approach,

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whereas Group 2 used the AR tool. The results for the second group were favorable: they appeared more self-sufficient during the task and needed less teacher intervention. This confirms that AR is effective in teaching complex subjects and courses.

PROBLEM STATEMENT

Augmented reality (AR) [3] is increasingly utilized in education, particularly in engineering drawing, to enhance students' learning experiences and knowledge transfer. This project reviews the recent research on the application of AR in engineering drawing classrooms, focusing on articles published between 2000 and 2016.

The review revealed that AR can enrich learning experiences and boost students' abilities to handle complex engineering concepts. Researchers have created AR teaching tools to aid the teaching and learning of engineering drawing [10]. Further research on AR technology is expected to enhance the effectiveness of engineering drawing classrooms, improve teaching and learning standards, and benefit both educators and students.

PROPOSED METHODOLOGY

Our proposed AR-based engineering-drawing education app revolutionizes the learning experience by seamlessly integrating 2D engineering CAD drawings with immersive 3D models in an AR environment. The application caters to students, professionals, and enthusiasts seeking a more interactive and comprehensive understanding of engineering concepts. Using this application, users can upload their 2D engineering CAD drawings, which are then transformed into AR-compatible 3D models. AR functionality enables users to view these models in a real-world context, facilitating a deeper understanding of spatial relationships and design details. When users position their devices over 2D drawings, the application generates related 3D models, overlaying digital information on the physical environment. The app offers several features, including the ability to manipulate and interact with three-dimensional (3D) models. Users can rotate and scale the models. In addition, the app provides annotations and text overlays, offers contextual information and insights, and enhances the learning process. Furthermore, the app supports collaborative features, allowing users to share their AR-enhanced models with peers or instructors and enabling group discussions, feedback, and collaborative learning experiences. This app aims to bridge the gap between theoretical 2D engineering drawings and practical 3D visualizations, fostering a more profound comprehension of engineering principles. It covers multiple engineering disciplines, from mechanical and civil engineering to architecture. The app's intuitive interface, extensive features, and AR integration make it an essential resource in engineering education, professional development, and creative exploration.

DESIGN AND IMPLEMENTATION

Augmented reality has been increasingly used in education, particularly in teaching and learning processes. Many courses, including those in engineering drawing, have adopted this technology to enrich students' learning experiences and optimize their knowledge transfer.

This project seeks to analyze recent studies on the application of AR in engineering drawing classrooms. To accomplish this, several electronic databases were searched for articles published between 2000 and 2016 using keyword combinations such as augmented reality, engineering drawings, engineering education, and teaching methods. The review results suggest that AR can enrich learning experiences and enhance students' comprehension of complex concepts in engineering drawings. As research into augmented reality technology progresses, it is expected that engineering drawing classrooms will become more effective. Consequently, the teaching aids developed in this research will raise the standards of teaching and learning, benefiting both educators and students. The application shows a list of available 2D models of technical drawings that can be viewed. The app projects 3D models of the above-mentioned using AR, which can be viewed as zoom-filled, zoomed out, etc., as per user choice.

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The system should integrate real and virtual objects within a real environment and align them simultaneously. It must operate interactively in real-time and be capable of dynamically adding 3D models and generating QR codes to access these models in the AR view. Developing a use case diagram for an AR-based engineering drawing tool app can help visualize the interactions between various actors and the system.

Figure 1 shows a simplified use case diagram for such an application. Please note that this is a high-level representation, and in a real-world scenario, you may have more detailed use cases.

1. *User:* The main actor who interacts with the AR-based engineering drawing tool app.
2. *Administrator:* A supplementary actor responsible for overseeing user accounts, permissions, and system configurations.
3. *View AR drawing (user):* The user launches the application. The app activates the camera and the AR capabilities of the device. The user can view engineering drawings overlaid on physical objects through AR.
4. *Drawing (user):* The user can create or edit engineering drawings using the application. This includes drawing, modifying, and labeling components or objects within the AR environment.
5. *Load existing (user):* Users can load previously created engineering drawings for reference or further editing.
6. *Save drawing (user):* Users can save their current engineering drawing work for future use.
7. *Share drawing (user):* Users can share their engineering drawings with other users or stakeholders through various sharing methods, such as email, messaging apps, or cloud storage.
8. *Manage user accounts (administrator):* The administrator can handle user accounts by creating, updating, or deactivating them. The administrator can assign different roles and permissions to users.
9. *Configure AR settings (user/administrator):* Users and administrators can configure the AR settings of the app, such as calibration, tracking, and display preferences.
10. *Provide feedback (user):* Users can provide feedback or report issues regarding the app’s performance or functionality.

