# Virtual Reality (VR) & Augmented Reality (AR) technologies for tourism and hospitality industry

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**Abstract**

Virtual Reality and Augmented Reality, these days, is offering many useful applications that is attracting greater attention from tourism researchers and professionals. As, AR and VR technologies are evolving, the number of scientific applications is also at increase. VR and AR are proving their worth especially when planning, marketing, education, tourist sport preservation coming to light. The aim of this research paper is to highlight top technologies for Tourism and Hospitality with regard to AR and VR.

*Keywords: Virtual Reality, Augmented Reality, Virtual Environment, Display Technologies, VR & AR Sensors.*

## 1. Introduction

Virtual Reality (VR) and Augmented Reality (AR) are regarded as the most world-changing technologies of 21st Century. By stimulating our senses with computer generated images, they are able to immerse our minds in the experience which temporarily accepts VR/AR as another real version of reality [1, 2, 3, 4, 5]. VR and AR are used to create powerful 3D interactive visual experiences for all kinds of purposes. At the International Tourismus-Börse 2017 (Europe), several tourism technology providers demonstrated VR/AR content, showcasing tourist destinations and attractions on location. These generations of types of companies typically produce content in assignment from destination providers, attraction providers and hospitality providers, and some offer a Content Management System (CMS) to travel agencies that they may use to develop their own immersive VR experiences to their clients.

VR is considered to a promising technology for the Hospitality and Tourism industry that has the powerful effect of fooling the senses into believing one is present in a virtual world, by providing interactive 3D surroundings simulated by a computer. These simulations, can depict any tourist location or attraction reproduced as 3D imagery, controlled by powerful computers creating a complete Virtual Environment (VE). VE is simply a virtual digital environment generated that makes the user with VR equipment feels as if he/she is present inside it. A complete VR System is regarded as the interface between the real world user and the VE.

According to a report published in May 2017,(Grand View Research, Inc)., the VR industry is expected to reach USD 692 billion by 2025 and the concept can potentially expand from basic gaming to other applications like Education, Medicine and Healthcare, Architecture, Sports, TV Programs, Movies and Music and many more [6]. VR is gaining forefront attention in 2017 as various companies like Google, Microsoft, Facebook, HTC and many others, have come up with their own designs of VR Head-Mounted Displays (HMDs).

AR is an integration of the real world and the virtual world, with the aim of providing additional information about something in the real world with information displayed in the virtual world. For instance a person could look at a painting or a machine in the real world, hold up their smartphone or tablet in front of the painting or machine, and see on the screen the painting or machine with additional useful information, thus augmenting reality. In the case of the painting, the additional information could be about the painter and the painting technique and the painter's life for instance. Where as, in case of the machine, the additional information could be about how to open the machine and replace a broken part. AR technology is also capable of revolutionizing the tourist experience by making possible the planning, previewing and accessing location-based information of the holiday journey and destinations, in an interactive, and simple manner, from various places. Users can preview and book their hotel, access information while they are there, navigate around their destination, translate written, spoken signs or conversations, locating dining and entertainment options. It can all be done simply through an app on a mobile device.

In 2009 the first AR smartphone apps came out, using AR technology to add a layer of guidance, content and entertainment to physical locations seen through the smartphone's camera view. Tuscany+ was the first app built specifically for tourism - an "interactive, real-time guide" - intending to enhance the visitor experience (Figure 1). The AR technology made it possible to layer the digital enhancements over an existing reality or real-life scenario.

**Fig. 1:** Tuscany+ the first app built specifically for tourism.

Another, world-famous example is Pokémon GO, an open, mobile multi-player AR based game since its release in July 2016 it has taken the world by storm. It is an application with which players can collect points by walking around in the real world, while holding up their smartphone, in a quest to find, catch and collect in their phone camera view, virtual characters, called "pocket monsters", which are located near and linked to specific geographical locations (Figure 2). It already had more than 65 million players by April 2017 and is still rapidly increasing user numbers. With these numbers, it has become the most successful game of all-time. It is praised internationally by health experts because it gets people out of their houses and motivates them to walk around outside and connect with others.



