# Augmented Reality in Engineering Graphics

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***Abstract***—*Engineering Graphics (EG) is a subject that helps in developing an ability to create and to read graphical representations of various structures. Developing 3D structures in Engineering Education necessitates spatial ability, as well as the ability to think creatively. In the classroom, the lecture durations are short it therefore becomes hard to clearly visualize the relationship between 3D geometry and the 2D projections of respective 3D figures. The students only get a two-dimensional view of the structures and are restricted to whatever the teacher will display on the projector screen or on the blackboard. Augmented Reality (AR) tools can guide students by providing an interactive way of learning and also build their interest and understanding of the subject in a much better way. AR can upgrade traditional books with a digital layer. Engineering Graphics play a vital role in engineering fields in a student's life. Our project aims at providing a brief insight into the potential of using AR in Engineering Graphics by building an application which will enable a better understanding of complex spatial problemsand relationships, which will help students in their studies. This app also provides effective teaching aids for EG courses. Based on the markers, the system generates the 3D object and blends it into the realworld. Here we can say that augmented reality adds virtual content to the real environment. Thistechnology provides attractive and efficient ways toenhance concepts in engineering graphics.*

***Keywords***—*Augmented reality, Education, Graphics.*

## I. INTRODUCTION

Augmented Reality (AR) is an enhanced version of realphysical world. Augmented reality merges the computer- generated graphics with the real-world scenes and enriches the user experience. AR system is a system that basically fullfills three features that is a combination of real and virtual world, real-time interaction and accurate 3D registration of virtual and real objects. Augmented reality merges the computer-generated graphics with the real- world scenes and enhances the user experience. It may alter how we use mobile applications and other visual graphic experiences.

The two types of Augmented Reality (AR) are Marker-based and Marker-less. The Marker-based AR requires a static image also referred to as trigger photo.When the Augmented Reality app is opened it uses the back camera of mobile device to track such markers/triggers. Once the device recognizes that particular image pattern marker it superimposes the image with the structure associated with it. The virtual 3D object is not adequately displayed when the camera is not focused on a certain area. The camera, picture collecting, processing, rendering, and marker tracking components make up the marker-based AR image recognition system. This type of AR is used in Instagram, Facebook, Snapchat filters and games like Pokemon Go.

The Marker-less AR refers to the software application that does not require any camera to put a mark for image pattern recognition. Marker-less AR places virtual 3D objects in the real-life environment by examining the features present in the real-time data. It relies on the hardware of any smartphone including the camera, GPS, digital compass, and accelerometer for the AR software to complete the work efficiently. It merges the digital data with input from real- time data that are registered to a physical space. There are four different categories of marker-less AR such as location- based AR, Projection based AR, Superimposition AR, and Outlining AR.

In contrast virtual reality gives user the experience of completely different environment altogether. This environment is perceived through a device known as a Virtual Reality headset or helmet. It makes us to feel like we are one of the characters in the video games. Whereas mixed reality combines both the augmented and the virtual reality. Mixed reality is sometimes considered a type of augmented reality (AR), but its capacity for interactivity between real-world and digital elements places it, which has physical reality at one extreme and immersive virtual reality at the other.

This project aims at providing brief insight into potential of using AR in Engineering Graphics subject. Our main aim is to simplify the complex graphic structure and to enhance the performance of students, to increase the interest of students in graphics subject and also to provide them with the low cost AR learning app. This app will provide an AR camera which will augment the respective questions selected from ND Bhat textbook for Engineering Graphics and provide the 3D view of complex structures which are available in 2D on book.

## II. PROBLEM STATEMENT

Engineering Graphics (EG) is a subject wherein a studenthas to imagine the two dimensional i.e. Orthographic views of three-dimensional structures which deals with the conversion of three-dimensional to two-dimensional like drawing the top view, side view and front view. The students are also required to imagine the three-dimensional structures (Isometric structures) from the two-dimensional views. So, in the classroom within the time limit given, it becomes difficult for students to understand the topics and visualise them thus, making the subject difficult.

