A Survey on Augmented Reality

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Abstract- A system combining digital content with real-world environments using computer vision, image processing, and computer graphics techniques is augmented reality (AR). Interactions between users, real items, and virtual objects are possible in real time. Through AR, for instance, a movie can feature 3D images that seem real, as if they were a part of the real world. In this paper, AR theory and applications are thoroughly explained. One of the challenges of AR is aligning virtual data with the environment. Two methods of resolving the problem entail the use of marker-based AR and markerless AR technologies. The purpose of this paper was to explore AR's characteristics, types, and compare them.

Keywords: augmented reality, marker based augmented reality, marker less augmented reality

I. INTRODUCTION

As a consequence, several cities began utilizing new technologies and paradigms, such as Augmented Reality (AR) and The Internet of Things (IoT), to increase their intelligence and smartness, including solving urbanism problems and improving citizens' lives [1]. Within the concept of smart cities, augmented reality is one of the new technologies yet to be widely exploited, which is capable of improving human-machine interaction, but in general is not widely available, if it actually exists, it lacks both sufficient and robust monitoring techniques, which might risk making applications less reliable and limiting their use. Traditional AR systems, such as those used by sport broadcasters for improving lines and records, were prohibitively expensive and demanded specialized hardware. The computing units' processing capacity, as well as Over the past decade, there has been a dramatic improvement in transmission bandwidth and memory capacity. Adding augmented reality to a versatile, low-cost device such as a cell phone is now technically feasible thanks to technological advancements. Computers typically have a built-in camera, and users usually use social media technologies such as MSN Messenger to videoconference as well as webcams [2]. Augmented reality appears to be well-accepted by most consumers as an option for digital content. Industrial applications using augmented reality can boost visual perception. Augmented 3D information benefits assembly line workers and maintenance and repair personnel. Additionally, this technology lets viewers see how future construction projects will interact with the environment on actual construction sites. The reliability of AR systems is an issue that is being addressed by much research [3]. It is not uncommon for AR systems to arrive at issues such as issues related to inaccurate scaling and prepositioning of 3D models. Researchers in the study have discussed the different types, applications, and methodologies of AR technology as well as the various limitations that developers will have to address when developing the technology. The papers suggests that image processing could be used in AR systems to achieve promising outcomes. Through real-time experiments and simulations, many researchers have succeeded in providing convincing results [4]. Techniques such as marker pattern detection and object tracking and object recognition are highlighted in most of the papers.

II. AUGMENTED REALITY

'Augmented' comes from the word 'Augment,' meaning to upgrade, improve, or make better.

With AR, digital images can be layered over real-world objects or augmented. AR can be the combination of real and virtual worlds, real time game play under a controlled environment [5], and 3D registration of devices are found in the term virtual reality system. In a sense, AR is a type of technology that mixes the real and virtual worlds. This technology combines graphics, sounds, and touch-based information with the real world.

A. Characteristics of AR

Its characteristics are as follows:

- Provides users with the ability to view real and virtual objects simultaneously as it combines real and virtual objects in a real environment.
- Real-time interaction. Since it runs at interactive frame rates, it allows superposition of information in real time.
- A 3D rendering is registered by placing the virtual content relative to the real.

Simplification of the Reality-Virtuality Continuum (RVC) proposed back in 1994 by P. Milgram and F. Kishino [5] is represented in Figure 1, defining the Mixed reality as “anywhere between the extremes of the virtuality continuum”. Real and virtual features may be mixed in various ways according to this taxonomy. To put it another way, AR supplements rather than replaces reality.

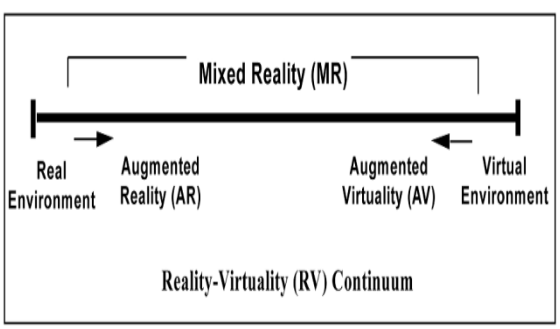

Figure 1: Milgram’s mixed reality continuum [5].

