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Hiro Card Marker Detection in Augmented Reality

[1]Vijayanarayanan A, [2]Savithiri R, [3]Lekha P, [4]Abbirami R , [5]Noble Lourdhu

[1,2,3,4,5] Department of CSE, PERI Institute of Technology, Chennai, India.

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Corresponding Author:
Vijayanarayanan A

Abstract— Augmented Reality is a combination of a real and a computer-generated or virtual world. It is achieved by augmenting computer-generated images on real world. It is of four types namely marker based, marker less, projection based and superimposition based augmented reality. It has many applications in the real world. AR is used in various fields such as medical, education, manufacturing, robotics and entertainment. Augmented reality comes under the field of mixed reality. It can be considered as an inverse reflection of Virtual Reality. They both have certain similarities and differences. This paper also gives us knowledge regarding those major threats that augmented reality will face in the near future and about its current and future applications. It provides a comprehensive study of Augmented Reality. One of the challenges of AR is to align virtual data with the environment. A marker-based approach solves the problem using visual markers, e.g 2D barcodes, detectable with computer vision methods. We discuss how different marker types and marker identification and detection methods affect the performance of the AR application and how to select the most suitable approach for a given application..

Keywords: ***Augmented Reality, Entertainment, Virtual, Computer***

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I. INTRODUCTION

Augmented Reality has its origin from the word 'Augment' meaning to add or enhance. The term Augmented Reality was given by Boeing Researcher, Tom Caudell. Augmented Reality (AR) is overlapping or augmenting of digital images on real world objects using various AR apps. AR intensifies one's understanding of the real world. AR can be defined as the system in which real and virtual worlds have been combined, there is real time interaction, and the device is registered in 3D. Here, the augmentation is being done in real time. One can say that AR is a technology in between the real reality and the virtual reality. Augmented reality (AR) is one of the technologies gaining increasing interest. By mixing virtual with the real world in different proportions, augmented reality allows a level of immersion that no virtual equipment can provide.

AR systems have been already used in many applications as surgery, inspection of hazardous environments, engineering. Most of those systems, however, only operate indoors and cover relatively small areas.The advances of the computer, vision and wireless technology make possible development of outdoor wireless systems to support complex analysis, decision-making and governing processes.This chapter is organised in four sections. The chapter gives a broad definition of AR systems, discusses AR problems with respect to similar techniques for representing, interacting with 3D worlds (VR and AV) and communicating with mobile users (LBS), and provides classifications of AR systems.

Very often AR is defined as a type of "virtual reality where the Head Mounted Display (HMD) is transparent". The goal of augmented reality systems is to combine the interactive real world with an interactive computer-generated world in such a way that they appear as one environment. As the user moves around the real object, the virtual (i.e computer generated) one reacts as it is completely integrated with the real world.

Augmented Reality allows us to interact with the real and virtual worlds at the same time. It is an example of Intelligence Amplification (IA), as told by Fred Brooks, which means using computer as a tool so as to make it easier for a human to perform a task . Thus, this technology has been applied in many fields some of which have been mentioned below. In Medical, Augmented Reality will be far-reaching in the near future. It is being widely used in healthcare sector where there is a need of visualizing the medical information and the patient within the same physical space. Augmented Reality can be used to perform surgeries and can help surgeons perform real time surgeries without being physically present near the patient. Some of the real life examples where AR is being used in medical field. Eye Decide is a medical app which simulates the impact of specific conditions or medicines on a person's vision using a camera. E.g Eye Decide can demonstrate the impact of cataract. Accu Vein app uses a handheld camera which projects over the skin. Thus nurses and doctors get to know where the veins are in the patients' bodies. Entertainment and Games on Augmented Reality can be proved to be a game- changer for entertainment and games. Here, it is possible to interact with the real world and reel world using this technology. AR can be used in Television Broadcasting. Many sports channels use AR thus allowing audience to view graphic overlays. AR is widely used in Gaming too. Apps such as Ingress and Pokémon Go use augmented reality to let gamers play with virtual characters in real world.

In Manufacturing, Augmented reality has helped in improving the understanding of the product assembly tasks to be carried out. Information overload and the training required for assembly operation can be reduced using the AR approach . In manufacturing, AR can help in complex assembly of machinery, in maintenance of parts and in providing expert support. In the field of Robotics, AR makes it easier for robots for communicating complex information to humans. Moreover, this technology can help robots perform surgeries by combining AR with surgical robot system for performing head surgeries. In a nutshell, AR is a platform that has made human-robot collaboration possible.

