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Application of Augmented Reality for Engineering Graphics

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Abstract - *Learning how to transfer information from 2D sketch or design to manufacture is the main idea behind the Engineering Graphics (EG) subject. It plays an important role for an engineering student to learn how to study 2D sketches and turn them into engineering structures. Thus, its crucial role for engineering college to teach and train the students who can communicate in and understand the Graphical representation language. As the lecture timings are limited in the classroom, it might be difficult and challenging for the faculty to relate the 3D geometry and its 2D projections and also it will be difficult for the students to understand the relations effectively. In this paper, we have discussed the advantages and difficulties in adopting Augmented Reality (AR) in engineering graphics. We studied and created an AR based solution specially for engineering graphics training. The approach aims in creating awareness and built interest in learners. Our main aim is to use AR system for teaching engineering graphics and provide personalised training experience to students. The AR application simplifies complex relationship and make it easier for the learners to understand which will be extremely helpful. Faculties have found this AR based approach to be a good and useful teaching technique. Using AR technology for learning different venture may prove popular in upcoming time.*

Key Words*: *Engineering Drawing; Augmented Reality; Teaching tool

1.INTRODUCTION

*T*echnology known as augmented reality (AR) can increase the sense of originality and give additional details about the outside environment. Many industries, including healthcare, business, and education use augmented reality technology. This project introduces augmented reality to the engineering drawing course. Engineering sketching is a knowledge that students rarely encounter, making it challenging to learn. The research suggests a practical augmented reality (AR) application (AR app) to maintain close contact with the models and views. Real views and virtual models are effectively merged with the aid of an AR software. Touching the screen will allow you to move and rotate the models. Thus, using a mobile phone for excellent engineering drawing study is advantageous for students. Students' spatial thinking is improved and their spirit of invention is fostered by the interactive learning environment.

This project's goal is to find the application of augmented reality in engineering graphics. Several electronic databases were used to discover articles published between 2000 and 2016 in order to accomplish the goal of this work. A limited number of keyword combinations, including augmented reality, engineering drawings, engineering education, and teaching methodology, were utilised to search for related articles. The review's conclusions demonstrate that the application of augmented reality can improve educational opportunities for students and their ability to deal with challenging engineering drawing concepts. To figure out the challenges in the engineering drawing, several researchers have created augmented reality teaching aids. When a result, as more study is done on the augmented reality technology, the results will undoubtedly improve engineering drawing classes. As a result, the teaching aids created as a result of the research will raise the bar for instruction and learning, which will be advantageous for both teachers and pupils.

2. RELATED WORK

Institutions of higher education (HE) and business are concerned about the loss in technical drawing (TD) standards that results from a lack of knowledge of the fundamental ideas and customs that guide optimal practises. Nowadays its seen that animated effect and visualization and augmented reality can improve the understanding of students and increase students' interest and fun of learning compared to the theoretical and traditional methods of teaching. The purpose of this study is to develop and evaluate techniques and tools based on virtual and augmented reality, as well as their overall effects on technical drawing ideas education in higher education settings. Based on the past finding of international study that examined the need of knowledge and understanding of TD and ability evaluation, and views of TD education, new tools and procedures have been developed. For the growth of unique designers and engineers, TD has proven as essential requirement. They play a key role in transition of the technical product specifications (TPS) (form, size, tolerances, materials, etc.) for manufacturing process and develop new product. For HE institutions and traditional training methods, the decline in standards brought on by a lack of understanding of key concepts and the protocols of drafting processes that support these practises is an issue. The majority in the teaching of technical drawing skills, it is fact that students studying engineering and product designing requires practical approach (sensing the design,

visualising) more that of theoretical sequence of teaching styles (abstract, auditory practices).

The theory on AR and its use in the different industries like automotive, construction architecture has been examined by a number of scholars.

Researchers have identified new applications for augmented reality in the classroom. Amir H. Behzadan showed the outputs & observations of a project that attempted to revolutionise the current environment of learning in construction field by creating and using an interactive augmented reality tool that would surely enhance the understanding of student about the construction process, equipment's used, and operational safety. The AR book was made with tracker photos by joining all of the pieces of paper. Using the AR toolkit, head mounted displays were used as a platform for displaying augmented information over markers (HMD). The study found that when used successfully, AR has an important action on student achievement, promotes teacher-student understanding, and aids in the development of students' problem-solving skills.

