# Augmented Reality Books: An Immersive Approach to Learning

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**Abstract — Learning from books is a very mundane and passive process. The user has to do all the learning merely with the help of a static text, which makes the learning process tedious and tiring. More importantly, there are no means for the user to learn more about unknown concepts or jargons given in those books. In spite of these pitfalls, most of the education systems today are based on learning from these old books. In this paper, the authors present a unique solution that uses augmented reality to make the learning process more interactive and interesting. A system is developed for the students wherein they have to just hover a camera over the text or image present in the book. In turn, the system shows the related graphical data augmented over the identified text or image. The system helps the students learn new concepts by simply using a smartphone and the intended book. Apart from the usage in education, it can also be used in the field of advertisement, medicine, gaming, and entertainment.**

**Keywords—augmented; reality; AR books; interactive; learning; education**

## I. INTRODUCTION

Today, the new age digital devices such as e-Book readers, tablet PCs, netBooks, electronic ink (e-ink), and electronic paper (e-Paper) are undergoing rapid development, offering opportunities and challenges for both the students and the teachers to innovate. This rapid growth of digital devices along with the development of a variety of software content transcend the limitations of paper books, which have the difficulty of updating the information with knowledge-cantered, and one-sided, linear learning materials [1]. However, the loss of paper-based books is not welcomed by everyone as they are cheap, easily transportable and provide a multi-sensory experience. With the help of the release of augmented reality books, which combine both real world and digital world, one can get an experience of mixed reality.
E.g.: In the case of an electrical circuit, the AR book will identify the circuit using a marker (image recognition) and demonstrate the flow of the current through the circuit without actually developing the entire circuit.

### *A. Motivation*

Books have been used as a tool to support learning and acquisition of knowledge. However, sometimes these books are unable to explain the concepts clearly. This is due to the limitations of paper books like static content without any interactive nature. The advancement in technology makes the book available in an electronic form. The electronic form of a book is claimed to support various type of multimedia, which makes the reading experience more interesting. Hence the motivation to develop a system that uses concept of augmented reality for educational purpose in the form of AR Books was aroused. This system of AR Books will enable the user to hover the camera on any page and identify the content on it to obtain a more intuitive and augmented information. This will make the physical books more interactive. Thus by means of AR books, students can understand a particular topic in a better way.
The rest of the paper is organized as follows. Section II covers the literature review, which throws light on the work done in the area of augmented reality in the education sector. Section III presents the proposed approach to implement the intended solution. Section IV describes the design and implementation details of the proposed approach. Section V presents result and analysis obtained from the system. The paper ends with conclusion and direction for future work.

## II. LITERATURE SURVEY

Different researchers have presented different approaches that use augmented reality in different fields such as medicine, architecture, education, military, and others. In this section, the related work on augmented reality has been explored. Most of the augmented reality based systems followed architecture, which has multiple components such as the camera module, image processing module and the rendering module. These systems capture a target image first, which is then stored in the database. Then the image is processed to identify the marker, and the virtual object is rendered. This object is combined with the original image to display the augmented information. The issue with this approach is that it requires more memory and processing time. Let us now see some of the prominent AR based systems currently available in the market.

1) wARna [2]: It is a mobile-based interactive Augmented Reality coloring book system. It not only extracts the texture from the coloring book but also maps it onto the corresponding 3D content. It follows a marker-based detection technique where a frame marker is used for 3D content augmentation. The texture is extracted from the marker to design a 3D model using texture mapping. The user can color the generated 3D models.
2) GeoAR [3]: It is an interactive book that uses augmented reality to teach geometry. The software is aimed at elementary school students. It engages and motivates them to learn new

topics. The system has various features such as animation, 2D images, and sound.

3) Magic Book [4]: This system integrates the physical object and augmented reality to immerse the user into the virtual space. It uses a smartphone to display augmented reality 3D scenes appearing out of the book. Multiple readers can simultaneously see the book immerse into the same virtual scene.

4) Interactive Circuits using Augmented Reality [5]: This system is designed for the students to perform physics experiments using Augmented reality. It eliminates the need and the cost incurred in using the actual components. It makes the topic interesting and interactive.

