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Comparative Study between Hologram Technology and Augmented Reality

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Abstract

The great development witnessed by our current age has led to the emergence of many diverse modern technologies, one of these advanced technologies is Hologram technology and Augmented reality technology, These two technologies are somewhat similar to somewhat, as it can be said that they perform almost the same purpose, and at the same time, Hologram technology differs from augmented reality in several aspects, as the way in which the three-dimensional images are created and the properties of that images itself. This paper aims to compare and study the similarities and differences between Hologram technology and Augmented reality technology. It is a standard comparison as the comparison takes place according to a number of different aspects of both technologies. Comparing the characteristics of the two technologies showed that there is no one of them excels over the other, but according to different systems and situations, it is maybe better and more appropriate to use one of them than using the other one.

Keywords: Hologram, Three-dimensional image, Augmented reality, Hologram fan, Technology.

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Introduction

Visual communication and illustration of things is an ancient science that began since the first human era as they used graphic images of expression and communication, as humans are by nature visual creatures (Visual communication, 2020). Imaging science has evolved considerably since ancient times and it has gone through several stages during its development, the new techniques developed allow taking shots of any object using different techniques and then present it in various needs, according to this evolution, images with its different types had been used almost everywhere (Robert & Grundberg, 2019). The new development introduced in this area is the three-dimensional imaging of the objects, which gives a larger view through the representation of the body from three different dimensions make it seem as if it is somewhat real.

Three-dimensional imaging technology came as an advanced solution to solve the problems in the traditional methods of viewing things; that provides people with a more comprehensive view and clarification of things similar to the natural look of the human eye, three-dimensional objects are illustrated either in simple ways such as photos and videos or in a more sophisticated way using new technologies (Rouse, 2016). Augmented Reality technology (AR) has been used as a means of three-dimensional viewing, and also, Hologram technology emerged as another technology to view the three-dimensional objects.

Background

Hologram technology is one of the three-dimensional imaging methods that enable the formation of an image with its three dimensions using light diffraction, this technology gives us a broader picture that is close to reality and so more information about the body that it represents in a 3D model. A Hologram (that is pronounced as HOL-O-Gram), is a special type ff mmage cccc ca ee eee aaee eye rrr HHggggaa c ee Gabor who coined it from the Greek rrr ”sssss s cccc aaa ”all ” aa "gram cccc aaa ”aaaaa ae ", the technology of creating and presenting these holograms using different methods and tools is called Hologram technology (Slinger et al. 46–53: 38). Holography is a photographic technique that records the light scattered from an object and then presents it as a three-dimensional image, to formulate it briefly the definition of holography could be the science and practice of making Holograms. A Hologram is a truly three-dimensional free-standing image that is created with a photographic projection of light, it differs from other technologies that present a three-dimensional object on a two-dimensional computer display or using special wearable glasses, Holograms could be seen with the naked eye because it is a physical structure that is created using laser beams or light diffraction (Holography, 2020) (Rouse, 2005). Augmented reality is a technology that augments the real world with computer-generated three-dimension objects, this superimposition of images into the real surrounding gives a sense of the real presence of the image into reality, people receive additional information visually, and the created three-

dimensional seems to be as if it is really present with them, that is why it is called augmented ll aiiyy a tt““agg”””””” ”rrrrrrr rrrrr rrr iiiiii iiii eeeeeeeee

The concept of augmented reality has emerged as a new field of virtual reality and comp uter science, it is a special field that combines digital data generated by a device with the real-world environment. The three-dimensional object in the augmented reality technology is created by programming using different methods and its viewed with the means of a number of devices (Ibrahim et al., 2018) (Wong et al., 2014).

The two technologies differ from each other in a number of properties, and too many people mix their definitions, and they were been defined as one technology that shows three-dimensional objects. Therefore, many researchers mix between these two concepts. One of the most important possible causes for this confusion is the literal definition of the word hologram as it is taken from the Greek words holos (whole) and gramma (message) and which refer to any three-dimensional image that looks like a real object, and augmented reality technology also displays a three-dimensional — and in some case two-dimensional — images, but this is not a sufficient reason for that these two technologies be defined as one concept.