In previous study, Behzadan and Shirazi created the CAM-ART ("context-aware mobile augmented reality tool") AR tool. An instructional tool for the civil engineering and construction industries is called a CAM-ART. The created AR tool was tested and evaluated for its effects on and advantages to student learning in a course at the undergraduate level. Students were instructed to access virtual information from the textbook on the subject delivered in a normal way using their mobile devices (such as iPads, iPhones, tablets, or smartphones). To make the process more engaging and collaborative, they organised into groups. Results showed that AR can aid improve learning environments and lower technological barriers for students in the classroom. Additionally, by occupying participants in a AV (Audio-Video) enabled learning environment, CAM-ART provided an interactive atmosphere that fostered engagement and cooperation between students and coursework.

Another research project looked on urban landscape interventions in Barcelona. In 2013, Ernest Redondo made the case for augmented reality as a potential new teaching tool. The study involved the S1 and S2 groups. While S2 used AR, S1 used more conventional techniques based on slides. The findings showed that AR is undoubtedly helpful in comprehending architectural proposals. Additionally, AR promotes spatial relationships by accurately and instantly displaying true scale and position.

David Fonseca examined the viability of using augmented reality on mobile devices for architecture education in a similar study. The study concentrated on the tool's convenience, how well students performed after using AR, and how much more students participated. In the academic year 2011–2012, the study was conducted with third-year Civil Engineering students. A course was made that was thought in class and assessed after each session. The findings suggest that while AR was effective for visualising straightforward models, it would be more difficult to employ with complex models. Students were inspired by their use of AR technology and welcomed other comparable innovations if they helped them achieve better academically. In the classroom, students were reported to be more engaged. With the use of 3D virtual content, they were better able to comprehend and communicate. AR maximises learning as a result.

Chen et al. conducted similar studies to improve students' spatial ability using AR (Chen et al. 2011). The project-built training methods that can improve students' spatial abilities in order to help them learn engineering graphics principles as effectively as possible using augmented reality (AR) models and tangible (3D) model approaches. The study concluded that AR piqued students' interests. Augmented reality and physical models working together can result in better results

The same research, which sought to determine the usefulness of AR as a teaching technique for pupils, was conducted in 2015. (Shirazi and Behzadan 2015). To create a model building out of basic building components, the project used a web-based programming environment viz Junaio. The mission was finished by two teams: Team 1 employed the conventional literature-based method, while Team 2 made use of an AR tool. The outcomes with the second group were successful. While performing the job, they appeared more independent and needed the teacher less frequently. It gave the assurance that AR could be applied with complex subjects and curricula.

In 2016, Steven K. Ayer tried used augmented reality (AR) in sustainable design instruction by remodelling a portion of an existing structure. In that experiment, the learners developed, imagined, and assessed external wall drawings to improve the sustainability of an existing structure. An application called Eco Campus and an augmented reality (AR) simulation interface were developed. Users of Eco Campus were able to see potential building designs in relation to current building space. In choosing the best design for the building, it also considered several factors. According to the findings, students who utilised Eco Campus were able to get a deeper knowledge and perform better overall across all subject areas than those who used paper-based forms. Internal dependencies between AR and simulation game technology were one research restriction. They could not be evaluated impartially.

3. DESIGNING EDUCATIONAL AR APPLICATION

Based on our study and research, we must take two important strategies for implementing an AR-based Engineering Graphics education system. They are 1. Realtime tracking and alignment strategy in which computer can provide and place a practical object in real environment

accurately. 2. Communal strategy in which user can communicate with the computer and relocate the object to different place easily. There are libraries and software specially for AR applications. For our objective which is rendering the object there are many ways but OpenGL is the best for mechanical structures as geometrical characters like chamfer, rib, cylinder, cone can be identified and put up quickly and easily.

The content of an AR application should be carefully and precisely added and for that proper procedure must be selected as graphical education is very important in developing a student's thinking and understanding skills. Graphics problem solving process involves some logical reference and to build user interface, educational requirements and mechanical standards are considered.