B. Classification of AR Interactions

The following classification of different AR displays and process of Augmentation is based on [6], which is mentioned through Figure 2.

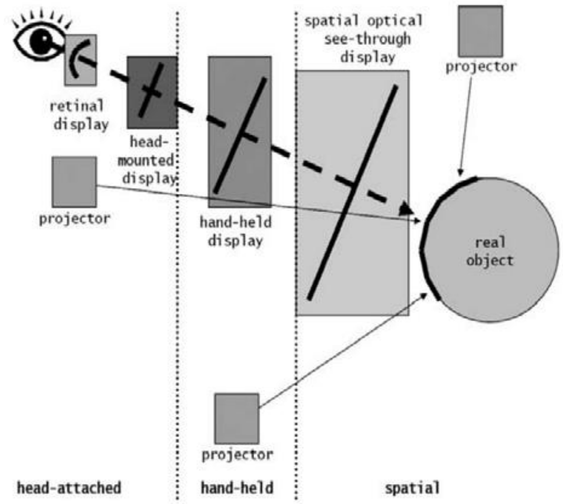

Figure 2: Graphics generation for different augmented reality displays [6].

First, the term see-through display must be clarified in order to provide a classification. These displays can be understood in two ways:

1) Video-mixing: In this method, a camera records the real world, which is then combined with virtual information and presented.

2) Optical: In this case, an optical combiner is used to allow observers to observe the real environment while overlaying it with a virtual overlay.

Below is a brief description of each of the three domains shown in Figure 2 above:

Head-attached displays: The display must be worn by the user on his or her head. The following two displays are depicted:

a) Retinal displays: consist of a low-powered laser that projects a picture onto a person's retina.

b) Head-mounted displays (HMDs) have been replaced by handheld displays. Also see-through displays are similar to them.

Hand-held displays: Modern hand-held displays are more often tablets or smartphones than flat screens, which can be categorized as video see-through displays.

Spatial displays: The main difference between spatial displays and body-attached displays is that the former frees the user from many needless technological compromises and instead allows the user to directly interact with the environment. As a result, they sacrifice mobility, while maintaining large displays and far better environmental control.

Projected AR displays: As shown in Figure 2, projectors can be used for various purposes. Consequently, there is no need for the projector to be located within the same domain as the object onto which it projects.

C. Types of Augmented Reality

Generally, Augmented Reality (AR) is observed in two types: [5]

1. **Marker based AR**
   It is also called Image Recognition reality.

2. **Markerless based AR**
   This is also called object-based or location-based reality.

D. Marker based AR

Information is presented in real-world context using marker-based AR. An augmented reality display shows the picture taken by the camera as well as additional information that makes up the environment. As a result, in practice, the camera's orientation must be determined by the system. In addition to calibrating the camera, the system is now ready to render virtual objects at the appropriate locations. It is a process of tracking the location (and orientation) of a camera in real time.

The marker detection process

Marker detection begins by identifying potential markers in the image and then by determining their corners. Lastly, the detection system should be able to decipher the marker's identity and confirm if it is indeed a marker. A pose is calculated based on the knowledge of the location of the marker [7]. Following are the steps involved in basic marker detection:

a. Image acquisition

A set of intensity images is acquired. In the acquisition step, the image simply provides the marker detection process with the image.

b. Pre-processing

It is necessary for the system to first obtain an image of intensity (grayscale) before the marker is actually detected. In the well-known process of intensity conversion, RGB images are transformed into intensity images. When detecting markers, the first step is to search for their boundaries. In order to cope with local illumination changes, thresholding systems that use the threshold approach normally use adaptive thresholding techniques. In the system, the background and objects are separated by thresholding Figure 3.

If an object is too small or otherwise clearly not a marker, the system may reject it during the labeling process. Lastly, the system measures the edges of all potential markers Figure 4 and confirms that the locations of all potential markers are undistorted for line fitting Figure 4. After line fitting, the system test each potential marker again to ensure that it has four straight lines and four corners. A marker coordinate system is depicted along with augmentation over the marker and detection of corners around the marker.