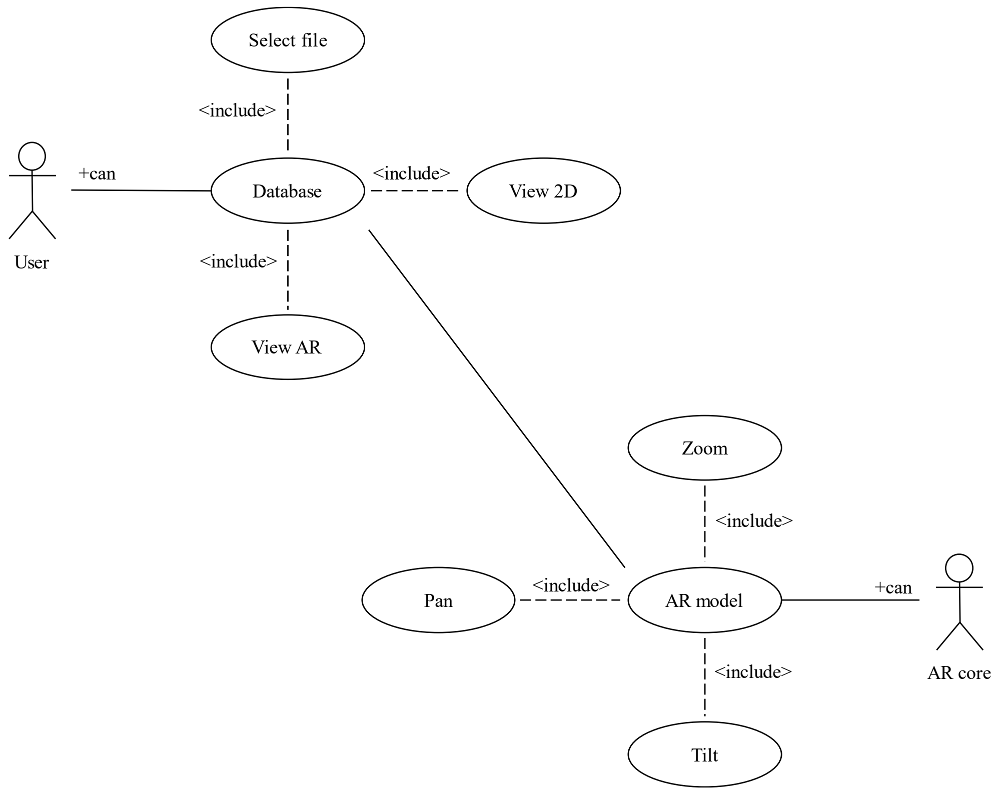

Figure1. Level 1 use case diagram.

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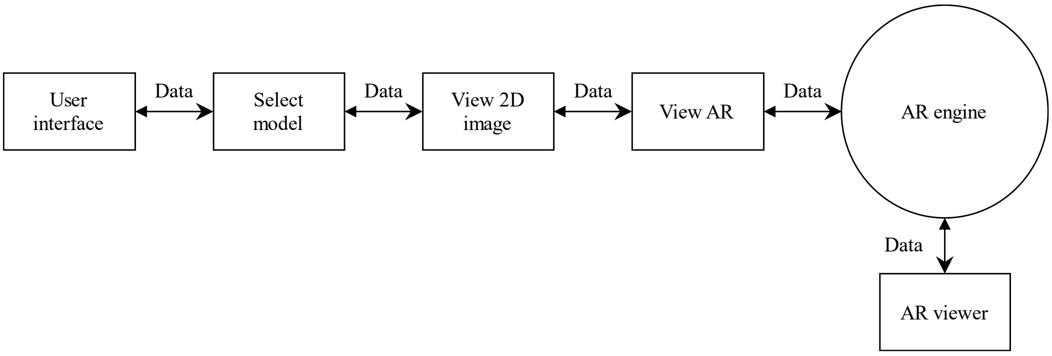

Figure 2. System architecture.

The architecture of an AR-based engineering drawing tool can be complex and involves several components. Figure 2 shows a simplified architectural overview of the application.