## III. METHODOLOGY

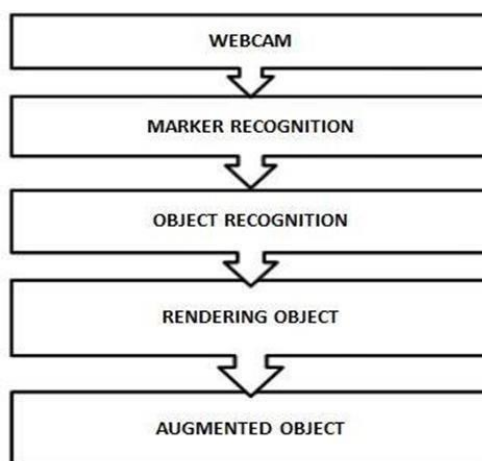Let us see the design of our project and its descriptionin detail as shown in figure below.



Figure 3.1: Flowchart ofan AR system

**Webcam**: The Web Camera provides the ability to scanthe pictures and recognizes the image on the page which acts as a marker. These markers are registered in the VuforiaSDK. Sensors can also be used which gathers the real worldinteraction information.

**Marker Recognition**: It requires a static image also known as a trigger photo that user can scan using their

mobile device via augmented reality app. The markers are images or objects registered with the application on Vuforia developer's portal which act as information triggers in application. Vuforia database is created which can be stored on device or it can be cloud based.

**Object Recognition**: AR camera helps to recognize the object within the real world environment with the help of feature points. These feature points are unique elements of each image. More the feature points better and faster is the augmentation. Augmented Reality object recognition will attach the digital 3D model to the real world object. By attaching a 3D model learners can explore models with different views.

**Rendering Engine**: is defined in three co-ordinates for describing the positions of the objects. The AR system keeps a record of the objects that are registered. It is used for mixing the structure or model with the real world scene. Drawing a scene on a computer screen is the process of rendering. Geometry computations, surface treatments, lighting, texturing, and spectator perspective are all factors in drawing.

**AR Object Recognition**: also known as object detection, attaches a digital 3D model to a real-world object that learners can pick up and manipulate. A virtual 3D model is linked to the real-world 3D object after learners scan it.

## IV. RELATED WORK

Heen Chen, Kaiping Feng, Chunlin Mo, Siyuan Cheng, Zhongning Guo, Yizhu Huang [1] proposes about a general architecture of AR based system for Engineering Graphics learning. A vision-based gesture recognition method for AR based system is introduced. This Engineering graphics education system using computer vision-based AR technology aims at improving the spatial awareness and interest of learning. By focusing a camera on the real page with specific marker, 3D model will appear virtually from the computer screen. The virtual models superimposed upon the real page will serve as an aid for solving the 3D spatial geometry question.

Jing Jin,Tong Lin,Yilei Wang,Chunpeng Wang [2] discusses an app designed in order to improve the learning interest, ensure experiment safety and save experience cost this AR app is designed. The augmented reality technology can create an environment processing function called communication, data storage and background. There are some chemistry experiments involving expensive chemicals, some dangerous and harsh conditions. So in order to ensure the safety of students and also save the cost this is developed. It is developed following these steps: the combination of card battle and combination of card battle and augmented reality,3D simulation of chemical reaction experiment process,wide application platform, random licen sing algorithm is used and also there is reward mechanism where the database stores users accounts making it more interesting.

Neetika Gupta,Mukesh Kumar Rohil [3] discusses about a number of studies that have been published stating the positive impact of AR in teaching process. The success of such ideology is supported by the fact that when technology is embedded in the learning process, it brings real world problems, innovative ideas and increased communication bonding between professionals. Also, author says that more and more studies are carried out in the field of science, social science and Engineering. Various applications stated by author were AR environment was designed for inquiry based astronomy learning using augmented views of celestial bodies. A nuclear accident emergency response system was built using geographical information and AR. The system provided various escape routes and instantly generated relief reports. The study proposed few useful research directions for AR related science learning from the perspective of modern technology.