Augmented reality in education has been proved to be very fruitful. The young learners can now visualize complex spatial relationship and abstract concepts. This technology helps students to engage in phenomena that are not possible in real world. Moreover, the invisible concepts like magnetic field can now be visualized easily using AR. Augmented Reality can open additional ways and methods of making the learning process easier and interesting. Classrooms and books become interactive. There are some AR student apps also. Some of them have been mentioned below.

AR Toolkit is a C and C++ language software library. Programmers can easily develop augmented reality applications with these software library files. Software library contains AR Toolkit C language source code and header files. In this project, source and header files are built by using Microsoft Visual Studio 2010 as a compiler. Visual Studio 2010 coverts source code into another language. It is usually called as machine code or machine language so it can be directly understood by processors.

Firstly, while early research in AR was primarily based on head-mounted displays (HMDs), in the last few years there has been a rapid increase in the use of handheld AR devices, and more advanced hardware and sensors have become available. These new wearable and mobile devices have created new research directions, which have likely impacted the categories and methods used in AR user studies. In addition, in recent years the AR field has expanded, resulting in a dramatic increase in the number of published AR papers, and papers with user studies in them. Therefore, there is a need for a new categorization of current AR user research, as well as the opportunity to consider new classification measures such as paper impact, as reviewing all published papers has become less plausible. Finally, AR papers are now appearing in a wider range of research venues, so it is important to have a survey that covers many different journals and conferences.

The existing system provided features for to easy to built in image and need more processing and programming steps to build in live time video. It can be inferred that traditional marker-based AR systems are restricted in applications due to the following issues:They must register markers and the corresponding augmented content before applying them.They only support a limited number of markers.They cannot correct errors or restore information when the markers were blocked or defiled.They often use markers that are not universal. Thus, their markers must be modified or require other additional procedures before being used by other systems. Above issues can be solved by employing QR Code as a marker.

II. IMPLEMENTATION

The proposed system aims to provide an environment that help users to place artificial 2D as well as 3D objects into real world through the use of AR Markers.Proposed system to build low cost and easy steps to augmented reality for low cost applications and lower end computers too customized augmented reality will helps to commercial usage of augmented reality. The proposed system also allows the user to decide, where to place the object in real world. Once the object has been placed in the scene, it will be displayed accurately according to the perspective in the original scene, which is especially challenging in the case of 3D virtual objects. The proposed system solves the problem of viewpoint tracking and virtual object interaction. The main advantage of the proposed system is that, we can able to use AR by using lower end computers also and cost efficient.

The proposed system work is a marker-based system, and its architecture contains the main three units as is illustrated in Infrastructure Tracker Unit, Processing Unit, and Visual Unit. The Infrastructure Tracker Unit works for collecting the data from real world, and sends it to the Processing Unit, which then mixed the virtual content into the real content and sends the result to the Video-Out Module of the Visual Unit. Video-In module of Visual Unit is used to acquire data which is required for the Infrastructure Tracker Unit. If the marker image is prepared correctly, marker-based AR content provides quality experiences and tracking is very stable, the AR content doesn't shake.Easy to use, detailed instructions are not required for people who use it for the first time.

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The proposed system solves the problem of viewpoint tracking and virtual object interaction. The main advantage of the proposed system is that, it is customer oriented and not product or service oriented thus allowing the users to augment a product of their wish. Augmented reality system requires integration of hardware and software to process the real-world image and virtual data. The real-world image detection and virtual object drawing must be processed in parallel, thus both can be displayed at the same time. Basically, there are two components of the developed AR system, which are the "Camera tracking system" and "Video mixing system". The transformation between real world space and virtual-image plane is represented by a camera matrix, and the marker-based augmented reality system utilizes the camera matrix for merging virtual objects with images.

