An Augmented Reality Application System for Teachers to facilitate 3D Structural Drawings in Civil Engineering

M.Ashokkumar[1*]

[1] Department of Information Technology, Arunai Engineering College, Tiruvannamalai, Tamilnadu

***Corresponding author: E-Mail: m.ashokme002@gmail.com**

ABSTRACT

This research aims to scale back the time, effort and cost needed for developing numerous educational materials for teaching Structural engineering drawings by doing replacement of actual teaching materials with virtual ones on an augmented realityapplication system .Augmented reality is a new Human Computer Interface(HCI) System, that enhances a real scene with computer generated three dimensional(3D) objects. The evolution of recent microprocessors and computer memories during the past decade has created the acquisition, recording and manipulation of virtual 3D objects technically reasonable, even with normal personal computers and hand-held devices. For this reason the augmented reality has numerous application areas like Military, Medical, Engineering, Gaming and goes on. So, this AR application system helps the teachers to train the students to facilitate structural drawings and also has following features. 1) The simulated structural models constructed by 3D modeling software are superimposed as real structural scenes as AR objects. 2) Students can view the 3D structures in different perspective views. 3) The structural objects are wrapped by realistic textures to give reality over objects.

KEY WORDS: HCI, 3D, Augmented Reality, Structural Drawings.

1. INTRODUCTION

Every day teacher develop various teaching materials like lesson plans, notes of lesson, presentations, and manuals to facilitate teaching. We can say that on a daily basis lecturers and professors design and implement an action plan, analyzing outcome observation, and modify plans to meet the requirements of students. Engineering course has several principles and domain which make tough to teach and tough to learn by teachers and students. From that several concepts this paper only concentrates on structural engineering designs which is a part of civil engineering. Let us discuss about some aspects of structural designs which help us to understand the difficulties occurs on learning the structural concepts. Structural design is a systematic and iterative process that involves: 1) Intended use and occupancy of structure-by owner. 2) Architectural plans and layout development –by architect.3) Structural framework identification-by engineer. 4) Loads estimation depending on use and occupancy. 5) Structural members design and connections. 6) Fabrication and erection –by fabricator and contractor and goes on. The primary responsibility of an engineer is ensuring the safety and serviceability of the structure. The engineers used 2D structural designs before 3D enters in an engineering that shows only the two axes along with dimensions alone. Later, the 3D has got entered in structural drawings which helps to draw the plans in all 3 axes that facilitates the load estimation and safety measures. The following image shows how 2d and 3d structural drawings looks:

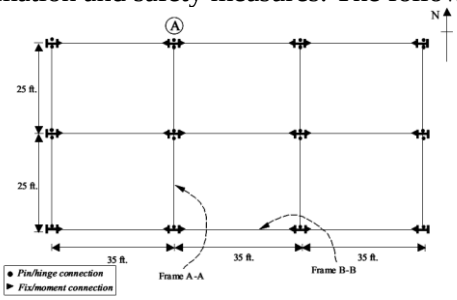


Figure.1. 2D Structural floor plan and layout

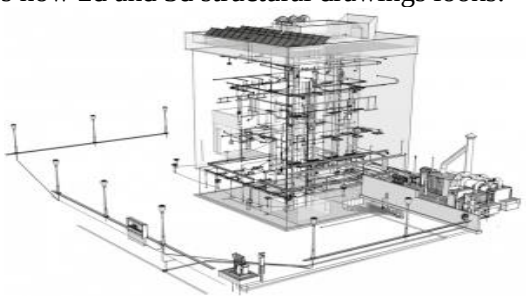


Figure.2. 3D structural plan and layout

Now, an awesome technology that handshakes with 3D technology name as Augmented Reality.AR is an emerging platform for many sort of applications like medical, games, audio-visual aids, industry, museums, edutainment. This platform, allows spatial virtual and real worlds co-existence, which aims to enhance user perception view in his real environment. Enhancement could concern all user senses like haptic, audio and visual. Here we focus on visual sense. Both indoor and outdoor environment could be used. User could be present in his environment or perceive it from away. Some comparative studies (Tang, 2003), have shown that yields better performance through AR. AR has also been widely used for training and teaching purposes where annotations of components operational steps, name and location are overlaid in the real scene as guides to new users. Neumann and Majoros (Neumann, 1998) suggested that AR can be used to support teachers for concurrent training and performance that greatly reduces the necessity of training as a distinct process.