### *A. General Observations on the Existing Systems*

The systems discussed in the previous section has various limitations that make the learning process uninteresting for the user. The reasons are:

1. Most of the systems use a marker based image recognition technique for detection. Since images are not available for all textual information, the systems cannot be used universally.
2. Text recognition is not supported, and hence no additional information about any keywords is provided. Without text recognition, the user will always need a predefined image with specific marker points for getting information.
3. The object has to be captured first, and the model is created. This causes the application to lag, thus not making it a real-time AR system.
4. The systems are developed on native platforms and are not compatible with other platforms thus targeting only a limited audience.

Considering the various issues mentioned in the existing systems and their importance in the e-learning domain, it is decided to address these issues in the proposed system. The system should use the camera module dynamically. The system should be able to detect and track markers in real time. It should allow interaction with the augmented models. It should work with both marker and marker-less images. Finally, the system should be cross platform. Details of the proposed approach are given in the next section.

## III. PROPOSED APPROACH

'The ability to learn is a skill', is rightly said by Brian Herbert. Learning or understanding any concept under the sun should be made fascinating and synergistic. This will eventually ensure that the user has his/her full attention and can grasp things at a higher rate. The same is being incorporated in the proposed system. The system is based on the concept of augmented reality. It basically simplifies the learning process for students. The underlying idea is that the smart phone will act as the medium for interaction with the book. For example, the user is studying an electronics subject where he/she comes across a section, which is about the P-N Junction diode. However, a static content of the book is not sufficient for him/her to understand the actual current flow of the diode. In that case, the proposed system will assist the user by showing augmented information such as a video showing the flow of the current using a smart phone.

First, the user has to install the augmented reality system on his/her smart phone. The user will also need a textbook from which he/she is studying. While studying from the paper book, the user may find some concepts or images difficult to understand. He/she might even need additional information about the same. In that case, the user can run the proposed system on his/her smartphone. The system will start the camera module and enable the device camera. The user can hover the camera over the image, which is recognized using the image target database. The image target database stores all the images in the form of image targets. Whenever a user comes across any of these targets images via the system, it will be recognized and detected.

Once the image is detected, additional information about the image will be made available to the user. In the example, the diode image will be detected by the system. As a result, a video showing the working of a diode will be played. The user will see the actual movements of protons and electrons which will help in the understanding the working of a diode in a better way. As a response to the image detection, even 3D models will appear on the system's screen. Some images are coupled with the explanatory videos. The videos will be shown having all controls like play, pause, forward, rewind. There might even be some cases when the user wants to understand the meaning of some technical jargons. Well, the user again just has to hover over that keyword, and he/she will be provided with the required information to understand the jargon. The information may be provided in the form of an image, a 3D model or a video. It is not always feasible to buy all the electronic components as most of them are very expensive. But without the components, the user might not get a clear idea about it. In such a scenario, the system will provide a 3D model or video which will demonstrate the working of that component. This will cut down the unnecessary expenses. Fig. 1 explains the flow of the proposed AR based system which helps in skilled learning. Now let us understand the architecture of the system.