Initially, a live video is captured by USB webcam and the l6-bit RGB color space image is converted into grayscale image. Preliminary noise level is reduced using the Gaussian pyramid decomposition method. Image thresholding is used to filter out tiny pixels to reduce its noise effect. There are

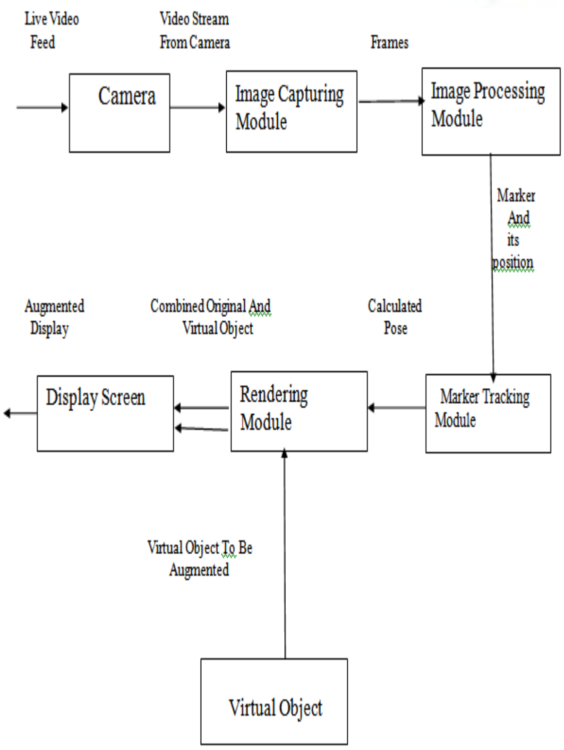

Fig 4.1 Proposed System Architecture

two thresholding methods used in the program: static thresholding and dynamic thresholding. In static thresholding, a value of 85 is set for all environment conditions. This lighting condition may affect the detection accuracy. This can be overcome by applying dynamic thresholding, where a slider bar is provided to adjust the threshold value manually. Marker-based Augmented Reality System is a computer vision based tracking system for Augmented and Mixed Reality applications. Marker-based tracking systems consist of patterns that are mounted in the environment and automatically detected in live video camera using an accompanying detection algorithm. When the user moves the marker. the virtual character moves with it and it appears attached to the real object. Important parameters for such marker systems are their false detection rate (false positive rate), inter-marker confusion rate, minimal detection size (in pixels) and immunity to lighting variation.

- Camera

A real-world live video is feed as an input from the laptop camera to the Camera module. Displaying this live feed from the laptop camera is the reality in augmented reality. This live video stream is given as an input to the Image Capturing Module.

- Template markers

Template markers are used in this bachelor's thesis. The first AR Toolkit markers were template markers. Template markers are square black and white markers that have a simple picture or text inside of a black border. When the system is identifying markers, application matches markers that the camera sees, and the best match defines its identity. The used markers have only text inside of the black squared markers Java is a high-level programming language that is cross-platform, object oriented, and can be run in a browser, on a server, or as a stand-alone application. It was created by Sun Microsystems and first released in 1995. Java plug-in.

A. NyAR ToolKIT

It is a class library for AR application built with Java, based on the AR Toolkit 3. In this experiment, we are using the NyaR Toolkit. Simply put, it is a contributed library/ toolkit designed for processing that gives us the tools to explore AR interactions. It is also free and open-sourced Implementations of each role of the component of the system. The implementation is done using processing Software. In this experiment, we are using the NyAR Tool Kit for Processing.

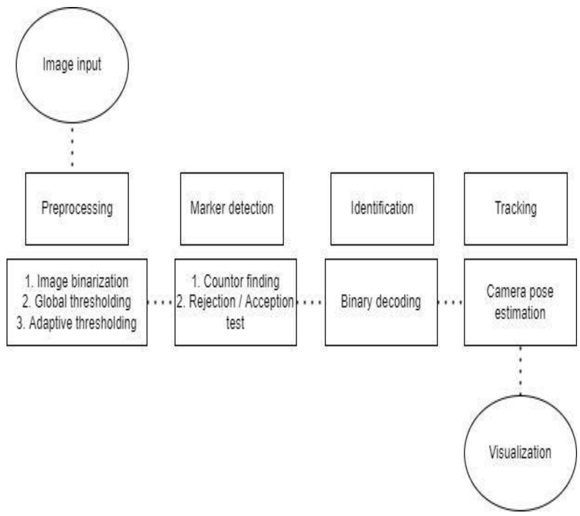

Fig 5.1 Modules

Processing is a flexible software sketchbook and a language for learning how to code within the context of the visual arts. It is open-source, free to download, easy to use, and very well documented. Processing is available for Linux, Mac OS X, and Windows NyAR ToolKit is a class library for AR application built with Java. In this experiment, we are using the NyAR ToolKit for Processing. Simply put, it is a contributed library/ toolkit designed for Processing that gives us the tools to explore AR interactions. It is also free and open-sourced.The C programming language is the most frequently used language for writing operating systems, other programming languages and compilers. It is also often used for writing application programs. ARToolKit is also written in C/C++ language.