Motivation and related work: A design process plays a key role in civil, mechanical and structural engineering. Structural design is an iterative process combined with several steps which includes identification of needs, goal statements, conceptual design, and structural design with proper load estimation. Nowadays, 3D drawing were been developing using many licensed commercial CAD packages like Autocad and Ansys. From the study that has been

done across many papers we came to know that Augmented Reality has many applications, that also been introduced in mechanical drawings to learn the concepts easily with hologram too. Let us discuss how an augmented reality helps the teacher to facilitate teaching aids over structural drawings and designs.

Fundamentals of AR: As we know that, an AR is a composite view of real and virtual scenes. While choosing augmented reality one can come across its types. AR has two primary types and implementation 1) Marker Based AR 2) Marker less AR. In this paper, we are going to concentrate on Marker based AR, let us have the short discussion about the types and implementation.

Marker Based AR: The implementation of Marker-based implementation requires some type of image which is having black squares such as QR/2D code to displays virtual objects which is sensed by reader like camera or mobile phones.

Markerless AR: It is also referred as Position based AR, where it generates virtual scenes without any markers.

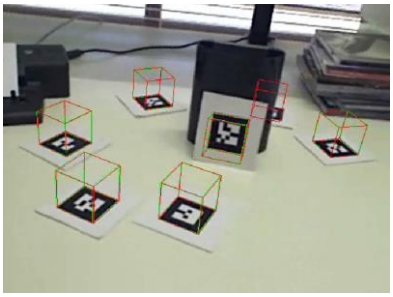


Figure.3. Marker Based AR

Figure.4. Markerless AR

2. METHODS

Development of AR application for structural drawings: This section explains the configuration of AR application system.

Overview and structure: The marker based AR system tracks and recognizes a AR marker from a digital camera image and overlays a virtual 3D objects or drawings made by 3D-CAD as educational material on the image.The hardware of the system is composed of a personal computer and a web camera. The AR environment is constructed by using some programming library kits, such as FLARToolKit, AIR marker generator, Flash and 3D CAD package. The FLARToolK it is a programming library for implementing augmented reality application via flash. A 3D virtual object is overlaid on an AR marker taken by the web camera. Position and orientation of the virtual object is defined by automatic recognition of AR Marker's position and the orientation. The following figure shows how the FLARToolkit overlay the virtual object on AR marker.

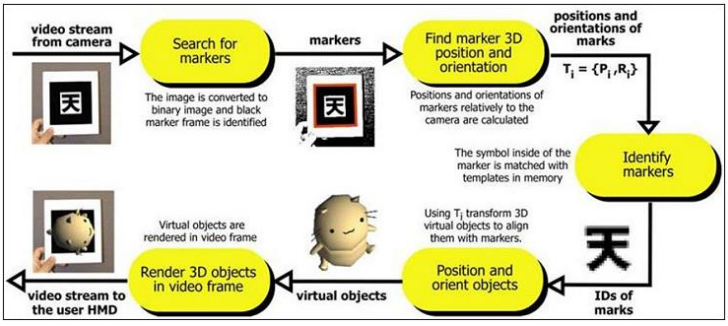


Figure.5. FLARToolkit Process to overlay virtual object

Simulating composite structure: With the proper simulation tools, designers will predict performance, analyze responsibilityand potential failures, optimize construction, and export correctdata to manufacturing, all before a physical paradigmis made. Now, here the teacher role is to develop or build a 3D structural design that meets the requirements of the related topic.so, this can be achieved by proper simulation 3D modelling tools. Once did the objects should be export as 3D file to make use of it in an AR environment.

