Faculty of Business Economics

Master of Management

Master's thesis

Augmented reality applications in tourism

Bih Mildred

Thesis presented in fulfillment of the requirements for the degree of Master of Management, specialization Business Process Management

SUPERVISOR :

Prof. dr. Marijke SWENNEN

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COVID DISCLAIMER PAGE

This master thesis was written during the COVID-19 crisis in 2020. This global health crisis might have had an impact on the (writing) process, the research activities, and the research results that are at the basis of this thesis.

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SUMMARY

The past two decades have witnessed significant growth in the field of technology, greatly influenced by the quest for innovative ways of executing tasks. One of such innovations that has greatly improved the way things are done is Augmented Reality (AR). It has been used in different fields in varied ways. In the domain of tourism, AR has been used to improve the touristic experience of people who are visiting unfamiliar sites. Being a flexible innovative technology, AR blends information about a particular destination with virtual images that have been augmented from the real world's view, to make the experience more enjoyable. By doing so, this technology identifies and makes use of features of already existing applications to add value to users' experience.

The existing literature on AR applications shows that the benefits of AR to tourists visiting unfamiliar environments for the first time have been immense. The literature on AR applications was explored as the main source to answer the main research question of this study, which is to examine the features of the already existing mobile AR applications that add value to users' experience, making them a better alternative to verbal tour guides. There were three specific objectives for this study. The first objective of the study was to identify what AR is all about and the various fields that make use of this technology. In this light, a series of definitions from different researchers were explored and examined together with the varied ways in which AR applications have already been used in other fields like medicine, education and marketing. Secondly, this study went in-depth to examine some already existing applications used for touristic purposes, identifying the features that enables them to create an amusing and scintillating experiences for its users. The benefits and limitations of these applications as highlighted by tourists in the existing research, were also highlighted.

It was also observed that despite the many benefits these applications bring to tourism industry bring destinations, they poses some challenges to tourists for instance, overloading of unnecessary information, connectivity issues and little or no updates on the application. Therefore, this research clearly outlined some obstacles that tourists' encounter while using these applications and how application developers should tackle these problems in order to encourage the technology's full acceptance and adoption in the tourism industry. AR applications function properly and deliver desired results with the use of sensors, GPS tracker, devices with high resolution cameras, and a good software system that is compatible with all devices. That is why the inability of AR applications to interact with other devices across different mobile platforms has been a challenge. It was realized that most applications are developed for devices that run on iOS platforms and Apple mobile devices, thereby limiting tourists who use devices that run on other platforms like Android and windows from effectively using the applications. Another challenge identified was that of internet connectivity. AR applications depend largely on internet connection to be able to function and considering the fact that not all cities are wired with WIFI connections, tourists are forced to incur extra cost on roaming data which is a limitation especially to the younger ones. However, developers of these applications have to create a software that will be compatible with all devices across different platform so as to enable all the users to get access to the applications and exploit them fully. As concerns the internet connection issue,

developers should design applications that could be accessed offline so as to make the application cost effective.

Some applications that are used in other fields and also used in tourism such as Microsoft Hololens were identified. Also the Autism Glass which is produced for patients with disability to help them feel included and accepted in the society.

Finally, it was concluded that AR is an important technology that has prospects for the tourism industry and if all the challenges are tackled by the application developers, it will increase the acceptance rate of the technology in the future. Gleaning from the trends and patterns in the examined literature, it was noticed that most of the researchers used the quantitative method to derive their conclusions. As a follow up, it was observed that future research could explore the qualitative method of research to generate thick data from interviews with tourists to better understand their perceptions and challenges with the use of AR applications. Similarly, application developers could also be interviewed to get their experiences and the obstacles they face while developing a software that permits these applications to run on all platforms. Lastly, it was recommended that an in-depth study could also be done on one or two of these applications so as to get detailed information about the functionality of the particular application(s) and the possibility of using them in other areas other than those created for. For instance, using Tuscany+ application designed for the Tuscany region in Italy out of Italy or using the cityviewAR application designed for the purpose of having an AR view of the buildings that were destroyed during the explosion that took place in the city of Canterbury in NewZealand, out of the designated city.