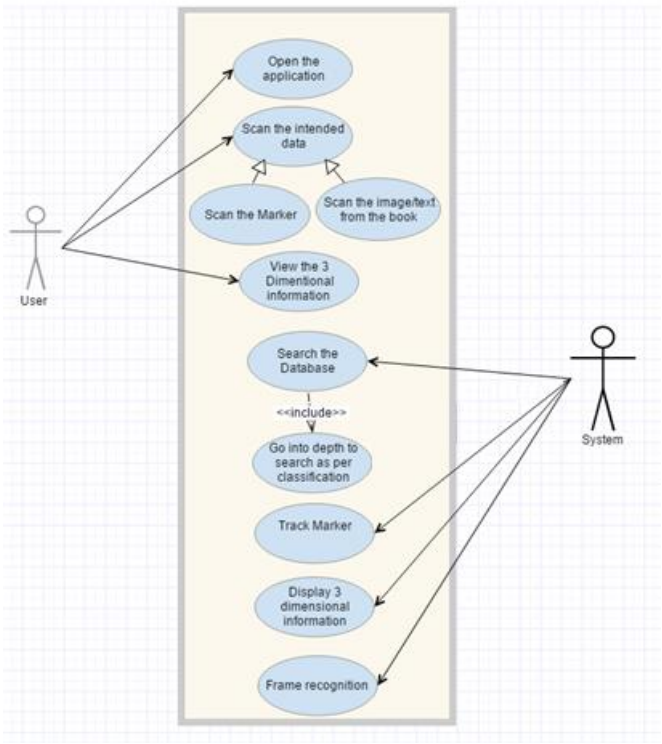


Figure 1 Proposed System Flow

## IV. SYSTEM ARCHITECTURE

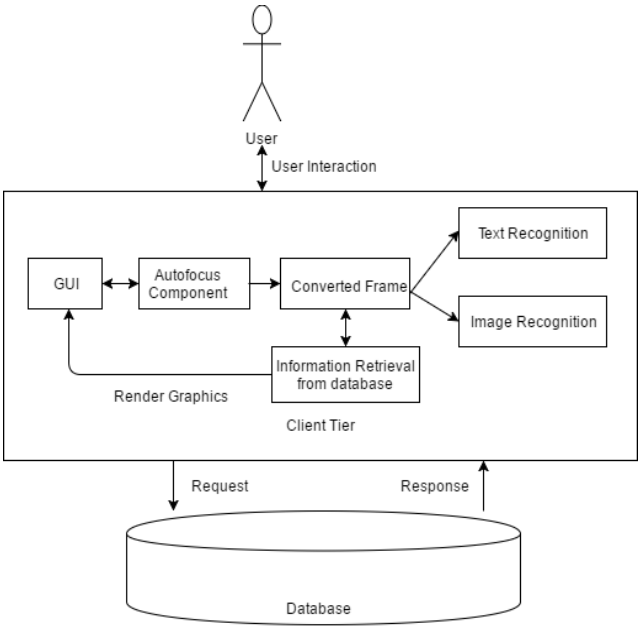


Figure 2 System Architecture

The first phase in designing the system is to select an architecture. Fig. 2 shows the architecture of the proposed system, where a 2-tier client-server architecture is selected. The main reason for selecting the said framework is that if all the data is stored on the client side, the system size will increase resulting the system to lag on low-end mobile phones. Hence a separate server is required to store and process all the target image and text. The server database also helps in mapping the corresponding model for the identified text or image target. The work of the client side is to display this mapped 3D model or video over the identified image and textual data.

The architecture of the system is thus divided into two layers, namely, the client side layer and the server side layer. At the client side, the user interacts with the system using the Graphical User Interface (GUI) which in this case is simply the display rendered from the camera module. The user hovers over the image/text with the help of the autofocus module which focusses the camera on to the target. Further, it is identified whether the target is an image target or text target. This is also done by the client side which identifies the type of input and then forwards it to the server side layer. The second layer is the server side layer which consists of the database. Once the image target has been identified, the corresponding information is retrieved from the database and forwarded back to the client. The user directly provides the input to the system at the client side while the processing of the input is done by the server side. Let us see the role of each module in the system.

1) *GUI Module:* This module invokes the camera on the smart phone. It lets the user hover over the image of which he/she wants to understand the concept. This module is of prime importance as the data is recognized solely by the camera.

2) *Autofocus Module:* This module focusses the camera on the content so that the content can be tracked easily. It lets the system to be used with any range of mobile phones. Also, it is a basis for the further text recognition module.

3) *Content Tracking:* The camera module is not useful without the content tracker which identifies the required content that is to be tracked and used for augmentation. It identifies the images with or without markers, and for text recognition, a blue box appears around the identified text.

4) *Marker detection*: The detection method will depend on the design of the marker. Square markers are detected searching for lines and contours while circular markers are detected searching for blobs. The contour detection algorithm for square markers takes advantage of the fact that the markers are four-sided quads with a black border. To keep the algorithms as low-cost as possible a fast rejection/acceptance test is often followed by the detection to ignore obvious non-markers [6].

5) *Text Recognition:* The Text Recognition feature allows developers to create apps that detect and track printed English words. The words are matched with a predefined list of words. The developer can build a better user experience by handling text recognition events. Vuforia can detect words that belong to a pre-defined word list. One can define a custom word list.

6) *Image Recognition:* Image target represents the images that can be recognized by the Vuforia SDK. These image targets do not require to have special regions to be recognized. Instead, these images are recognised on the basis of feature points which help the system to identify an image. Each image is rated by Vuforia on the basis of its feature points. Higher the rating, the faster the image is recognized by the system. After target detection, the image will be tracked as long as it falls under the camera's purview.