4. OVERVIEW OF AR BASED ENGINEERING GRAPHICS SYSTEM

The AR based Engineering Graphics System consists of Five Modules viz; Track and register module, gesture identification module, action directions/instruction module 3D model database and rendering/display engine. For easier understanding of this modules following flow chart can be used which is also the algorithm of our application.

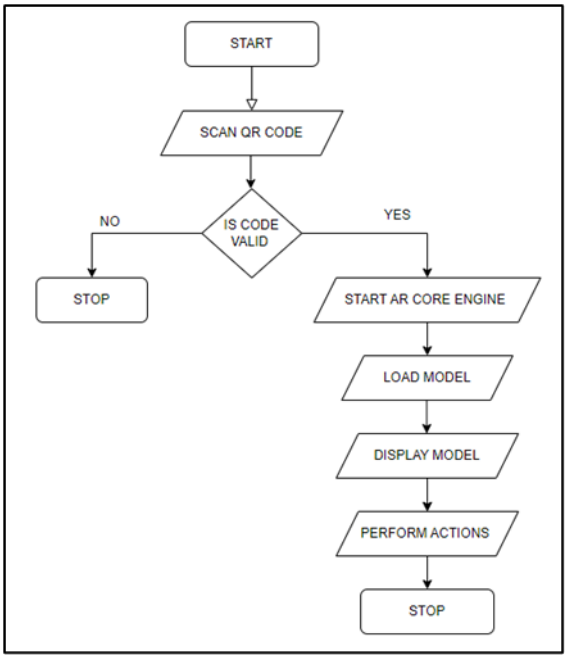

Fig 1. Architecture or Algorithm

Out of which the first two modules the track and register module and gesture identification module plays a vital role in AR system. The work of this module is to collect the video captured/traced by camera which in all is responsible for evaluating the position of the camera. The system picks up the 3D model from the database or backend and displays it accurately with respect to the camera position of the smartphone. The utilization of the QR code for getting the models is based on vision-based tracking system. Later when the required data is collected the rendering engine which is the AR core engine is started. Lastly the operation data provided by the user are collected and interactions are made due to which the users can zoom, rotate or cut the object based on their requirements.

The 3D models were made on SolidWorks and Fusion360 software. This models from the database can be accessed or retrieved by using a scanner code as shown in figure 2.

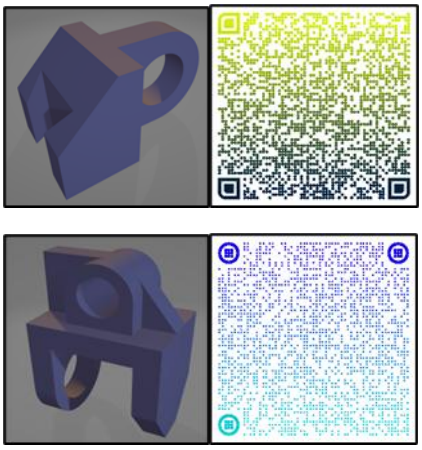

Fig 2. 3D Models and Scans

5. IMPLEMENTATION

Our app uses a normal book as an interface which will have the 2D sketch of models and the scanning code of 3D model for respective sketch. Students or learners can simply look the Sketches imagine and scan the code from their mobile phone application and complete their assignments and understand the relation between sketches as easy as they write their other assignments. When they focus their camera on the valid scanning code from the app, the 3D model comes on the mobile screen with the help of that they can understand the relation between the 2D and 3D projections. They can also use different features like 360° rotation, zoom in and out and Section cut in any direction.

The hardware requirements for our app to work on mobiles phones are 4GB of RAM and 1GB of ROM and the android version of the mobile phone should be Android 5 or more. The hardware requirements required for app development are 8GB of RAM or more and 16GB of ROM or more and operating system is Windows 10,11. The Software we used are Google AR core, UNITY, and Android Studio. Learners can install the app by scanning the code from their phone camera and they will be redirected to the drive link where they will find the APK file for the app which will be used for app installation.