The major difference between Hologram technology and Augmented reality is the object presence which is the biggest benefit of Hologram technology where the Holograms could be seen with the naked eye because it is a physical structure that uses light diffraction to make images, and so there is no need to wear special glasses or use an application to be able to see the 3D virtual image as in Augmented reality. In addition to this property, a number of other differences is discussed below. Hologram technology and Augmented reality technology are considered two of the most important modern techniques and most useful in various fields, as they could be used in a huge number of fields to positively affect it and add good technical features depending on the needs and the capability of the technology itself, accordingly, the two technologies must be studied well, knowing all their characteristics, and most importantly, not to confuse them and define them incorrectly.

Regarding our knowledge, there is no scientific paper that detailed the difference between a Hologram and Augmented reality in particular, in this paper, we are trying to make these concepts clearly defined and to compare between Hologram technology and reality properly. We will address a number of aspects of comparison between the two technologies, and then explain the characteristics of each.

Comparison Aspects

There are many things that differentiate between Hologram technology and Augmented reality technology, As mentioned that both technologies produce almost the same result by adding a three-dimensional image to the surrounding reality, but each of them is a separate technology that differs in the way it creates the image, the way it is displayed, and the hardware and software needed, also each has different types. A number of comparison aspects

are listed below to differentiate between Hologram technology and Augmented reality technology in terms of the history of the technology, the created image properties and method of creation, the requirements needed, types and usage fields.

The development of each of the two techniques went through different stages, as well as the methods of creating the image and its specifications differ, each of the following aspects clarifies the most important differences between them, which clearly shows the difference between them and removes the widespread confusion of being one thing.

Hologram Technology – Augmented Reality History

The two technologies went through many stages of development until they reached what they are now and over the years a number of discoveries and research have been made by a number of scientists. Here is a brief illustration listing the history of both hologram technology and augmented reality technology over the years, showing the most important events that took place and the acceleration that both technologies went through until they reached what they are now:

- ***Hologram technology history:*** The Hologram was discovered in 1947 by accident when scientist Dennis Gabor was working on his research to develop electron microscopes. .. rrrhtt eeeeeeeee tt aa vv eccc ccccœee a aa ”nyyy yyy ” ggggggg agmmm azzzcce iiii eeee eeee

  Figure 1 shows the timeline history of Hologram technology over the years (Holophile, Inc, 2010).