7) *Information retrieval from database:* After text detection using Vuforia SDK information is retrieved from the database by matching of the keywords. When an appropriate match is found, the information is displayed to the user. If a particular keyword is not present in the database, then an online search is performed and the information about the keyword will be displayed to the user.

## V. IMPLEMENTATION

Looking at the role played by each component of the system, let us see the implementation of the system with respect to the proposed approach. In order to implement this system, various tools and technologies are required. Several approaches exist to make Augmented Reality applications. A marker less image and text based approach are used wherein an image or text is recognized upon which the corresponding information is augmented.

### *A. Setting up Vuforia*

To get started, Vuforia's Developer Portal is set up, and an account is created. Once logged in, a developer page is available. A license key works as an ID to create an application in Unity using Vuforia. This license key is created in the developer page with the help of a "License Manager". Next, the "Target Manager" is used to add Image Target in Unity. This is done by adding an Image Target database and filling in the details. Images are added to the newly made database. Vuforia supports various kinds of targets like a single flat image, cylindrical, cuboidal, 3D image, etc. Lastly, this Image target

database is downloaded for importing into Unity. This is done with the help of the "Download Dataset". Fig.3 shows the Vuforia Developer Portal where the license keys can be managed and the targets can be uploaded.

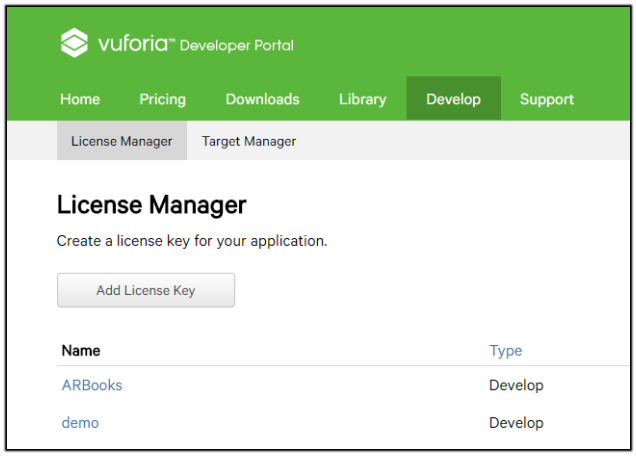


Figure 3 Vuforia Developer Portal

## B. *Integrating with Unity*

Unity is a cross-platform application engine developed by Unity Technologies which provides a framework for designing game or app scenes for 2D and 3D. "ARCamera" is an Augmented Reality camera prefab from Vuforia. Image Target is added to the scene which is be found in the "Prefabs" folder. Fig. 4 shows the Image Target that is added into Unity which is obtained by importing the dataset downloaded from Vuforia.

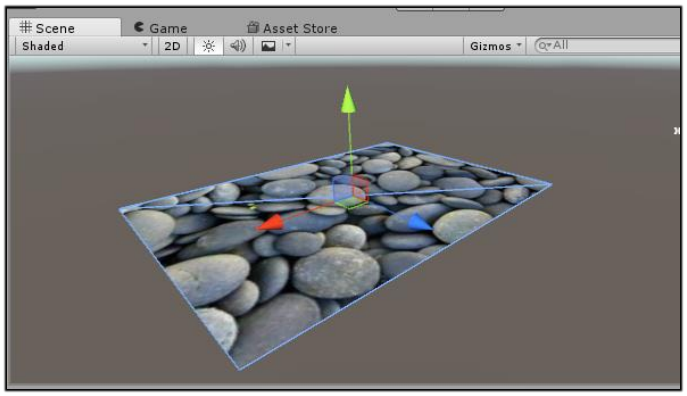


Figure 4 Adding Image Target

## C. *Text Recognition using Vuforia*

To identify words in unity, the Core features of Unity is downloaded and imported in Unity. TextRecog module is then dragged on the Scene and in the inspector, Word list is selected as Vuforia-English-word. Also, the word to be recognized is provided to the TextRecog module which helps the system to identify and recognize a specific word. Fig.5 shows an example of the system where the word "Fixed Resistor" is identified and highlighted with the help of a blue box. In the same manner, the 3D models or videos can be augmented over this identified text.


Figure 5 Text Recognition

## D. *Model Augmentation*

After the system is ready with Image and Text recognition modules, a 3D Model is augmented over the identified text or media. It is found under "Model" folder in Assets. For the model to appear over Image Target, it is made a child of Image Target. This is simply done by dragging the model prefab in the Hierarchy panel. Whenever the Image Target is detected by a mobile device's camera, all the children of the target also appear together. The same is also performed for augmenting model over a text. Fig.6 shows the system augmenting a 3D Ceramic Resistor model on the identified text of "Ceramic Resistors".