CONTENT

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INTRODUCTION

1.1: Background of study

Extant literature shows that tour guides (TG) play an essential role in the tourism industry (Al Jahwari, Sirakaya-Turk, & Altintas, 2016; Liao, Chen, Chang, & Tseng, 2011; Pereira, 2015). For instance, the research of Mak, Wong, and Chang (2011) refers to TG as the 'Cinderella' of the tourism industry because of the effective services they offer which makes tourism attractive. They play different important roles for different parties: for tourists, they are the mentors and pathfinders; as employees of tour operators, they are the speakers that represent the images and good reputation of the companies they work for; and for the host destination, they are the intermediaries between the host country and its visitors.

However, in order to satisfy the needs and demands of the 21st century tourist, tour guides have to upgrade their services and embracing technological advancements is of the essence (Weiler and Black (2015). One of the major setbacks of the TGs, is their inability to provide services that match the fast-advancing technological world (Mak et al., 2011). Garau (2014) Posits that technological transformation in the domain of cultural sciences is on the rise and this has pushed most towns to improve the nature of their touristic activities, which has always gained the support of bodies like UNESCO and World Tourism Organization. This improvement has redefined the communication strategy, from the use of verbal tour guides and maps drawn on papers to current technological tools like Augmented Reality.

Similarly, (Katkuri, Mantri, & Anireddy, 2019) identifies AR to be an innovative technology that will add value to tourists' experience, improve the attractive nature of a destination and boost the tourism sector without necessarily employing the services of a verbal tour guide. These demands to meet up with the rapidly advancing technology have inspired this study to focus on Augmented Reality (AR), which is defined as "the combination of technologies that enable real-time mixing of computer generated content with live video display"(Mekni & Lemieux, 2014). Han, Jung, and Gibson (2013) hold that AR has been the watchword of today's technological advancements and is experiencing speedy growth and implementation in many industries. Similarly, Kounavis, Kasimati, and Zamani (2012) assert that although AR applications have existed in other fields such as Medicine, Engineering and Education, it was only in the last two decades that modern technology has made possible the formulation of a well-defined field of research in tourism. In addition, T. Jung, tom Dieck, Lee, and Chung (2016) posit that AR in tourism only made its appearance after the launching of modern smartphones around 2007 which allowed specific area location and highlighted components required for AR apps such as cameras, solid state compasses, flywheels and accelerometers(G-sensor).

1.2: Statement of Problem

According to Yovcheva, Buhalis, and Gatzidis (2012), modern technology has constantly been changing, and on a daily basis, new technology is being introduced to individuals. They are mostly devices or appliances that assist to make life easy for people, and are mobile or adaptable, very convenient to use and multi-skilled. AR applications are one of these innovations that have enormous benefits in several fields, with tourism inclusive (Qiao et al., 2019). Even though, most researches in tourism are centered on specific aspects like implementation of the application, usability and acceptance theories, prospects of the application and general benefits (T. Jung, Chung, & Leue, 2015; Qiao et al., 2019; Tuli & Mantri, 2020), there is paucity in research on the value that each of the already existing applications offer its users.

Therefore, this inspires the study to examine more carefully the already existing Mobile AR Applications (MARA) in tourism as well as other fields, to bring out their characteristics that contribute to helping tourists achieve their desired results.

1.3 Objectives of the study

To define, explore and improve the use of Mobile Augmented Reality applications (MARA) by tourists in the tourism industry, making them a better alternative over verbal Tour Guides.

1.3.1 Specific objectives;

   i.   Define AR and its use in various domains
   ii. Identify the characteristics of AR applications and their contribution to the tourism industry.
   iii. Examine some of the obstacles tourists face while using AR applications
   iv. Explore the prospects of these AR applications for the tourism industry.

1.4 Research method

This research is completely based on secondary data. It is the result of a detailed study of many articles and library studies. A literature search was conducted to select articles on Augmented Reality applications in tourism and other fields like Medicine, Education and Marketing, using search engines and databases like research gate, Google scholar and UHasselt data base. The literature on AR applications in tourism was probed as the main source to answer the research questions. Different composition of words were used to perform the research such as "AR applications benefits" "challenges of using AR applications by tourists" and "prospects of AR applications in the tourism industry." Since the term "Augmented Reality" was established many years ago, the search was carried out in favour of articles on AR application from the year 2000 till 2020. The search included a selection of articles that talked about some already existing mobile AR applications in tourism as well as other fields.