Matt bower, Cathie Howe, Nerida McCredie, Austin Robinson, David Grover [4] proposes that Augmented Reality has been used to develop students understanding of science including environmental science, microbiology and biomedical science. The uses of AR described in this paper by far is related to the provision of information and lower thinking capabilities. These are important functions of AR – to offer knowledge in a way that is more likely and related to the world around us.AR allows educators to create a scenario, provide location specific information based upon GPS position inject scripted or non-Player characters into the learning experience and embed data within the real world.

Per Anders Lovsletten, Linda Kioning, Tone Vold [5] describes the real estate business mainly about dealing property and developing properly for sales. The students attending the real estate study program learn about which factors may influence the pricing of a property or a property in development, to have the possibility of seeing interiors in a new flat or a new house influence on their willingness to buy, to be able to teach the students about these possibilities opens up for a number of different benefits. the text edit has been completed, the paper is ready for the template. Duplicate the template file by using the Save As command, and use the naming convention prescribed by your conference for the name of your paper. In this newly created file, highlight all of the contents and import your prepared text file. You are now ready to style your paper; use the scroll down window on the left of the MS Word Formatting toolbar.

## V. IMPLEMENTATION

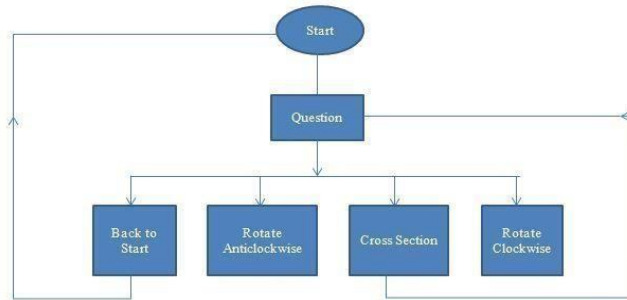The design and implementation is shown as stated below.



Figure 5.1: Flowchart of the designed application

Homepage is the hub where one can navigate through various questions. The above figure is shown for only one question but the process is followed for set of ten questions. Depending upon the question selected the corresponding scene will get opened which will comprise of the following options as shown in the figure above. The options available on the scene of each questions are rotate clock-wise, rotate anti-clockwise, the cross section and back to start.

**UNITY SOFTWARE**: UNITY 3D is a real time development platform where games, films can be created easily and efficiently. When a new Unity project is created it will display an untitled and unsaved scene. This scene will be an empty scene with default objects - either an orthographic camera, or a perspective camera and a directional light, depending on whether you started the project in 2D or 3D mode.

Here we work with the content in Unity. There are various assets available in UNITY which can be imported as per need. For example, if one wants to build a simple game a single scene is enough. While for a more complex game, one might use more than one scene's. To start with augmentation the player settings should be proper and vuforia augmented reality support has to be checked.

Unity makes use of scene templates to create new scenes. Scene templates are assets that are stored in a project. After selecting the necessary template, scenes are created. Scenes will have the objects that are needed. They can be used in order to design main menu, environment etc. The scenes that are created have to be numbered according to the order and using buttons which are programmed using C sharp scripting these scenes are linked.

Unlike most other assets, scripts are usually directly present in UNITY. This scripting helps the objects how to behave, helps scenes to interact with each other. The language that's used in Unity is called C sharp. All the languages that Unity operates with are object-oriented scripting languages. This scripting language will have syntax and primary parts called as variables, functions, classes. Once the scenes are created the necessary figures needs to be imported. These figures are present in .FBX format.

**Image Target** is a specific type of marker used in Marker- based tracking. They are images you manually register with the application, and act as triggers that display virtual content. The image target that we selected is as shown below.



Figure 5.2 : Image Target

The image target shown above is stored in the database. Vuforia creates the license key of that particular target which is to be pasted in the unity app under resources of Vuforia configuration. Different or same markers can be selected for different structures as target.

**The Vuforia Target Manager**: It is a web-based tool that enables one to create and manage target databases on Vuforia's developer portal. The Target Manager supports target images of various types like image targets, multiple targets, cylinder targets and VuMarks.

**Tracking and marker types commonly used in Vuforia application's** : The markers are images or objects registered with the application which act as information triggers in the application. When the device's camera recognizes these markers in the real world, this triggers the display of virtual content over the world position of the marker in the camera view. Marker-based tracking can use a variety of different marker types, including QR codes, physical reflective markers, Image Targets and 2D tags.