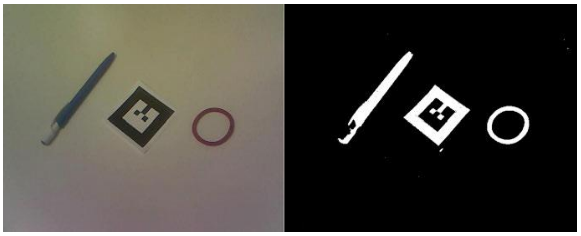

Figure 3: Original image and its adaptive thresholded version [7].

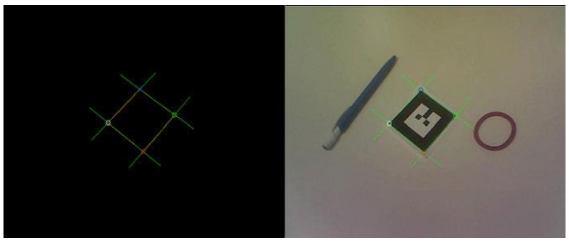

Figure 4: A line fitting example using ALVAR [7].

c. Fast acceptance/rejection tests for potential markers

It is often something else besides a marker, and though it is a marker, its small size means it is extremely far from the camera. The system cannot identify the marker if its dimensions shrink to few pixels unless it keeps track of its appearance history. During the detection process, the system needs to take care not to remove parts of cells that belong to a marker. Marker detection systems may check the bipolarity of the histogram of a black and white marker to provide a quick acceptance criterion.

d. Marker pose calculation

Objects are positioned and oriented based on their pose. The coordinate location can be represented by three translations (x, y, z), and the angle location by three rotations (α, β, γ) around the three coordinate axes Figure 5. There are six degrees of freedom in a pose (6 DOF). Calibrating cameras involve measuring the pose at a minimum of four coplanar but noncollinear points. By using the four corners of an image coordinate, a system can calculate the position of a marker in 3D coordinates (relative to a camera).

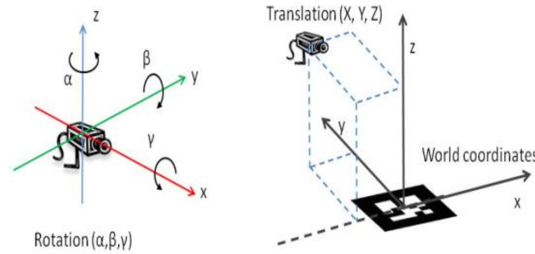

Figure 5: The camera's pose, its location and orientation in world coordinate angles.[7]

E. Markerless Augmented Reality

Human-machine interaction has greatly improved in recent years. Human activities are invariably influenced by references to digital entities [8]. Markerless (AR) combines one dimension of real objects with another dimension of virtual objects in human-machine interaction. Most often such virtual objects are superimposed on a scene captured by a camera to place them where they are desired. These real objects are displayed to the user along with the augmented one so that they appear seamlessly together.

Methodology of Markerless AR

With markerless tracking, Augmented Reality can be fully integrated into the real world, increasing its realism. As a result, when the system runs, it will be able to track any changes in camera motion caused by movement in the feature map, and estimate the new motion based on the change. An algorithm based on map making is used to determine the estimation, and then a sensor-based approach is used to determine the tracking of features.

It is based primarily on features that are detected in the creation of a map to estimate the camera's orientation (blue highlights). In addition to reporting additional information to the system, this sensor will complement the tracking function performed by the camera. Orientation value is to be measured by attaching the sensors to the camera and comparing them with the ground truth. The workflow shown in Figure 6 will be used as the first step in the process. It is necessary to calibrate the system in order to determine the origin of each coordinate in the system, so that the position values are determined relative to this origin.

By using the dominant plane position as part of the map creation process within the previous step, the calibration points are going to be determined. A position will be used as ground truth when measuring, and the measurements will be made in relation to it. A 2-DOF orientation measurement can be made by measuring gravity vectors using an accelerometer.