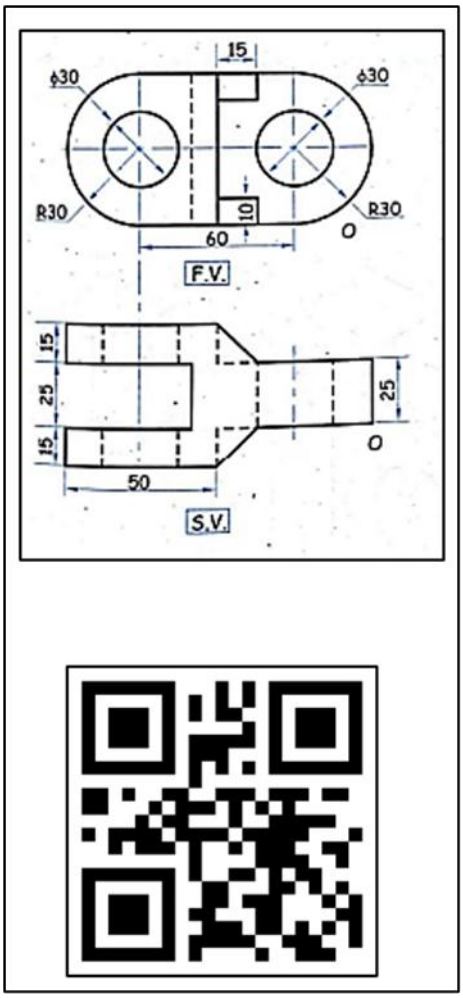

Fig 3. Drawing and scanning code as it appears in book

Fig 3 represents the eye of the knuckle joint. When students face problems in imagining the sketch, they can start the AR app and see the 3D view of it. The virtual 3D object will get on their screen from the database and can create an environment of self-learning as AR application provides self-learning tutorials. They can also rotate the object and can see the sectional view by using the section feature.

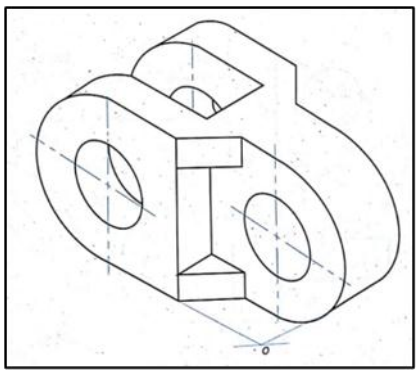

Fig 4. Axonometric drawings of 3D solid

Students can access the 3D model and some important information from the AR-based learning Approach which also reduces the amount of the time which teachers spend in the classroom teaching using a traditional technique. Using AR-based learning is significantly beneficial when compared to traditional technique which uses axonometric drawing for explanation as shown in fig 4. These drawing are displayed only in single plane projection and since they are fixed, it conceals the rear view of the 3D model due to which a new comer or students face difficulties to understand the model whereas AR approach shows all of the external features from all sides. The students can keep busy themselves with the model in a real environment also they can communicate with the models by rotating or zooming it to visualize the minute details in space. They can also identify between the fixed construction and hidden constructions in the drawing by having sections at any distance in any directions. For learners planning their future in Design background, requires a lot of practice other than classroom practice, so this self-spaced, AR-based application provides flexibility and convenience to them. This can also help to students who are unable to focus or concentrate due to classroom environment or settings.

6. CONCLUSIONS

The possibility for using mobile augmented reality to educate and learn orthographic projection to engineering students has been identified by this study. The usage of this technology has been viewed as most promising learning strategies to provoke students' interests and improve learning outcomes. Due to the promising potential of this technology's use among 21st-century citizens, this strategy, which made use of Mobile Augmented Reality (MAR) technology, was chosen. It encourages self-directed learning and can give pupils a flexible learning environment. Students learn more quickly and efficiently thanks to its simplicity, and they are more interested in learning overall thanks to this technology's novelty. In order to understand how respondents, feel about and accept the use of MAR in teaching and learning, this study evaluates how respondents use apps. Results show that respondents strongly agreed that it could satisfy all of the characteristics, including usability, concept comprehension, visualization help, and usage aim. In order to raise the standard of education and deepen students' understandings, it is hoped that these findings would inspire additional researchers to continue integrating MAR in teaching and learning.

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