**Fig. 2:** Pokémon GO mobile multi-player AR

Gastronomical providers have already started benefiting from the Pokémon GO craze, and there are more ways in which Pokémon GO can benefit tourism industry. The game makes use of "PokéStops", strategically placed at sightseeing locations, such as monuments and other public areas of interest; while in the game, these locations are displayed with a photo and a brief description. Tour operators can design new tours according to the location of PokéStops or the known locations of rare collectable Pokémons. During the tour, players can expand their knowledge of the world around them in a playful and spontaneous manner, when they encounter PokéStops that have interesting historic, artistic or cultural value.

Pokémon GO has made AR technology popular among consumers, and many variations on this theme can now be easily envisioned and introduced. This new technology can bring new opportunities to the Hospitality and Tourism industry. According to an article[12] published by Marketwatch.com in July 2017, in 2016 the AR market was valued at USD 2.39 billion and is expected to reach USD 61.39 billion by 2023, growing at a CAGR of 55.71% during the forecasted period [7]. The concepts of VR and AR are also referred to as Mixed Reality (MR) and various levels of integration are possible. The VR, AR and MR concepts will be defined in more detail in the sections below.

## 1.1. Virtual reality

A useful definition of VR was created by Lavalle, professor in the Department of Computer Science at the University of Illinois at Urbana-Champaign *"Inducing targeted behavior in an organism by using artificial sensory stimulation, while the organism has little or no awareness of the interference."* [9], formerly Principal Scientist at Oculus, currently Chief Scientist of VR/AR/MR at Huawei Technologies Co. Ltd. and creator of a series of 71 VR lectures available on YouTube [8].

This allows us to break the functional elements down into four main components associated with VR [9]:

1. *Targeted Behavior*: The organism has some "experience" which is designed by virtual reality developers. Example: Walking, flying, space exploration, doing lab experiments and interacting with other organisms.
2. *Organism*: Organism refers to the VR user, to include other life forms. Example: Human beings, animals and chatbots.
3. *Artificial Sensory Stimulation*: With the integration of modern techniques of engineering, various sensory experiences of organisms can be replicated and the sensory inputs are replaced by artificial stimulation.
4. *Awareness*: With effective virtual reality experiences, the organism experiences a smooth interaction and there is no friction between the user and the experience of the interface to the simulated world, thereby easily "misleading" the user into really feeling present in virtual world.

## 1.2. Augmented reality

Augmented Reality (AR) is regarded as a variation of VR. For this reason AR is often listed in combination with VR, as "AR/VR" and sometimes "VR/AR", and also "AR/VR/MR" where MR is short for the term Mixed Reality (MR). Mixed Reality is a useful term because it encapsulates the fact that there are various different configurations or hybrid AR/VR systems, as described by Milgram&Kishino [10], which can be depicted as a continuum with the real environment at one end and VR at the other end (Figure 3). The real environment refers to the Real World (RW) with all the objects and interactions that we are used to, AR refers to virtual objects overlaid on real objects. VR refers to an entirely virtual world with virtual objects in it. AR technology is beneficial to various industrial application areas, where there is a requirement for advanced user perception, and can help workers to have quick access to relevant information and instructions, during the manufacturing processes [11, 12].

Augmented Reality Systems have the following characteristics [13]:

- Mix of real world and virtual objects in real environment.
- Synchronize real and virtual objects with each other.
- Highly interactive and runs in 3D in real time.

In recent times the scope of AR applications has expanded to include innovation for the domains of Research, Science, Medicine, Telecommunications, etc. A software development platform called AR Toolkit is now also available for end-users to create AR applications. AR Toolkit is an open-source computer tracking software development toolkit (SDK) for the creation of AR applications that overlay virtual imagery on the real world, allowing the end-user to create annotations and animations of the virtual image that is overlaying the real-world object or scene [22].

Some AR systems can be used on a smartphone and tablet, so AR applications are not necessarily limited to use on display technologies like HMDs. However, many companies are working on developing dedicated AR HMDs. The AR headset market has been steadily developing as the technology matures [12, 13] and is widely expected to reach $4 trillion by 2030 as compared to $1 trillion in 2017. It is also expected to grab almost 28% of M-

Commerce market share which is expected to reach about $1.3 trillion by 2025 [13].

This enormous growth of AR/VR technology has motivated us to conduct a study on the current state of art on the technical aspects of this technology. The section 2 discusses the technical aspects of AR/VR technology in brief, section 3 discuss the impact of this technology on field of tourism and hospitality management and finally the conclusion in section 4.