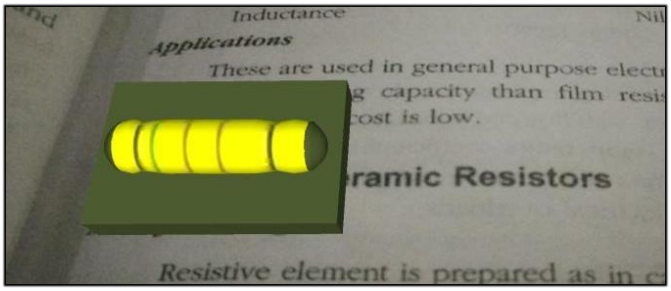


Figure 6 Model Augmented on a text

## E. *Video Augmentation*

For augmenting a video on an Image target, the Advanced Topics of Vuforia are imported into Unity. The video is added over the image by using the video playback prefab on image target. Multiple components are added such as trackable event handler, play video controls, tap handler, menu options, etc. Finally, the Video Prefab under Image target is selected, and a play video component is added. This ensures that a particular video plays when the image or text is selected. Fig. 7 shows the system displaying a video when it identifies a corresponding image target.

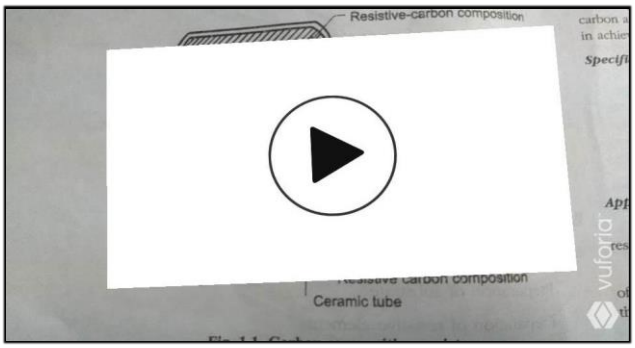


Figure 7 Video Augmentation on an Image

### F. *Deploying the System*

After developing the system, the most important step is to deploy it on platforms which make it usable for users. Unity provides the advantage of deploying the system on multiple platforms such as Android, iOS, etc. [7]. The company name and the Bundle identifier are changed in the build settings for the system to be deployed. Fig.8 shows these changes where the Bundle identifier and company name are added to the system deployment build settings.


Figure 8 Changing Build Settings

### G. *Running the Application*

After deploying the application, a package is made available for installation. After installing the package, the system will start, and the camera module will begin. Then, the user has to only hover the camera over the provided text or image, and the corresponding graphics will be rendered. Fig. 9 displays the fully functional system where a 3D model of a Resistor is augmented on the text "Fixed Resistors" which is identified by simply hovering the camera over the book.


Figure 9 An Interactive Learning System

## VI. CONCLUSION

The system "Interactive Virtual Assistance with Projected Augmentation" is implemented where a user can hover a camera over a page and obtain augmented information such as 3D Model, video or an explanation about that page. It is a system where no typing or searching is required for getting information. The system provides a helping hand to the user by facilitating them to learn new concepts using graphical aid. Since the application can be deployed on any smart phone, a student can use it as per his/her convenience. Also, there is no need of any extra maintenance for this system thus making it an economical solution. The interactivity aspect like showing the 3D model allows the user to understand the concept from every angle. Also, the video shown with the controls gives the user the exact feel of learning in an actual classroom. The system can be expanded further and used for various age groups for not only learning but also helping the users to visualize and grasp things faster. It provides a unique and interesting way of learning and understanding of unknown concepts.

## VII. FUTURE SCOPE

It is rightly said that 'Knowledge has a beginning but no end'. During the implementation of this system, it is found that there are instances and scopes where the system could be improved. Following was the observations:

1) Apart from its application in the Electronics field, it can be expanded to multiple domains and areas of books

2) The media content can be directly accessible from the cloud thus saving the memory of the installed system

3) Applications with school books, restaurant menus, and newspaper advertising may be performed

4) A universal search tool for identifying content dynamically and providing information of it from the Internet can be implemented to make the system truly universal.\

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