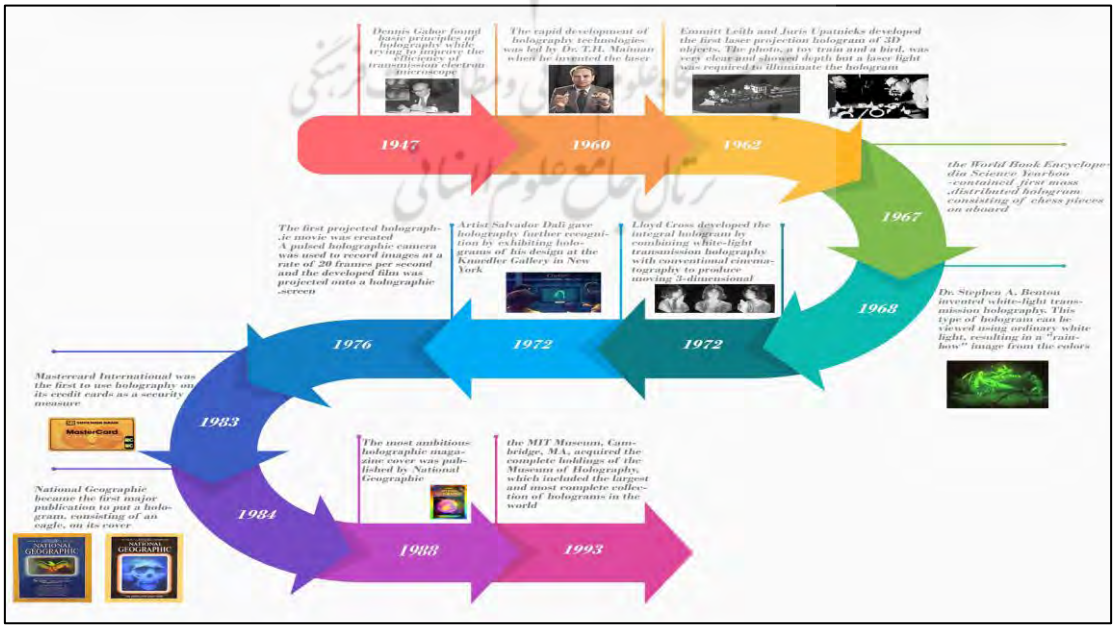

Figure 1. Hologram Technology history info-graphic

- ***Augmented Reality technology history***: Augmented reality was developed after Hologram technology by many years; the reason for this can be attributed to the fact that it is a technology that relied entirely on technology and programming, unlike Hologram technology, which was its primary basis dependent on devices, light, and physics, and then it evolved after that and became more dependent on technology. The following Figure 2 shows the timeline of Augmented reality technology and the most important events that It has undergone the development of this technology (Wong et al., 2014) (Bridget Poetker, 2019).

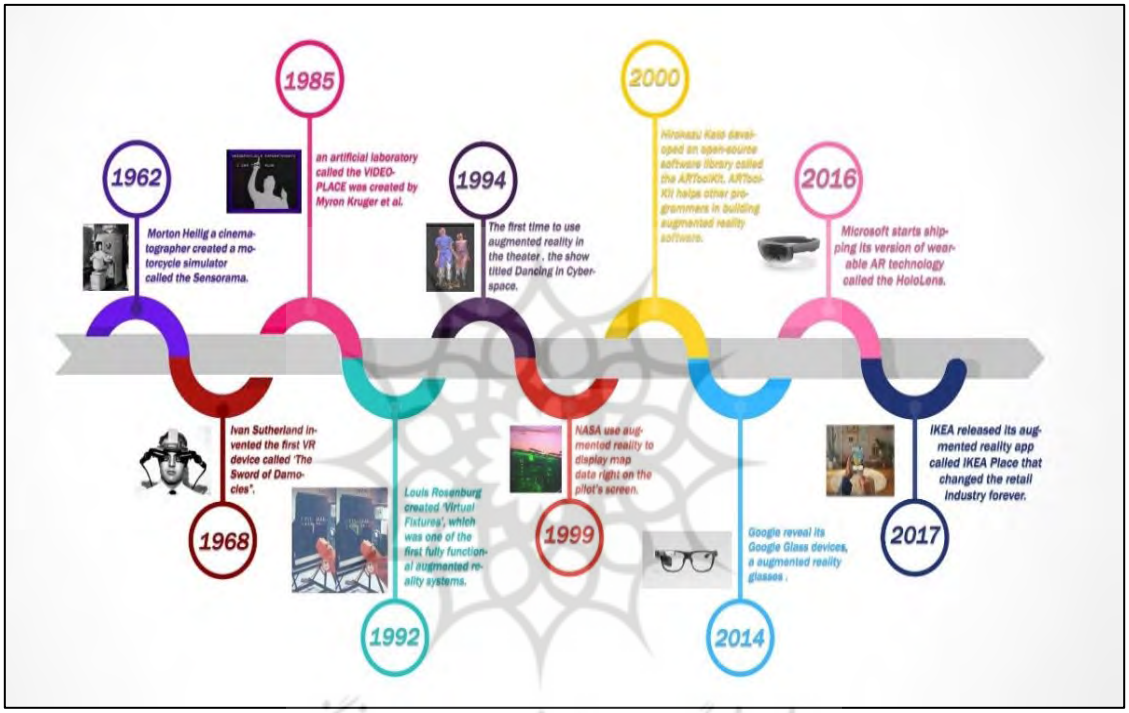

Figure 2. Augmented reality Technology history info-graphic

Hologram Technology – Augmented Reality Images

Hologram technology and Augmented reality technology both give the users a 3D images that are floating in the reality and added to it, but this created image differs in its properties and the method of creation, and to identify this difference; a classification of the image depending on its properties and creation method is listed for both Hologram technology and Augmented reality technology.

A. Image properties

- ***Hologram technology:*** The image is a 3D, really existed, and float in midair as shown in Figure 3. The observer can see the image directly without any additional devices like the 3D glasses or smartphone screen (Ibrahim et al., 2018).

Figure 3. Floating 3D Hologram (Augmented Reality in Marketing: 8 Current Examples, n.d.)