1.5 Research Question

Based on the objectives of this study, the following research questions were formulated.

1.5.1 Main question:

To what extent do the features of the already existing Mobile Augmented Reality Applications (MARA) add value to users' experience making them a better alternative to Verbal Tour Guides?

1.5.2 Specific questions:

I.   What is AR and what are some existing application fields of AR?
II.   Does the existing AR applications for tourism meet tourists' demands?
III.   What are some of the challenges tourists face while using these already existing applications and what are the prospects of these AR applications for the tourism industry?

LITERATURE REVIEW

Chapter review:

This chapter is divided into three sections according to the three objectives listed above. The first section will focus on the general understanding of AR gleaning from the existing definitions from different fields, like healthcare, education and marketing. It shall go further to consider the use of AR in these fields, showing how the use of AR in these domains have impacted the use of AR in tourism, which is our bone of contention in this study.

In the second section, AR in tourism is discussed with some already existing applications and their characteristics that adds value to tourists' experience. The last section outlines some challenges encountered by tourists while using these applications and prospects for the future of these applications are discussed. Still on the last section, applications used in other fields which are also useful for tourism are outlined.

2.1: Understanding the use of AR in other domains

This section will give an overview of some definitions of AR that some researchers have brought up and it will also go in depth to talk about AR in other fields and what importance it adds to this research on tourism. Although our focus in this study is on AR in tourism, this study is not oblivious to the influence other disciplines have had on tourism. As earlier noted, AR applications were only recently introduced in tourism (Kounavis et al., 2012), comparatively to the use of AR in other disciplines. Therefore, this section focuses on showing how other disciplines have defined and applied AR to improve practice in their fields. By painting a general picture of the development of AR through other fields, the use of AR in tourism will be situated in its right context, with clearer definitions and differences outlined.

2.1.1 Definition of AR

The notion of augmented reality surfaced as a new branch of virtual reality and technology in the late 90s and has spread across many disciplines (Pagani, Henriques, & Stricker, 2016). Different researchers have defined AR technology in different ways. Ilhan and Celtek (2016) defined it as a technology that deals with the combination of real world and virtual world, to give added information about something in the real world with information unveiled in the virtual world using virtual objects. These virtual objects comprises of data created by the computer such as texts, images, and GPS data (Chen, 2014). Edwards-Stewart, Hoyt, and Reger (2016) asserts that these applications can be grouped based on their functionalities and analyzed individually. Validating the preceding statement, Pentenrieder, Meier, and Klinker (2006), add that "*Although all these systems build on the same kind of tracking object, they differ in areas such as usability, reliability and accuracy*". According to T. Jung et al. (2015), it is "a technology that allows the superimposition of synthetic images over real images, providing augmented knowledge about the environment in the user's vicinity which makes the task more pleasant and