ARToolKit uses computer vision algorithms to solve this problem. The ARToolKit video tracking libraries calculate the real camera position and orientation relative to physical markers in real time. This software library gives an easy way to develop many different AR applications. Some of the features that are included in ARToolKit, these are directly retrieved from ARToolKit site

- Image capturing module

The input to Image Capturing Module is the live video feed from the camera of a mobile device. This module analyses the camera feed, by analyzing each frame in the video. This module generates binary images i.e., a digital image that has only two possible values for each pixel. Typically, the two colors used for a binary image are black and white.These binary images are provided as an input to Image Processing Module.

- Image processing module

Inputs to Image Processing Module are the binary images from Image Capturing Module. These binary images are processed using an image processing technique to detect the AR Marker. Detection of AR Marker is essential to determine the position, where to place the virtual object. Once the AR Marker is detected, its location is provided as an input to the Tracking Module.

B. Marker tracking module

The tracking module is “the heart” of the augmented reality system; it calculates the relative pose of the camera in real lifetime.The term pose means the six degrees of freedom (DOF) position, i.e the 3D location and 3D orientation of an object. The calculated pose is provided as an input to Rendering moduleThere are 2 inputs to Rendering module. First is the calculate pose from the Tracking module and other is the virtual object to be augmented. The rendering module combines the original image and the virtual components using the calculated pose and renders the augmented image on the display screen of the mobile device.

Marker detection algorithm

Line detection algorithm works on pixel-based edge detection. There are several other algorithms used for detecting edge of a marker from which a general working of an algorithm is explained here.

Edge pixels found by an edge detector are linked into segments, which in turn are grouped into quadrangles. At first, line segments are found by detecting edgels (edge + pixels) on a coarse sampling grid and linking them together, then they are merged to a longer line.

Finally, these are grouped into quadrangles. These steps of line detection, line extension and line grouping are described further. Following the steps shown in figure-. First an input image is divided into several equal regions for an accurate result .Then the next step is to find edgels in the region which are candidate points for lines. To avoid processing of all pixels in an image this is done on a rather coarse sampling grid, making the algorithm very fast.

The sampling grid consists of horizontal and vertical scan lines. To avoid processing of all pixels in an image this is done on a rather coarse sampling grid. making the algorithm very fast. The sampling grid consists of horizontal and vertical scan lines.

Each of these scanlines is co--volved with an 1D derivative of Gaussian kernel to calculate thmponent of the intensity gradient along the scanline. If th intensity gradient that are greater than a certain threshold are considered edgels and the orientation of each edgel is calculated using

$\theta = \arctan(g_y/g_x)$;

g_y : y-component of the gradient

g_x : x-component of the gradient

Dividing images in regions

First the image is divided in small regions of 40×40 pixels and each region are divided into horizontal and vertical scan lines 5 pixels apart. The next 3 steps are executed apart inside these regions which boosts the performance dramatically.

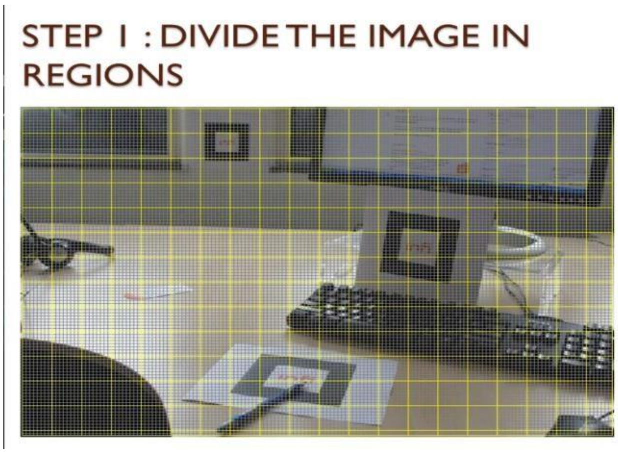

Fig 5.5.1 Diving Images In Regions

1) *Detecting edges in the region*

Then a derivative on each scan line to estimate the component of the intensity gradient along the scanline. This is used to detect black/white edges in the image. This is based on convolving the image with a small, separable, and integer valued filter in horizontal and vertical direction and is therefore relatively inexpensive in terms of computations. Local maxima along the scanlines stronger than a certain threshold (for all three-color channels!) are edges.