- ***Augmented Reality technology:*** The displayed image is completely 3D virtual. As in Figure 4, the object added (augmented) to the real world and it would be visible to observer with the help of head-mounted displays, 3D glasses, or smartphone screen (Holography, 2020).

Figure 4. Augmented reality object (Spandana, 2019)

In both technologies, the user still sees the real world but receives additional information displayed but the effect of the presence is the biggest benefit of Hologram technology as there is no need to wear special glasses to see the 3D image (Ibrahim et al., 2018) . On the other hand, the resolution of the object for AR exceeds the resolution of 3D hologram object owing to the effect of the mid-air in which the 3D hologram object is displayed.

B. Image creation:

- ***Hologram technology:*** There are many types fall under the 3D hologram technology and each type differs in the method of image creation and projection. The image creation is done by two main methods; the first is image creation using interferometer and transmission. This method includes two categories of hologram creating process, the Reflection and Transmission Hologram.

- Reflecting Hologram: the laser beam splits into an object beam and a reference beam. Two mirrors placed in front of the object beam and the reference beam to reflect the beam and form a 3D hologram on the photographic plate (Wong et al., 2014).

- Transmission Hologram: the laser splits to form an object beam and a reference beam. Then the illuminated beam from object and reference reflects into photographic plate to form a 3D hologram (Wong et al., 2014).

Another method to create the 3D hologram is a computer-generated hologram (CGH). As in Figure 5, CGH gives us an advanced method by creating a 3D visual representation for the object and calculating the holographic fringe pattern then use it to set the optical properties via a spatial light modulator (SLM) such as liquid crystal microdisplay. The laser is required in CGH to display the 3D hologram because of its spectral purity (Rouse, 2005).

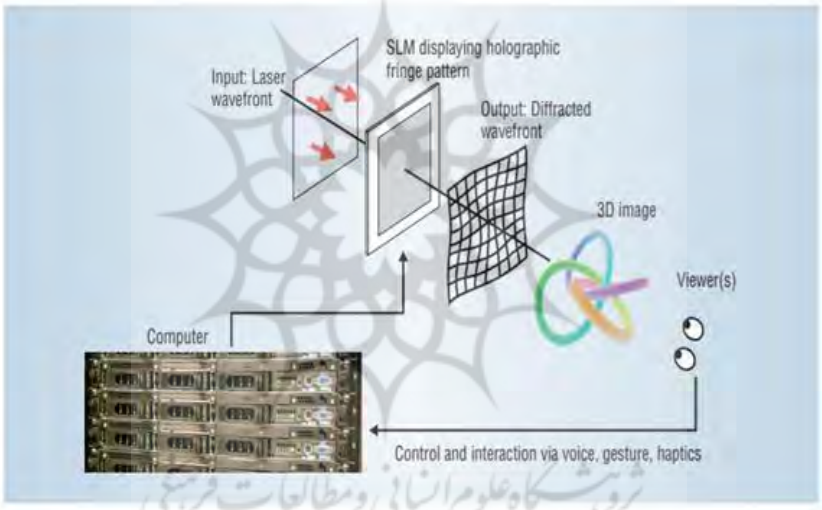

Figure 5. Computer-Generated Hologram (Rouse, 2005)

- ***Augmented Reality technology:*** The AR systems combine augmentations with the real world realistically using computer software and algorithms. To augments the real world with 3D objects, the real-world coordinates must be derived using computer software using different methods of computer vision, and this process is called image registration. The methods of computer vision of AR usually consist of two parts, the first is to detect the points and optical flow from a camera image. Some feature detection methods used as corner detection, blob detection, edge detection, or threshold. The second part restores a real-world coordinate system from the data obtained in the first stage (Özkul & Kumlu, 2019). There are many choices to create a 3D model for a real object and use it in AR applications.

- Photogrammetry: Series of object's photos taken to create a high-density mesh of that object and then defines its shape with the mesh. In addition, determine the color of the object and the way of light interaction with it from the texture image of the object.

- 3D scanning: This process is similar to Photogrammetry but the used devices differ. Many data collected from different views for object and the result is a large file size of a non-optimized model, which would require many hours to make it ready to use.

- 3D Modeling Programs: 3D modeling programs provide tools to create a 3D model from scratch. The 3D model is optimized and accurate but requires a lot of time and expert designers (Chen et al., 2019).