## 2. Technologies for virtual reality and augmented reality

In this section the technologies that enable to user to see and interact with the VR/AR application will be discussed. The technology for VR/AR are still rapidly evolving. The software is becoming more sophisticated, and faster and the graphical imagery more detailed. The hardware is becoming less expensive and less bulky. And last but not least, the user experience is getting better due to these advances in the technologies. AR requires more sophisticated technology compared to VR, but the key components have remained the same since the 1960s, when Ivan Sutherland, who is widely regarded as the "father of computer graphics", and his students invented several foundations of modern computer graphics in the 1960s. The most essential components for AR/VR are Displays, Trackers and Graphics Computers and Software. The following sections give a short overview of the relevant technologies for AR/VR.

### 2.1. Display technologies for virtual reality

With regard to selecting VR devices, the main importance is to select a device that is user-friendly, i.e. comfortable to wear, flexible in operations, and the viewing depth and visual experience has to provide a good dynamic VE experience for the user. The race is on between the different VR hardware and software developers and technology for VR is so rapidly evolving that reviewing the latest technology specifications at the time of writing this, may very well be out of date by the time of printing this. For this reason, the underlying principles for a good user experience are discussed here. These principles can be used to evaluate any VR display and help ask the right questions when deciding which technology is best. The principles for successful VR display technology are:

- *Stereoscopic imagery:* A binocular HMD can display slightly different viewing angles for each eye, creating binocular overlap, which gives the viewer the illusion of stereoscopic depth and a more or less realistic 3D viewing experience, creating the illusion that some objects are near and others far away. It is important that the binocular overlap is correct, because it is not, the user will experience an unfocused, double-vision image.

- *Interpupillary distance (IPD):* The distance between the two eyes, measured at the pupils. It is important that a head-mounted display has an adjustable IPD, because the effectiveness of the stereoscopic imagery depends on it and every end-user has a slightly different IPD setting at which they will experience a clear focused image.

- *Field of view (FOV):* The natural FOV of human beings is about 180°, but so far HMDs are not capable of creating this. Current HMDs offer a field of view of between 60° to 150°. A bigger field of view results in a more realistic user experience, with a greater sense of immersion, allowing the user to establish greater situational awareness and more effective interaction.

- *HMD Resolution:* For an effective visual experience, a resolution of 1920x1080 (960x1080 per eye) is required. HMDs like for instance Gear VR offer a resolution of 2560x1440 (1280x1440 per eye). HMD specifications are usually described by the total number of pixels or the number of pixels per degree, also called "pixel density",

specified in pixels per degree or in arcminutes per pixel. The human eye, at the fovea (the part of the retina where the visual acuity is the highest), with normal vision can not perceive more than 60 pixels/° (also referred to as 1 arcmin/pixel). This is limit is called "eye limiting resolution". HMDs typically offer 10 to 20 pixels/°, though advances in micro-displays help increase this number. As display screens technology improves, it will approach eye-limiting resolution in the HMD and achieve photo-realistic experiences.

- *On-Board Processing and Operating System:* Wireless HMDs, also known as "smart goggles", have on-board operating systems such as Android, allowing applications to run locally on the HMD, and eliminating the need to be tethered to an external device to function. The challenge is to make the HMD construction as light as possible, and early solutions of HMD plus "backpacks" which contain the processing system and battery pack are already available.

### 2.2. Display technologies for augmented reality

AR is enabled by new technical features such as computer vision, object recognition, miniature accelerometers, a Global Positing System (GPS) and the solid state compass. The AR display technologies that are essential to create the AR experience are briefly described below:

- *Marker-Based AR*: the marker based AR relies on the image recognition technique that takes help of a camera and certain types of visual markers like QR/2D code , that gives result only when sensed by a reader. The marker based apps with the use of camera can differentiate between the marker and other real world objects. Markers are generally based on simple patterns, easily recognizable, requiring comparative low processing power for reading. Here the orientation and the position is also calculated where certain content and/or information is then overlaid on location of marker.