effective for the user, since the required information is spatially superimposed over real information related to it". Carmigniani et al. (2011) defined it as producing a direct or an indirect scene of the physical environment by adding up information on the virtually created world through the use of computer technology. Ramos, Trilles, Torres-Sospedra, and Perales (2018) suggest that it is a technology that coats computer generated images over the physical world in order to make meaning out of it by interconnecting with it. Ozkul and Kumlu (2019) defined it as an improved technology that gives an indirect viewpoint to users through the implementation of visuals derived from high resolution cameras into the virtual world via computer technology. Voit, Mayer, Schwind, and Henze (2019) expatiates by saying that AR combines digital information with the physical nearby surroundings it relates to, by virtually overlapping content on top of the view of the physical world as seen in figure 1 below.
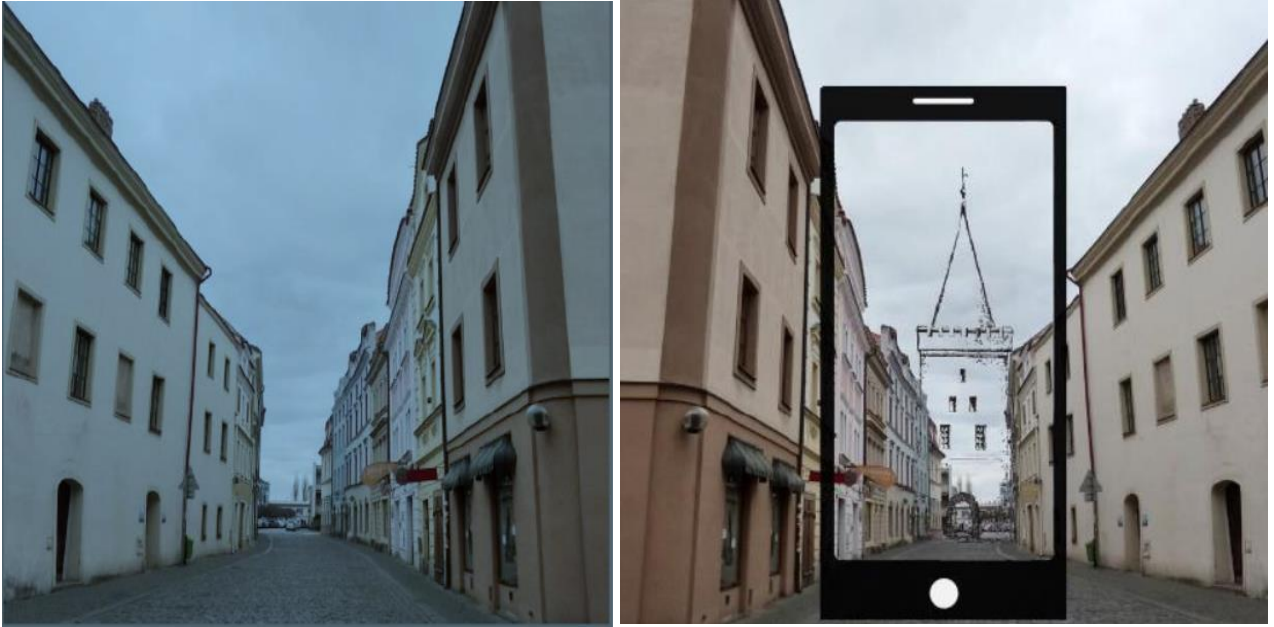
A) REAL WORLD VIEW   B.) AUGMENTED VIEW

Fig 1: Picture showing the real world view and the augmented view (Kysela & Štorková, 2015)

2.1.2: Some existing fields of AR

The fast advancement in technology has necessitated an improvement in the way things are done to match up with the changing times. AR applications have come in handy to respond to the growing needs in the society. For instance, Han, Jung, and Gibson (2013) observe that with the help of AR technology, many industries have experienced rapid growth. Specifically, AR applications have made everything possible with the use of sensors to design virtual images or augment already existing ones (Parekh, Patel, Patel and Shah, 2020). However, although AR technology has passed the 'create awareness stage', more is still left to be exploited for the growth of industries (Han, Jung, and Gibson, 2013). The section that follow will trace the development and use of AR application in different domains in the society, precisely in the fields of medicine, education, retail and subsequently in the field of tourism, which is our main concern in this study.