Hologram Technology – Augmented Reality Requirements

The specification of requirements is very important in every system to be sure that it will reach the wanted goals, these needs differ from system to system and also according to different technologies used, there are some technologies that have special requirements needed to be used even when used with a different type of systems and situations and it will not be present without it, other requirements may be added or changed as systems changes. To differentiate between Hologram technology and Augmented reality technology in this paper; some of the most regularly needed requirements are stated for the two techniques and are classified into user requirements, hardware requirements and software requirements.

A. User requirements

First, for user requirements, the two technologies' users mostly require the same properties, Humans are visual creatures, and they have a 3D perception when they look at an object, the retina in each eye forms a two-dimensional image of our surroundings and the brain processes these two images into a 3D visual experience, as a result, it is important for them to get a semi-real image when communicating visually, 3D objects offers users a larger perception and so more information to get. When the technology is able to give the user the possibility of a complete view of a not actually present object, it will be considered as a very useful technology that results in users satisfy. Hologram technology and Augmented reality both have the ability to display a floating 3D object that same as if it really exists in the user's surroundings.

Figure 6 shows a three-dimensional object in Augmented reality, the virtual 3D object does not really exist but using AR application users will be able to discover the 3D object. And in Figure 7 a 3D object created using Hologram technology is shown below.

Figure6. 3D object in Augmented Reality
(Spandana, 2019)

Figure7. 3D object in Hologram Technology
(Wehner, 2019)

Whenever situations change, the user's detailed requirement changes, As stated that Hologram technology and Augmented reality offer the same desired result approximately, but of course they differ in their capability. Here in Figure.8 a chart that shows the changing result and so the capability of both Hologram technology and Augmented reality in different user changing requirements.

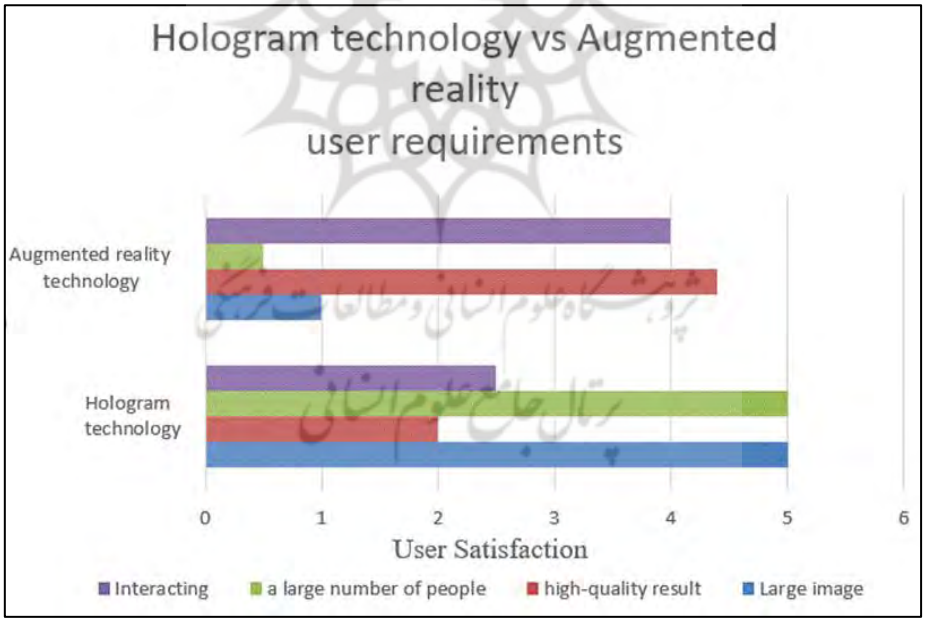

Figure 8. Hologram technology vs Augmented reality user requirements
(prepared by researchers)

B. Hardware requirements

Hologram technology and augmented reality technology both need a hardware device to view the objects, they differ in the needed devices and in the ways how this device displays the 3D

objects and also there may be a need for a hardware device to create the object before displaying it.

The great development witnessed by these two technologies led to a big difference in the devices used over time. Large and multiple devices were used in the past, or now, the development of technology led to the development of the quality of the devices used, at the present time advanced devices of different sizes and features are used.