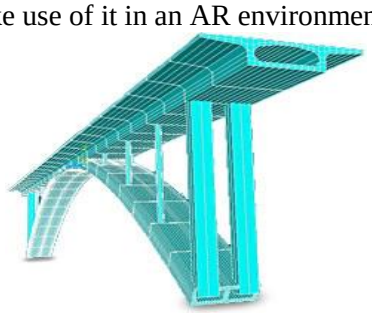


Figure.6. Structural Building Design

AR Marker: As we discussed in a previous section, The AR system overlays virtual objects on real world. In order to do that, the system need to read the vertices of the position and the axis orientation of the virtual 3D objects. It is sometimes referred as registration. The registration procedure to overlay a virtual coordinate over a real coordinate of an object.The distance of a virtual object from a webcam is calculated by tracking the AR marker edges with the help of binarized web camera image. Our augmented reality application system uses a AR marker for the registration, which tracks each and every aspects of virtual objects. so the student takes the cubic AR marker in hand and watches the structural design from various directions of front, back, top, under, left and right. This technique helps the student to learn structural designs with real experience similar to seeing an actual educational material .

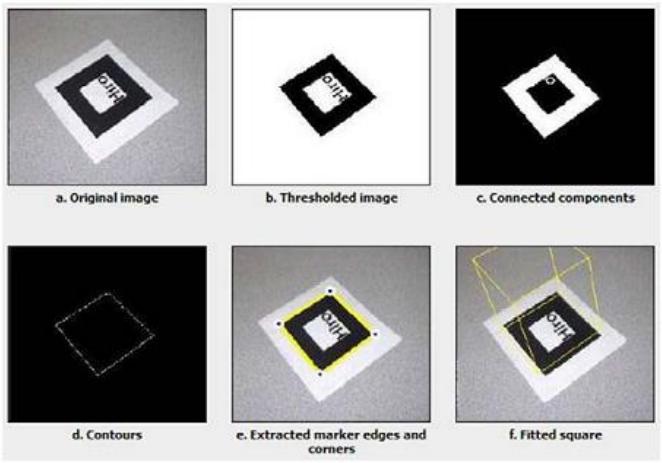
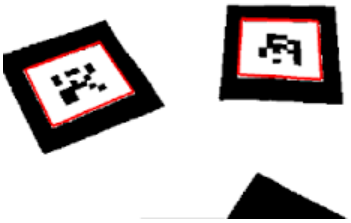


Figure.7. AR Marker recognition from camera.

3. RESULTS

This section shows how the AR application system overlays the 3D structural designs generated by computer software in an AR marker with the realistic texture expression. a) The first step is detection of registered marker using a digital web camera which reads the image and convert it into binarized image. b) The Flar Toolkit setup an AR environment along with the 3D structural designs which has been developed from any 3D CAD packages. c)The toolkit recognizes an registered AR Marker then it overlays an 3D virtual environment which has been setup in a previous step with realistic textures. d) Finally, this can be used as teaching aid which helps the teacher and student to explain and learn the very difficult structural design concepts in a more realistic manner.



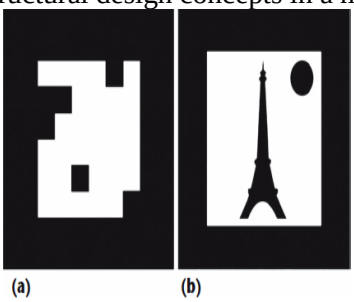


Figure.8. Marker Detection **Figure.9. Marker identification** **Figure.10. 3D AR structural design**

4. CONCLUSION

In this paper, we developed an AR application system that facilitates teaching the structural drawing. The 3D objects were made by 3D structural modelling packages. The realistic user experience was achieved by AR marker and a flash based augmented reality toolkit with more realistic texture. As the result, the AR application system reduces the time and cost for preparing various structural 3D drawings as teaching aids by replacing a regular materials with virtual ones.

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