2.1.2.1: AR in Medicine

One of the domains that has been greatly improved by AR applications is medicine, where recent studies have shown that the phenomenon of using AR applications is on the rise since the early 2000s (Ha, Hong and Hanyang 2016;Rochlen and Levine, 2017; Yeung, Tosevska, and Klager, 2021). With the help of AR applications, real objects and virtual images are generated to give the user a feeling of real physical interaction. For example, the use of AR applications in medicine has made it possible for virtual images to be displayed on the screen for easy identification of body parts to be targeted for any procedure (Ha, Hong and Hanyang , 2016; Parekh, Patel, Patel and Shah, 2020). Furthermore, AR technology is envisaged to have great prospects in changing the face of surgical proceedings as it enables regions of interest on the human anatomy to be easily identified on screen thereby reducing the occurrence of errors while carrying out the operations in real life (Hsieh, Lee and Nurs, 2018). Research has suggested some reasons for the rise in the use of AR in medicine. Firstly, Yeung, Tosevska, and Klager (2021), noted that AR has permitted constant repetition of easy tasks in clinical practices within an immersive environment without continuous supervision by a medical personnel, which reduces training cost by a considerable amount. Secondly, hospital visits could greatly be reduced via the safety usage of Head Mounted Displays (HMDs) by housebound patients in nursing homes (ibid). Lastly, patient safety is guaranteed because of reduced surgical errors (Hsieh, Lee and Nurs, 2018). In another study carried out by Parekh, Patel, Patel and Shah (2020) on Visual computing for industry, it was observed that AR technology in medicine has grown over the years and it has been helpful to doctors and patients in the following ways; patients can be educated about their diseases, complex surgeries can be performed with the help of this technology and doctors are able to carry out these procedure with high accuracy, which demands a considerable level of expertise and effort as the technology is very costly and operating it needs lots of care and accuracy. Also talking about the benefits of AR to the medical field, Hsieh, Lee and Nurs, (2018) noticed that AR technology is more of a learning tool for trainees or inexperience surgeons with surgical training when operating a surgical simulation system, so as to

enable them replicate the process with little or no errors in future when carrying out a real operation. However, Yeung, Tosevska, and Klager, (2021), using a quantitative research technique to evaluate 8399 publications from 1992 till 2020 on AR, posit that despite the usage of AR in medicine, very little is known about using AR technology for certain treatments like chronic pain management. They also noted that it is quite expensive to run this technology in clinical practice and there is a low acceptance level of this technology among the older generation (ibid). Examples of Some of these applications used in the medical field as seen in table 1 below includes machine learning gloves which acts as an instinctive and less costly Human Machine Interface (HMIs) that can easily track the motion of human fingers (Wen, Sun, He, Shi, Zhu and Zhang, 2020) and the Autism glass used by children with autism, which helps them to interpret people's emotions (Hsieh, Lee, Nurs, 2018).Also, the Microsoft Hololens Holoanatomy Application (MHHA), which permits end users to envisage the human anatomy in the form of a narrative, through the use of Head Mounted Displays(HMDs) like Microsoft Hololens which enables the end user to mingle with the models through finger motion (Sen, Chuen, & Hta, 2018) and the HeART application which is used to enhance a 3D anatomy model by generating a heart image for viewing(Sen et al., 2018).Drawing insights from the above analysis, it can be concluded that AR technology is of great value to health care in so many aspects of treatment and diagnosis. However, there is still a lot of setbacks to its full implementation in the medical field and this findings corroborates the ideas of (Yeung et al., 2021)who talked about the expensive nature of implementing these applications in clinical practice and low acceptance rate among the older generation. Considering the fact that this study is based on examining the features of the already existing Mobile Augmented Reality Applications (MARA), the Ms Hololens and the Autism Glass are suited for touristic purpose as they exist in the form of Head Mounted Displays (HMDs) which are portable, and the Autism Glass is designed to assist tourists with special needs to also enjoy a touristic experience without any limitations. The HeART and the Machine Learning gloves are not applicable for touristic purposes due to the fact that they are designed for specific uses, that is, to view the image of the heart through an augmented 3D anatomy model s

Name of application	Reference	Function of the application	Applicable to tourism?
Microsoft Hololens Holoanatomy application	Sen et al., 2018	Envisage the human anatomy with the use of HMDs	Yes
HeART application	Sen et al.,2018	Enhance 3D anatomy by generating a heart image	No
Autism glass	Hsieh, Lee, Nurs, 2018	Assist children with autism interpret others emotions.	Yes
Machine learning gloves	Wen et al.,2020	Used to track motion of human fingers.	No

Table 1: classification of AR applications used in the medical field.