The orientation is then saved with the edges. In the image above, the green dots are horizontal orientated edgels, and the blue ones are vertical orientated edges.

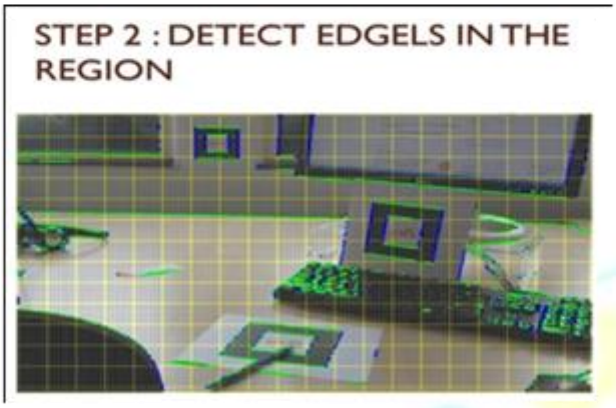

Fig 5.5.2 Detecting Edels In The Region

After the detection of the edges, a algorithm is used to construct line segments in each region. the orientation of the edges from previous steps, we can give the line segments an orientation. In the image above, the constructed segments are displayed as red and green arrows. Over-segmentation algorithms produce a segmentation that obeys the colour boundaries of the scene. This means that each segment belongs to one objection the scene, although many segments might belong to the same object. We use the algorithm of [9], where a graph based approach is proposed. The nodes represent the various layers in the image and edges represent spatial neighbourhood information. The weights of each edge represent the similarity of colour/ texture / edge information between the two nodes.

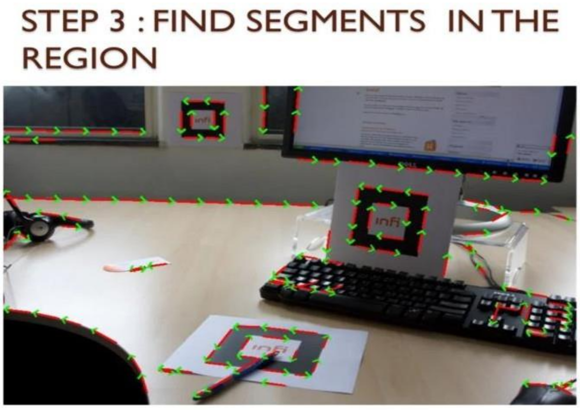

Fig 5.5.3 Finding Segments In The Regions

Two segments are merged if:

- The orientations are compatible.
- The segments are close to each other.
- If the pixels along the line between the two segments are on an edge, using the same edge detection criteria as used in step 2.

First all segments are tested in their own region using this algorithm. When all possible segments are merged in their own region, the same operation is repeated for all segments in the whole image. The merged lines are displayed as red/green arrows in the image above.

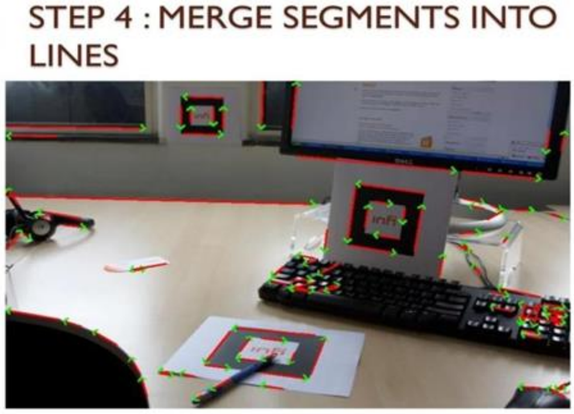

Fig 5.5.4 Merge Segments into Lines

In the next step the lines are extended along the edges. Because we scan only pixels on scan lines 5 pixels apart, it’s inevitably that the merged lines don’t fit on the entire length of the edge of a marker. So, in this step we extend the detected lines pixel by pixel until we detect a corner. Extend each end of a line and check if each pixel is on an edge, using the same edgels detection criteria as used in step 2. Do this until we hit a pixel that’s not an edge. Take a pixel a couple of pixels further. If this pixel is ‘white’, we might have a found a corner of a black on white marker.