- **Hologram Technology Hardware requirements:** Many devices involved in using the Hologram technology, starting from the cameras used to take pictures of the object being displayed to the projector that will display it. Some of the most important hardware needed in Hologram technology are: Cameras, Computers \ Smartphone \ Remote control and light source generation device.

    - ***Hologram projectors*:** Hologram technology needs a special projector to display the Holograms, and as the Hologram is a really existing image the Hologram projector is responsible for creating it in the surround so it can be seen by the naked eye. There are different types of projectors to display the 3D image, some of it is very simple using general light concepts to view the Holograms and others are so complicated and needed several steps and devices to generate the images.

There are several types of Hologram projectors that display the holograms using different methods, including the hologram projectors that create Holograms that are scalable to interact directly, also, some other types are used mainly in theatrical performances, and the type which creates a hologram using different media such as smoke, water, etc. Below are the most used and known types Figure.9 shows the hologram fan projector and in Figure 10 a pyramid hologram projector is displayed and finally Figure 11 displays the laser hologram projector which came in many forms (Elmorshidy, 2010).

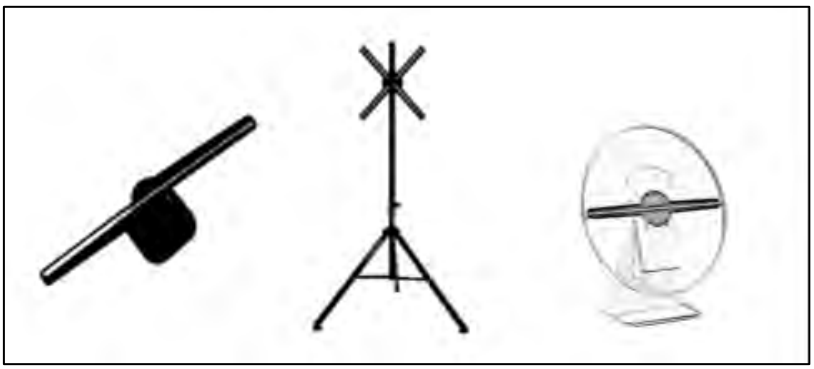

Figure 9. Fan Hologram projectors

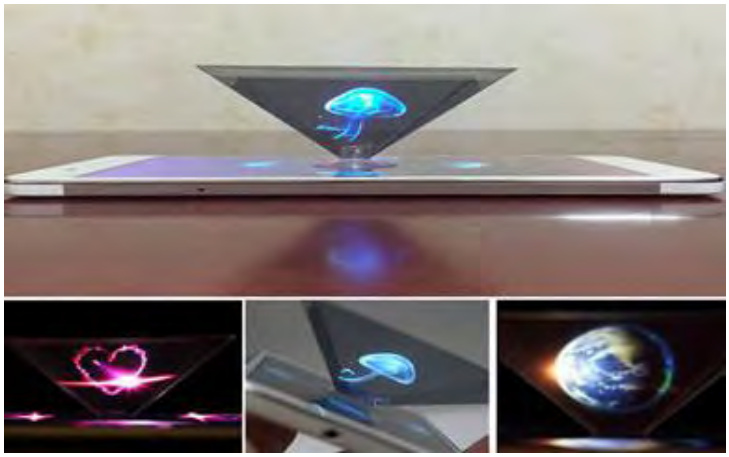

Figure 10. Pyramid Hologram projector
(Amazon, 2020)

Figure11. Laser Hologram projector
(Nikolov, 2016)

- **Augmented reality Technology Hardware requirements**

Augmented reality technology requires hardware also but it is few in its number and costs less than the hardware needed for Hologram technology. The created image in AR as stated is completely virtual image; as it is created using programming technology and does not need a light, mirrors, and laser as in Hologram technology, for example, the object that is augmented to the reality could be created and seen just by using a laptop device. Most used device to apply Augmented reality are: Cameras and AR object viewer which include different type of smart device that supports AR software enables users to see and interact with the object created in AR technology, such as: Computers, Smartphone and AR glasses. Figure 12 shows Augmented reality glasses and in Figure 13 you can see how the image is displayed

to user who wears the glasses. In Figure 14 the Augmented reality object is viewed using a smartphone device.