1. *User interface (UI):* The User Interface is the front-end of the application, providing a graphical and interactive platform for users to interact with AR and create engineering drawings. This includes all required UI components.
2. *AR engine:* The AR Engine is responsible for handling augmented reality functionalities.
3. *Drawing engine:* The Drawing Engine is at the core of the application and is responsible for creating, modifying, and managing the engineering drawings.
4. *Object recognition and tracking:* Object recognition and tracking modules are responsible for recognizing physical objects or surfaces on which drawings can be placed.
5. *Measurement and analysis tools:* This component provides measurement and analysis tools for engineers to calculate distances, angles, and dimensions, and perform other engineering-related calculations.
6. *Data storage and management:* The data storage and management modules handle the storage, retrieval, and management of user-created drawings.
7. *Performance optimization:* Performance optimization components are tasked with providing a smooth and responsive AR experience.
8. *User authentication and authorization:* For a secure and personalized user experience, the app can include user authentication and authorization modules.
9. *User training and help:* This component provides user tutorials, help guides, and customer support to assist users in learning and effectively using the app.
10. *Continuous updates and enhancements:* Regular updates and enhancements ensure that the app remains up-to-date with the latest AR technologies and user requirements.
11. *Device compatibility:* The application should be compatible with a broad range of AR devices, including smartphones, tablets, and AR headsets.

Creating a comprehensive data flow diagram (DFD) for an AR-based engineering drawing tool app requires an in-depth analysis of the system’s functionalities and data interactions. Figures 3 and 4 show DFD levels 0 and DFD level 1respectively for the application, highlighting the main data processes and components.

This project utilized an Android operating system. The minimum version required for the installation of this app was Android 5.0. Once the app is installed, the user can view the list of engineering (technical) drawings preferred in the system. The user must select the desired drawing and press it continuously.

The unity engine was initialized and set for the AR view. The selected 3D model of the drawing can subsequently be viewed in AR [7]. The user can interact with the 3D AR Model using the buttons provided on the interface. The system also has an updated feature to upload new models and create QR to access the linked models in AR view.

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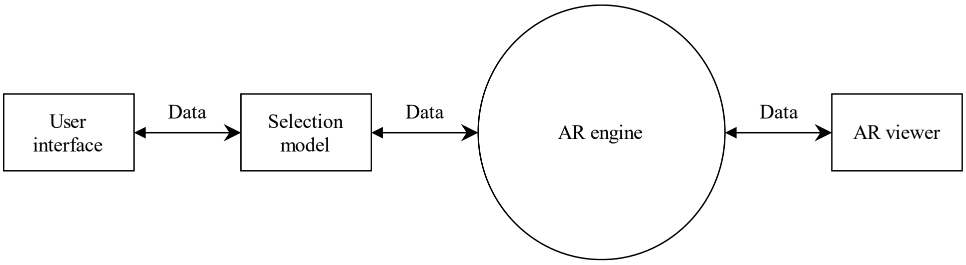

Figure 3. Data flow diagram level 0.

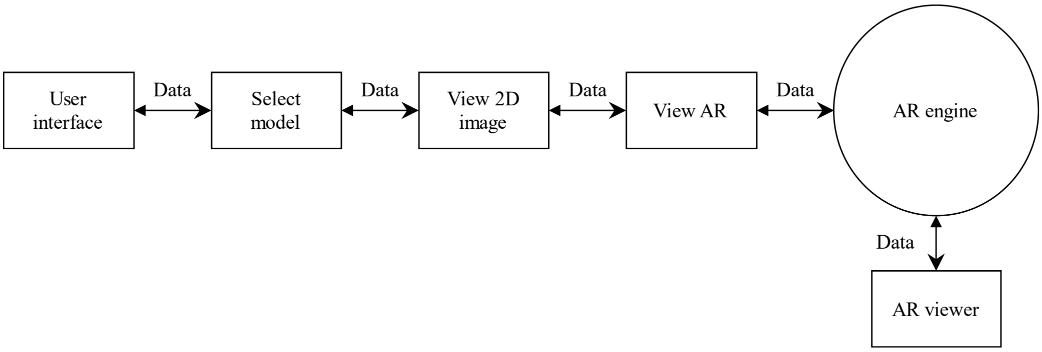

Figure 4. Data flow diagram level 1.

RESULT AND DISCUSSION

Augmented reality has been applied to education, particularly in teaching and learning processes. Many courses, including engineering drawings, have adopted this technology to improve students' learning experiences and optimize their knowledge transfer. Therefore, this project seeks to evaluate the recent research on the application of AR in engineering drawing classrooms. Several electronic databases were searched for articles published between 2000 and 2016.