- *Markerless AR*: (also known as location-based, position-based, or GPS-based AR) uses miniature versions of a GPS, a digital compass, and a velocity meter, or accelerometer, which are embedded in the device, to provide data based on the exact location and orientation of the device. A strong force behind popularization of the Marker-less AR technology solution is the availability of smartphones everywhere with the location detection features. They are mostly used for mapping directions, finding nearby businesses, or other location-centric mobile applications.

- *Projection-Based AR*: Projection-based AR works by projecting artificial light onto real world surfaces. Projection-based AR applications allow for human interaction by sending light onto a real-world surface and then sensing the human interaction (i.e. touch) of that projected light. Detecting the user's interaction is done by differentiating between an expected (or known) projection and the altered projection (caused by the user's interaction). Projection-based AR can utilize laser plasma technology to project a 3D interactive hologram into mid-air, and although early demonstrators have come out in 2014, consumer version applications are still in the early stages of development.

- *Superimposition-Based AR*: Superimposition-based AR partially or fully replaces the original view of the object with an augmented view of that object. Computer vision and object recognition play a vital role, because the original view has to be recognized before it can be replaced with the correct augmented version. It is very suitable for the low-end consumer, who can use their smartphone or tablet to experience an augmented version

of their view, in for instance a museum or cultural heritage location.

## 2.3. Tracking sensors

Tracking sensors are essential to allow the user to roam in real environment, in order to move their viewpoint in AR/VR, and be able to continuously update the location of the user in the virtual world. For this reason it is regarded as one of the main components of VR/AR systems. These sensors basically interact with a system processing unit, relaying the orientation of the user's point of view to the system. Using the sensors in combination with VR/AR systems does not only allow the detection of the location of the user, it also helps detect the user's direction of movement and speed of that movement in any direction. The following three concepts are relevant to tracking for VR setups:

1. 6-DOF: Six Degrees of Freedom (DOF) for detection of movement; the freedom of movement (forward/backwards, left/right, up/down, yaw, pitch and roll) of a rigid body in 3D space, (Figure 4).
2. Orientation: It is based on the combination of yaw, roll and pitch of an object in 3D space.
3. Coordinates: Position of the objects on the X-axis, Y-axis and Z-axis known as orientation of objects.

These three concepts are relevant to the design of tracking for HMDs. All tracking systems consist of a device which generates a signal that can be detected by a sensor. The entire VR/AR unit is involved in the processing of this signal generation, and the transmission and sending information to the Central Processing Unit (CPU) and the Graphical Processing Unit (GPU). The signals generated from different sensors can take different shapes including Electromagnetic Signals, Optical Signals, Mechanical Signals and Acoustic Signals. Different tracking systems use these respective types of signals.

## 3. VR/AR in hospitality & tourism

VR/AR application areas for Hospitality and Tourism are still under development as the technology becomes more mainstream, both the industry and the consumers are starting to appreciate the possibilities this technology has for their hospitality and tourism interests. As the technology matures, the application areas are rapidly being explored by the early-adopters. This section analyses the immediate application areas for the Hospitality and Tourism industry and highlights the opportunities that lie ahead as the technology evolves.

With the advancements in VR/AR technologies, the implementations of VR/AR technologies continue to impress consumers and investors and as a result, these increasingly sophisticated technologies are being envisioned and implemented for end-user benefits in the Tourism and Hospitality industry. The following analysis highlights the impact and importance of AR/VR technology for the Hospitality and Tourism industry [6, 7, 13, 14, 15, 16, 17, 18, 19, 20]:

- *Effective Planning and Suitable Management:* With the help of AR/VR technologies in tourism, the potential has widened in terms of implementing effective tourism policy and also effective planning. VR devices create almost realistic, easy and detailed navigation of tourist places for tourists in order to plan their trips. With VR technologies, travelers can experience bird's-eye views of their destination, to have detailed look and feel of the place to be visited. It also acts as an important and effective tool for tourist activity planning, as tourists can connect to each other via social media apps to get feedback regarding their previous experience.

- *Effective Entertainment Tool*: Considering the important history of VR devices starting with the introduction of

the "Sensorama Simulator" in 1962, which provided people a virtual experience of driving a motorcycle, including realistic movement, sound, scent and airflow, VR technology has evolved to much greater heights since then. It has been implemented in various theme parks like Disneyland and other kids entertainment parks to provide virtual based environments in terms of rides, flight simulators and so on. Nowadays, the concept of 3D and 4D theaters are also on the rise in different parts of the world.