2.1.2.2: AR in Education

The education sector is one of the domains that has made great use of AR to improve learning and teaching. Research shows that the phenomenon of using AR applications in the domain of education is on the rise and has encouraged students to be innovative and creative in broadening their horizons (Ozarslan, 2012; Antonioli, Blake, and Sparks, 2014; H Tekedere, Göke , 2016; Uygur, Yelken, and Akay, 2018). Research has also shown that AR has contributed with the help of multimedia and technological innovations to improve and enhance students and teachers motivation towards learning and teaching in the classroom (Uzunboylu and Yıldız, 2016). For instance, instead of using the traditional teaching methods, AR applications are installed in the students' devices, therefore, granting them access to the material in time, which has greatly improved the students' anxiety to learn (Uzunboylu, and Yıldız, 2016). Another method of implementing AR in education is through the use of Quick Response (QR) codes whereby students use their mobile devices to scan barcodes, in order to get access to material within the classroom and this increases participation in the class as students are able to exchange material with their fellow students and tutors (Antonioli, Blake and Sparks, 2014). In a quantitative study carried out by (Radu, 2014), reviewing 26 online publications, he made a comparison between augmented reality and Non- Augmented reality in education concluded that AR in education has both positive and negative effects, but will register more success if the AR designed for education will answer the questions which were spelled out in the questionnaire diligently. Pantelić and Vukovac (2017) also noticed that using AR applications in education is a mixed blessing by positing that AR encourages active learning through the display of digital content as it can be very difficult to explain by word of mouth, and instills a sense of familiarity with the use of technology in kids at a very tender age. However, they also noted that an enormous focus on virtual content could deprive students of their perception of reality and the motives for which these technologies were created could be missed out by the students who get carried away by the technology's performance. Furthermore, Baldiris (2014), using a quantitative research technique to analyze data gotten from five most relevant journals on AR technology in education, noticed that AR in education is a vibrant field of research for most researchers as the number of researches are increasing yearly. Examples of some existing AR applications as seen in fig 3 below, used for education include *Google's Sky Map* which layers information about the stars as end users glance through the displayed image of the sky in their smartphones by use of the phone camera (K. Lee, 2012). Another app is the *voice translator* which carries out translation of over 30 languages facilitating students' practice of articulation and translation (Bower, Howe, McCredie, Robinson, & Grover, 2014). Also the *fetch lunch rush* is another application that enable students' build-up basic statistical skills by demanding answers to questions which requires them to find an AR marker that contains the right answers (Hodhod, 2014). From the above analysis, we find that AR in education has progressively increased and a lot of researchers are interested in investigating the characteristics, achievements, drawbacks and prospects of AR in education. Based on the results obtained, AR

applications in education are very vital and this findings confirms the ideas of (Pantelić & Vukovac, 2017; Radu, 2014). Given the fact that these applications are portable (embedded in mobile devices), Google sky map and the voice translator are suitable for tourism as they provide the opportunity for tourists to switch the application to any language of their choice, and instead of focusing the application to identify the stars and other masses up the sky, geographical features on the landscape could be embedded so as to enable easy access and location of any place. The fetch lunch rush will be more suitable for gaming since it is an application that deals with recording the accuracy of students at finding answers to basic statistical problems.

Name of application	Reference	Function of the application	Applicable to tourism?
Fetch lunch rush	Hodhod, 2014	Improve upon students' statistical abilities	No
Google's sky map	K. Lee, 2012	Facilitate the study of astronomy	Yes
Voice translator	Bower et al., 2014	Helps student to articulate and pronounce well.	Yes

Table 2: Classification of AR applications used in education

2.1.2.3: AR in Marketing

Research has it that AR is one of the highest topics discussed in marketing as concerns retailing, though little is known about the circumstances surrounding its acceptance by users (Spreer and Kallweit, 2014). As AR denotes an approach in which computer generated images are merged with images in the physical world, it has enabled the display of 3D product portraits in different sizes, shapes and colors so as to facilitate consumers' buying choice (Esch, Arli and Gheshlaghi, 2019). As shown in the table below, Poushneh (2018);Zhao, Shi, You, and Zong (2017) identify some of these applications and classifies them in the following categories: mobile (snap shop, start chart), HMDs (Google glass, Microsoft Hololens), contact lenses and devices (Magic mirrors). One of the most significant benefit of AR applications in retail is that time is saved as useful information is readily available to facilitate users purchase decision (Pantano, Rese and Baier, 2017). Furthermore, in a study conducted by Riar, Korbel, and Xi (2021), analyzing 29 Articles on AR applications in retail, showed that AR is a very useful technology for both online buying and buying in person at the local stores. They arrived at this conclusion because the AR technology embraces customers of different mental capacities through the colorful display of products that enable a vast number of different reactions and behaviors from