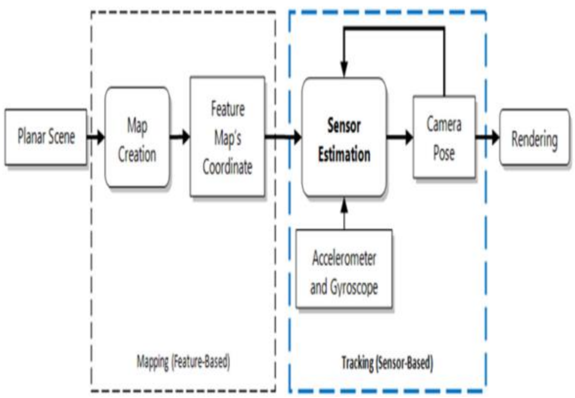

Figure 6: Overview of markerless AR process[8]

III. Comparison between Marker AR and Markerless Based AR

A wide range of applications are being developed using AR platforms. A comparison is shown in Table 1 of two different optical tracking systems for augmented reality, which are MB AR and ML AR. Both contribute equally in different scenarios and can work well with gesture recognition. Marker-based (QR codes and Natural Feature Detection) Indoor Navigation systems can provide the best accuracy and precision in situations where perfect accuracy is required, so it can be effectively implemented in areas like shopping malls, university campuses, hospitals. Positioning an object in the real world using marker-less technique is possible and uses Bluetooth, GPS, and Wi-Fi [9]. It is therefore possible to perform various types of outdoor tracking today including active tracking, hybrid tracking and recognition, without the use of special markers, however, when the area is small, the use of mark-less applications is challenging due to its less accurate tracking [10]. Hence it can be tuned and used for indoor navigation in any indoor environment, including malls, hospitals, museums, airports etc. There is a tremendous potential in augmented reality for indoor navigation.

Table 1 : Difference between Marker based AR and Markerless AR

Parameter	Marker based AR	Marker-less AR
Definition	Tracks and triggers an object using a marker	Detects location and triggers an object based on the location
Position accuracy	Comparatively higher	Comparatively lower
Influence factors	Brightness	Localization technology
Stability	Relatively lower	Relatively higher
Hardware or software support	Visual markers and cameras	Digital compass, GPS, accelerometer, and camera

Advantages

- Incorporated into education, augmented reality enhances students' engagement and interaction with academics.
- Augmented reality makes home appliances smarter [11].
- It enhances the experience of virtual visualization for users in video games.
- Using it helps in accurate diagnosis of disease and saves the lives of patients.

Disadvantages

- Using augmented reality applications poses many privacy and security concerns.

- The price of hardware and software implementation for augmented reality is very high.
- A person's sense of perception is narrowed by the capabilities of augmented reality.
- Using augmented reality applications too much can negatively impact human health and cause vision damage [11].

IV. Conclusion

A growing interest in augmented reality has been seen in recent years by researchers. The development of augmented reality technology has been greatly accelerated by advances in computer vision and artificial intelligence. It has greatly improved both the tracking registration accuracy and equipment performance as well as the human-computer interaction. Nevertheless, augmented reality technology is still fraught with many problems that need to be resolved. Currently, in terms of tracking registration technology, the technology can only utilize a little amount of information such as the location of feature points in the scene, which leads to a lack of understanding of the system within the environment. A high sense of submersion can be achieved by augmented reality glasses, but the size and cost of these glasses cannot meet the needs of the public. It remains to be studied how augmented reality can interact with more natural and multi-user methods. A large number of applications of augmented reality technology will emerge in the next few years, including those involving mobile intelligent terminals. Despite their less submersible nature, mobile devices are still popular.

V. Future Scope

The healthcare sector is projected to lead the way in expanding the use of augmented reality in the upcoming years. 'Enhanced reality' poses a number of privacy concerns to users, so AR's future development should take account of these concerns without compromising users' privacy and comfort. AR could achieve a value of $122 billion by 2024 with a mix of reality and fiction.

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