Figure12. Augmented reality glasses
(Sharma, 2016)

Figure 13. Augmented reality glasses user's view
(Livia et al., 2019)

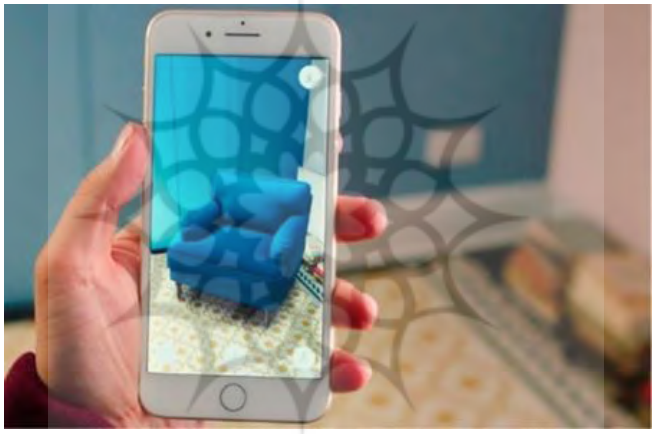

Figure14. Augmented reality smartphone app
(AR in marketing, 2019)

- **Software requirements**

The software needed to operate both hologram and augmented reality technology is very different and varies even in its advantages. Augmented reality technology needed software to create the AR object and apply it to the reality and software to make the using and interacting with object easy, to summarize it; the most needed software in any AR system are (Ibrahim et al., 2018):

Operating system, Augmented reality program, Programming language and Sometimes a 3D object crating and photo editing software.

And Hologram technology, on the other hand, is very flexible in the type of software needed, as the needed hardware differs and result in more technologies that could be used, and the most needed software to applying Hologram technology are:

Operating system, Programming language, 3D object crating and photo editing software, Hologram device programming software and Hologram projector controlling software.

Hologram Technology Augmented Reality Types

Several types fall under both Hologram technology and Augmented reality technology and the classifications that underlie each type also differ. Under this comparison aspect, Hologram technology excels on Augmented reality technology; because of its different multiple types and so high flexibility, as the user can create and use Holograms with the least possibilities to meets their requirements because Hologram technology include types that create images with various properties using several types of projectors that suites with user's capabilities. All of that diversity made Hologram technology more flexible than AR technology.

- ***Hologram technology types:*** Hologram technology has various types, which are classified differently based on the way of recording, recording and display environment, and reconstructing way, and this is an advantage to favor the hologram to be used in many areas and different purposes. Some 3D Hologram types, which are widely used are:

  Reflection Holograms, Transmission Holograms, Laser plasma Hologram, No-logram, Smoke Hologram, Underwater Hologram, HoloLamp, Fairy light Hologram, Physical Holograms, 360°Hologram and Stereogram IIŞI 4444) (Fairy Lights, 2015) (The mathematics of light, 2004) (Watson, 2006).

  The Hologram types also classified depending on the projector device, and we are going to list three main types:

  - Hologram Pyramid: it uses the concept of light interference and reflection (Holography, 2020).
  - Laser Hologram: a laser of different types forms the image (Markgraf, 2019).
  - Hologram fan: This type of projector display Holograms using small propellers merged with high tech RGB lights that can switch colors in milliseconds.

- **Augmented reality type**

AR includes classifications based on various characteristics, such classifications can help people consider the appropriate problem area and situations in which the use of certain AR types may fit with the classification is mostly made according to the image formed and the

medium in which it is created. AR has six different types that fall under two overarching categories (Edwards-Stewart Et Al., 2016):

A. Triggered augmentation: This category includes: Marker-based AR, Location-based AR, Dynamic Augmentation AR and Complex Augmentation AR.

B. view-based augmentation: Under this category AR types are: Indirect Augmentation and Non-specific Digital Augmentation.

Hologram technology Augmented reality Usage

Hologram technology and Augmented reality technology are both used in different fields, their useful result enables them to bring about development and improvement in many areas of life to make human lives easier and more developed. The two technologies aim to produce the same result, and mostly they are able to be applied and used in the same life fields, but there are situations when the technology will not be able to give the proper result or make users satisfied and these situations differ according to the technology's capabilities and properties. Some common field in which both technologies could be applied to are: Education, Advertising, Museums, Military Weather and maps, Astronomy, Training, Entertainment, Advising. There are some fields in which the use of one technology is preferable to the other technology due to its ability and is suitable for the situation. For example, in entertainment, it is difficult to use Augmented reality because then every single person must have a mobile device that supports the AR specific application or must ware an AR glasses and which considered somehow costly, in the other hand, a single Hologram projector may be used to offer to any number of people the same view.