- *Education Tool*: VR has tremendous potential in terms of education and effective research of many years has proved that VR devices and even the latest AR technology can serve as a great tool for entertainment. A VR model can be an efficient means of communication of large amounts of information because it leverages the user's natural spatial perception abilities. VR has great potential to entertain and educate people via games, interactive sessions, Artificial Intelligence based Interactive Systems and many more.

- *Virtual Attractions at Effective Cost*: New AR and VR travel tourism experiences can be added to existing applications by simply modeling and animating them. These create a perfect digital environment and digital content can just be added or uploaded on demand considering the visitor's requirement and even used for location marketing purposes.

- *Interactive Dining Experience*: Amazing food and entertainment is the primary focus for the travelers planning a trip from home. With the help of augmented reality technology a virtual tour of the restaurant is possible along with that they can even make diving decisions using the virtual menus available. There are other attractive features like accessing mobile, coupons or advance reservation features that may facilitate the visitors to try new dining experience.

- *Convenient Translation Capabilities*: AR technology may help the non-local travelers facing the language barrier as a challenge towards interacting with people. The technology makes the translation simple and effective that increases the experience as well as understanding.

- *Real Time and Reliable Navigation*: the landing of the people in an unfamiliar environment may tend to develop frustration as well as challenging at times. The technology may help in elevating the navigation maps with addition of digital elements like arrows as well as other helpful information to the map. This technology augments the feeling with simplified directions to follow and ensuring a safe and easy travelling to the desired destination.

- *Booking Rooms*: AR technology provides the perspective guests to survey the rooms prior to booking them. The travelers can physically visit the rooms to cross check with size as well as floor plans. These guests may further be approached for upgrading to a suite by looking at additional amenities, mesmerizing view and the comfortable spaciousness around them.

- *Exploring the property*: the visitors need not imagine the hotel using website images and paper brochures, instead they can virtually visit the hotels, restaurant spa or fitness center. The eco-friendly hotel may also provide users for a virtual tour of its roof top, herb garden, or show-off green building materials that enhances the customer loyalty. The Casa-madrona mansion, uses the printed or augmented brochure.

- *Experience of Rich luxurious Restaurants*: The hotel may also add, AR content to their restaurant menu, that can

help non-native guests to be able to read it in their own language. The AR images may also be projected on the restaurant table that may allow the guests to decide and select their choice of table theme.

● *Local attractions*: the locational advantage of a hotel is one of the most attractive feature for a guest to choose or select a hotel. This technology may allow a user to give a glance at the hotel location also give a view of the eminent historical events, cultural experiences of the nearby destinations. Along with beautiful sight seeing the AR may advertise more of its attractive features as long as the guests interact with their apps.

● *Marketing*: The AR tech enhances the guests satisfaction through the process of effective marketing, on billboards placed at airports or high traffic areas, or scanning the clicked images as well as information about the hotel.

● *Hotel Management*: AR has also contributed in the field of business and the back of house operations. The advanced AR technology can create blue prints allowing the investors to look through the end results. And in the areas of staff training , these hotels may provide a real feel that can help the employees to enhance their soft skills while guest interaction.

Though AR technology is at the budding stage in the hotel industry, but it may not be too long to dominate in this field since the recurring of this technology may contribute as a huge impact on its scales.

## 4. Conclusion

This research paper covered a description of the history of VR/AR enabling technologies, the currently popular VR/AR equipment, and several Use Cases of VR/AR applications for the Tourism & Hospitality sector. It reviewed the successes, failures and challenges for the development and use of VR/AR applications to improve existing marketing funnel designs, improving client conversion rates and thus providing the required added value and ROI. From the Use Cases many examples can be drawn that showcase a substantial amount of institutions that have made the investment in VR/AR apps to help their potential customers with their pre-purchase decision making, indicating that they consider VR/AR technology particularly suitable for supporting the decision-making process of intangible products such as the holiday or event experience. AI driven chatbots are flagged as a new application area beneficial for the Tourism & Hospitality sector, particularly where it comes to answering the frequently asked questions from pre-purchase customers and helping those in the process of purchasing, thus helping reduce this type of repetitive, time-consuming workload of customer support personnel.

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