Various keyword combinations were employed to find relevant articles, including terms such as augmented reality, engineering drawing, engineering education, and teaching methods. The review's findings indicated that AR could improve learning experiences and enhance students' ability to understand complex engineering concepts. Numerous researchers have created AR teaching aids to support the instruction and learning of engineering drawings.

As research into AR technology advances, it is expected to enhance the effectiveness of engineering drawing classrooms [9]. As a result, the teaching aids developed in this research will enhance teaching and learning standards, providing advantages for both educators and students. AR technology represents a cutting-edge innovation.

This can improve the perception of reality and offer additional information about the real-world. AR technology has been applied across various fields, including medicine, industry, and education. In this project, AR was incorporated into an engineering drawing course. This course is challenging because it involves the knowledge that students seldom encounter. To facilitate closer interaction between models and views, this study proposes a user-friendly AR application (AR app). The AR app effectively merges virtual models with real views, allowing users to move and rotate the models by touching a screen. Therefore, students can effectively use their mobile phones to study engineering drawings. An interactive teaching environment enhances spatial reasoning and encourages a sense of creativity.

The main page of the application is shown in Figure 5, where the user lands once they open the application. The page of the application is shown in Figure 6, where QR scanning will be available. The model was displayed after scanning the QR code, as shown in Figure 7.

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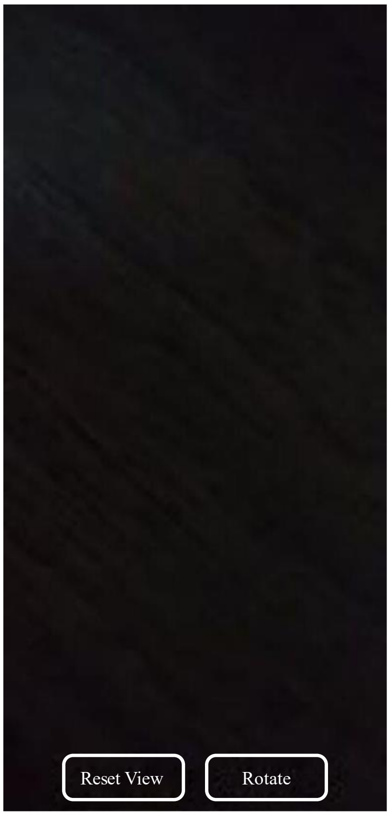

Figure 5. Main page.

Figure 6. QR scanning.

Figure 7. Output.

CONCLUSION

This study highlights the potential of integrating mobile AR into the teaching and learning of orthographic projection for engineering students. Technology has shown promise as a teaching tool that boosts student interests and positively influences learning outcomes.

This approach, which employs mobile AR technology, was selected because of its potential for 21st-century learners. It offers students flexible learning experiences and supports self-directed learning. Its user-friendly nature facilitates quicker and more effective learning, while the novelty of technology boosts students' interest in the learning process. This study assessed the use of the app among participants to evaluate their perception and acceptance of mobile augmented reality (MAR) in education. The results revealed that participants generally agreed that MAR effectively addressed all key aspects, including ease of use, concept understanding, visualization support, and intention to use. It is anticipated that these findings will inspire more researchers to further integrate MAR into teaching and learning, to improve educational quality and deepen students' understanding.

Future Scope

Future work for an AR-based engineering drawing tool app should focus on expanding capabilities, improving user experience, and addressing emerging trends. Some areas should be considered for future research.

1. *Enhanced AR features*
    i. Explore more advanced AR features, such as better object recognition, tracking, and occlusion handling, for an even more seamless AR experience.
    ii. Integrate AR Cloud technology to create persistent shared experiences, enabling multiple users to interact with the same drawings in real-time simultaneously.
2. *3D modeling and visualization:* Add support for 3D modeling and visualization, enabling users to create and manipulate 3D objects in the AR environment alongside 2D drawings.

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3. *Machine learning and AI integration:* Incorporation of machine learning and AI algorithms for automated object recognition, text extraction from images, and intelligent assistance in drawing creation and analysis.
4. *Cross-platform compatibility:* Ensure compatibility with a wide range of AR devices, including headsets, smart glasses, and mobile devices to expand the user base.
5. *Cloud integration and collaboration:* Enhance collaboration features by integrating cloud-based services for real-time collaboration, secure data storage, and version control.

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