Discussion

We did a simple questionnaire on numerous people of different age groups to measure their knowledge of Hologram technology and Augmented reality technology and measure their awareness of the difference between them, we received 740 answers as shown in Figure 15, and after analyzing, it was ensured that there is confusion in the definition of both technologies, also, a lot of people replied that they had heard about the two technologies, but they do not have enough information about them or about the difference between them. Approximately 40% of them answered that they heard of the technologies, but they don't know any additional information about them and over half of the people stated that they do not know the truth about the relationship between them.

The two technologies possess many advantages, and for the reason of the convergence between them; it was important to distinguish and clarify the differences between them. There are many differences between them as well, there are several similarities, but the characteristics of both technologies make it clear that there is not the best one, but each of

them is the best option according to the different cases. Due to the presence of ambiguity in a not a small percentage; the distinction between the two technologies may be an appropriate solution.

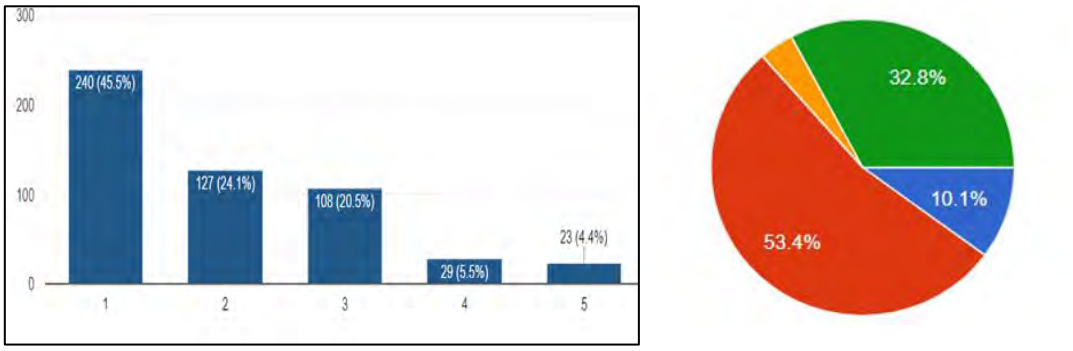

Figure 15. Questionnaire results (prepared by researchers)

Below is Table 1 that summarizes the most important difference between Hologram technology and Augmented reality technology:

Table 1. Hologram technology *vs.* Augmented reality summary

Comparison Aspects	Hologram Technology	Augmented Reality
History	The basic principles of holography were found by Dennis Gabor on 1947	The start of AR dates back to the 1950s when Morton Heilig, the cinematographer, thought of cinema
Image existing	Hologram which is a particular type of an image that truly exists	Virtual3D object
Hardware Requirements	Hologram projector	Smart devise or smart glasses
Possibility of Vision	Directly by Humane	Eye Using 3D Glasses
Cost	Cost-effective in the case of viewers numbers increased	Costly when needed to apply to a large number of people.
Popularity	Not widely known and has a restricted range of applications	Commonly and has Many applications
Types	Many types of hologram depending of: the image created type and projection device type	Different types depending on the type of medium in which the image appears
Usage	Used in different fields	Used in different fields

Conclusion

Technology has a tremendous ability to change and improve our lives, the technology evolved over time and many technologies have been discovered and others have been developed to solve various problems and facilitate human lives. Visual communication was and still is one of the most important issues in people's lives where there is visible content in almost all areas

of our lives, Hologram technology and Augmented reality technology are two of the most important techniques in this field, after searching we discovered that there is ambiguity in their definition and people define them as one thing. This may be due to the presence of several elements common to them and that they produce similar content, so it was very important to differentiate them clearly.

By comparing the advantages of each of the two technologies, it can be concluded that there is no specific winner, but the capabilities of each one of them enable it to be appropriate in a specific system and according to the needs of users.

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