Fig 5.5.5 Extending Lines Along Edges

The last step is the detection of quadrangles based on the set of extended lines. To obtain quadrangles we search for corner points by intersecting lines. The algorithm picks one line out of the set and tries to find a corner by intersecting the chosen line with the right one among all other lines of the set. To find a suitable second line several tests are carried out. First of all the two lines must not be nearly parallel, because we want to find quadrangular markers.

We must find four corners belonging to the same marker. Also, their sequence should be ordered to avoid cross-sequences, which means that if we follow the corners according to their sequence we should not cross the marker's interior. Hence the corner detection algorithm is recursive. It starts with a first line and tries to find a corner by intersecting this line with a second one, just like described above. If a corner point has been found, the algorithm continues with the second line. It now tries to intersect this line with any of the remaining lines in order to find a second corner point.

Fig 5.5.6 Keep Lines With Corners

To detect the markers in the image, we try to find chains of 3 to 4 lines. A chain is a list of lines where the end of one of the lines hits the start of another. After finding such chains, we only want to keep chains which form a rectangle counter clockwise. These chains will have black 'inside' and are probably markers. Knowing the orientation of the lines, a cross product for each two successive line segments in a chain is used to check this condition. After finding all markers, for each marker the 4 intersections of the lines in the chain are the corners.

Fig 5.5.7 Finding Markers

Calculating the positions of corners by these line-intersections gives a robust algorithm. Even if only 3 lines are detected and/or a corner is occluded, the marker will be correctly detected most of the time. In the image above, all detected markers are displayed as red rectangles. Notice the correctly detected marker at the bottom of the image, although one edge is partially occluded by a pencil. Now we have the coordinates of the detected markers.

III. RESULTS

This graph shows the efficiency of the algorithm used in the existing system of Hiro detection on Marker based augmented reality.

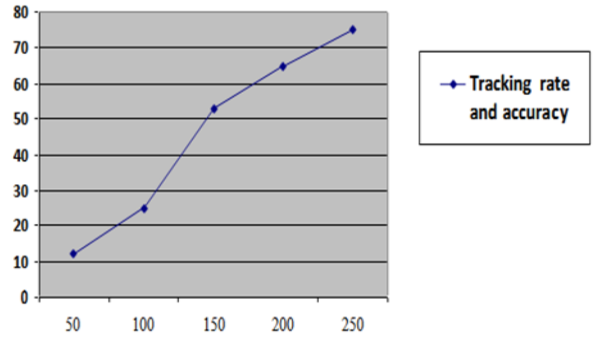

Fig 5.3.1 Analysis of Existing System

This graph shows the efficiency of the algorithm used in the proposed system on Hiro detection of Marker based augmented reality

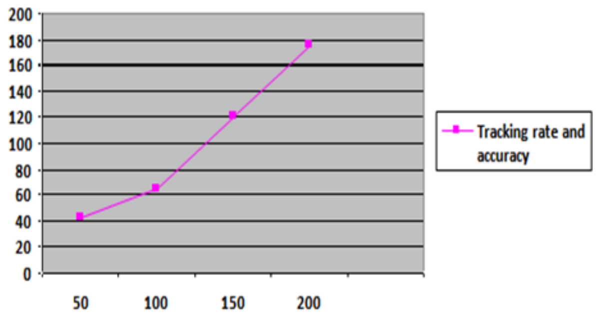

Fig 5.3.2 Analysis of Proposed System

IV. CONCLUSIONS

This paper proposes a marker based augmented reality application using windows operating system which will help to combine virtual objects with the real environment facilitating various applications as mentioned in this paper. The main advantage is use of low-cost devices as compared to the costly head mounted display devices. Secondly with the help of this project you need not buy product and then see how it will suit your environment. Aforementioned, we have studied about Augmented Reality and its various application in the field of medical, manufacturing, entertainment & games, robotics and education. We also concluded how the use of Augmented Reality can be beneficial in our day to day lives. This term paper gives information about marker based Augmented reality and the uses of applications regarding marker based. The technology of AR still under research and development and is emerging day by day. Many things have been developed recently using this technology.

V. FUTURE ENHANCEMENT

AR may have hit the scene like a ton of bricks as a way to bring virtual objects into the real world, but over the last few years, it has evolved into a valuable tool for various industries.It has become a common tool in everyday life, and the future seemingly has no limits.AR and more specifically, mixed reality (XR), which combines aspects of virtual and augmented reality will become a more common part of daily life.

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