The simplest and most common type of marker in game applications is an Image Target.
In order to work with this target manager one needs to create and account on Vuforia developer portal. All databases created in the Target Manager must be associated with a license key. Once you have a license key defined in the License Manager, you can proceed to create a database.
Once the database is created it needs to be downloaded and imported into the unity. The image target has to made a child object of the AR camera. The Unity AR camera settings provider is an experimental mixed reality toolkit component that allows mixed reality applications to run on Android and iOS devices.
**UI in UNITY** : Unity UI is a UI toolkit for developing user interfaces for games and applications. It is a GameObject- based UI system.
**The Canvas** is the area that all UI elements should be inside. The Canvas is a Game Object with a Canvas component on it, and all UI elements must be children of such a Canvas. Every UI element is represented as a rectangle for layout purposes. This rectangle can be manipulated in the Scene View using the React Tool in the toolbar.
Rotations, size, and scale modifications occur around the pivot so the position of the pivot affects the outcome of a rotation, resizing, or scaling. When the toolbar Pivot button is set to **Pivot mode**, the pivot of a React Transform can be moved in the Scene View.
In order to link different scenes, button will not do anything on its own; it only calls the specified method in its scripting. In the Button's properties, we have to set it to OnClick() property.
Scenes are linked with the help of programs written in C sharp scripting language. Depending on the particular button appropriate scene will get displayed. The user than have to keep the target image in front and the app will display the 3D structure.
**AUTODESK FUSION 360**: It is the cloud based software with 3D modelling, CAD, CAM and PCB platform. It can be used for product design and manufacturing. In order to work with Autodesk Fusion 360, student version is selected which is for a period of 1 year and the software is installed on the system. After uploading the required credentials, a student's license is given.
For creating the structure one has to click on create sketch and draw the structure diagram. Once the structure is drawn as per the dimension it has to be extruded as per the required width. The appearance of the structure can also be changed also the structure can be designed as per requirement and made using different tools available. The required structure is designed with the proper measurement and then the final model is obtained.
Once the structure is ready it has to uploaded online and converted into .FBX format and transferred in UNITY. Also the cross sections of the figures were designed by creating a mid-plane followed by splitting the body by using tools available in Autodesk Fusion 360.
The Total 10 structures that were designed in this software are shown below. The structures are taken from N. D. Bhat textbook for Engineering Graphics.

Figure 5.3: Structures created using FUSION 360.

## VI. PROPOSED SYSTEM RESULTS

The below figure shows one page of the booklet having the top view, side view and the front view to compare with the augmented 3D structure, along with the marker.
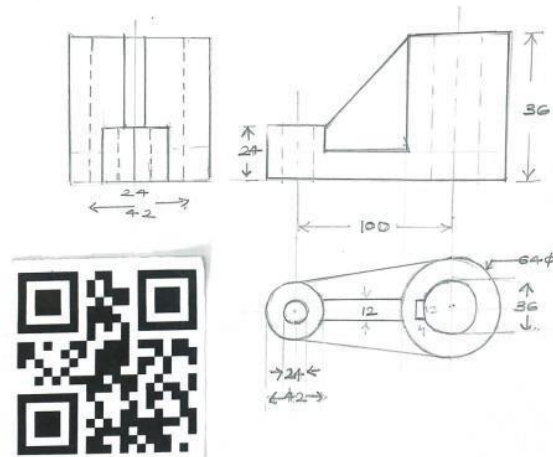


Figure 6.1: Page of booklet with front view, side view and top view.

The UI consists of buttons which represent the questions and an exit button is also present. This main menu is created using canvas and panels are used to align different parts properly on the screen; buttons are linked to the different scenes using c# scripting. C# scripting is done using Visual studios. Videos is put in the background to make the main menu look attractive which is playing continuously in a loop.

Figure 6.2: Home page of application

On clicking a particular button it opens up the scene where a user can scan the marker using camera and the structure gets augmented which is already stored in the vuforia database and imported in the unity. An augmented image of the object is visible through mobile screen.
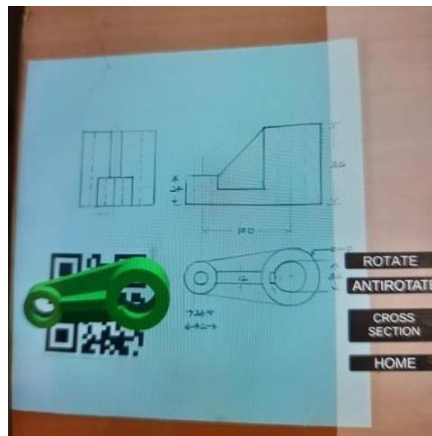

Figure 6.3: Augmentation of the figure.

There is an option to rotate, anti-rotate , to see the cross- section of the object and one can go back to the main menuby clicking on the home button.
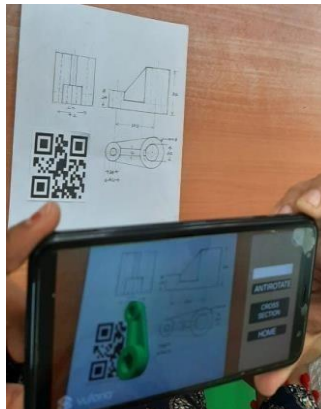

Figure 6.4: Rotation of structure by clicking rotate button

Figure 6.5: Augmentation of Cross – section of structure

Here, the structure is cut in the middle into two halves usingthe FUSION 360. Finally the apk file is generated and installed on the mobile.

## VII. FUTURE SCOPE

Interface can be made wherein the user can vary X, Y and Z axis according to convenience and view the structurefrom different angles.

To display top view, side view and front view separately for a given 3D structure. An algorithm can be designed so that the user can just show the top view, front view and side view and the structure will be generated automatically.

## VIII. CONCLUSION

The current system of teaching 3D Geometry inschools and colleges can make widespread use of this technology. Our research will help students to develop an in depth understanding of 3D spaces and objects in the 3D spaces. The use of Augmented Reality in education is useful in making students understand the course in much better way. The augmentation in markerbased AR system is faster as compared to marker less. The time taken to create a structure in Blender is much more than in Fusion 360.

## REFERENCES

[1]. H. Chen, K. Feng, C. Mo, S. Cheng, Z. Guo, and Y. Huang, "Application of aug□mented reality in engineering graphics education," in 2011 IEEE International Sym□posium on IT  in Medicine and Education, vol. 2, 2011, pp. 362–365.

[2]. J. Jin, T. Liu, Y. Wang, and C. Wang, "Isea: An  interesting application of chemistry education based on ar," in 2019 International Conference on Virtual Reality and Visualization (ICVRV), 2019, pp. 283.

[3]. N. Gupta and M. K. Rohil, "Exploring possible applications of augmented reality in education," in 2017 4th International Conferenceon Signal Processing and Integrated Networks (SPIN),  2017,  pp. 437– 441.

[4]. M. Bower, C. Howe, N. McCredie, A. Robinson, and D. Grover, "Augmented reality in education — cases, places, and potentials," in 2013 IEEE 63rd Annual Conference I

[5]. P. A. LØvsletten, L. KiØnig, and T. Vold, "Using ar in higher education - suggested use in the real  estate agency study program," in 2019 18th International Conference on Information Technology Based Higher Education and Training (ITHET), 2019, pp. 1–4.

[6]. M. F. Hossain, S. Barman, and A. K. M. B. Haque, "Augmented reality for edu□cation; ar children's book," in TENCON 2019 - 2019 IEEE Region 10 Conference (TENCON), 2019, pp. 2568–2571.

[7]. J. Yeargan and K. Hernaut, "The globalization of european engineering education: an american observer's perspective," in 31st Annual Frontiers in Education Confer ence. Impact on Engineering and Science Education. Conference Proceedings (Cat. No.01CH37193), vol. 3, 2001, pp. S2D–1.

[8]. S. Patil, C. Prabhu, O. Neogi, A. R. Joshi, and N. Katre, "E-learning system using augmented reality," in 2016 International Conference on Computing Communication Control and automation (ICCUBEA), 2016, pp. 1–5.