consumers. Similarly, Spreer, K Kallweit (2014), carried out a qualitative research in collaboration with the highest Germany book seller and a leading AR development company, whereby 100 randomly selected visitors at a very busy bookshop in the city center of a large city in Germany, were given Tablet-PCs with the app installed on it already to enable them answer a survey. The result gotten indicated that AR users got outstanding information from the applications than those visiting the store and therefore, showing that AR is an effective technology in marketing. However, Pantano, Rese and Baier – (2017) in a study using the qualitative research technique, used two groups of consumers from two different cultural backgrounds to investigate consumers' acceptance of AR in retail and got very striking similarities and differences in the responses received. The result registered shows that the purchase of products like glasses from physical shops is more preferable, as there is the possibility of trying them on before purchasing by both groups. As concerns the willingness to use "virtual try-on" to purchase classes over visiting an optician's shop, Italians showed a more positive reaction towards this optician than the Germans. Therefore developers should tailor the design of their AR system to suit the buying habit of the specific culture they are targeting, so as to increase online presence and use of these application. Drawing insights from the above analysis, it can be concluded that AR in retail is still a very new concept that is increasingly being studied and has potentials of expanding the marketing sector if the developers of these applications tailor the design of these apps to meet consumers' needs. The google glass being a wearable device that is portable, makes it easy for use in tourism. It will be even more applicable and appreciated if it could be customized to suit the taste of different users, owing to the fact that some tourists would prefer to enjoy privacy during their touristic experience, while others will prefer to make it more general by updating the data stored in cloud where everyone can access. The snapshop and magic mirror applications are not suitable for tourism due to their static nature, as they are most suitable for displaying of items and adverts.

Name of application	Reference	Function of the application	Applicable to tourism?
Snap shop	Poushneh (2018)	Display products in an AR view	No
Google glass	Poushneh (2018	Display information in a smartphone like hands free format.	Yes
Magic mirror	Poushneh (2018	A virtual shelf used to display a vast product range that couldn't be displayed on a physical shelf	No

Table 3: classification of AR applications used in retail

2.2: AR applications in Tourism

From the above section, it is observed that tourism is not a stand-alone field, it is connected to the rest of the disciplines and thus it is influenced by the advancement in the technology of other disciplines. Literature on tourism has identified several AR applications developed to improve the experience of the tourists. These applications are structured to facilitate navigation and so registration and tracking technologies are very important elements to handle (Pentenrieder et al., 2006). In a study carried out by T. Jung et al. (2015),two different categories of tracking in an AR system are discussed being the marker-based and location based. The former has to do with detecting points of interest, by recording the positions of three-dimensional (3D) objects in the physical environment, using high resolution cameras of mobile devices to run a Quick Response (QR) code. This triggers additional content to appear over the landscape. The latter does not need codes as it identifies particular components from the surrounding environment with the help of a GPS location which is suitable for the countryside. Most of the already existing AR applications use the location based tracking system, since navigation is made possible with the aid of the GPS, which instantly displays the location of interest. For the purpose of this study, four of these applications are discussed namely, Tuscany+, pokeman Go, CityViewAR and urban sleuth.

2.2.1: Tuscany AR application

According to Nayyar, Mahapatra, Le, and Suseendran (2018), Tuscany+ was the first app to be used for touristic purposes in the Tuscany Region. It is termed a "digital tour guide" because it has the ability of superimposing a digital layer over the physical world via the use of a smartphone camera, thereby boosting the tourist's experience as seen in Fig 2 below.

Fig 2: Tuscany+ the first app built specifically for tourism (Nayyar et al., 2018)

Garau (2014) carried out a study in which he realized that this application was developed to serve the need of this particular region because of its attractive nature which acts as a point of contact for many business to blossom, as well as a destination for many tourists visiting the area. In a related study carried out by Teobaldi and Capineri (2014), they identified that Tuscany has been explored by a significant group of tourists due to the attractive nature and the strategic positioning of the town of Florence in the Tuscany region in Italy. From the statistic obtained from their analysis in 2011, 12 million arrivals were recorded which accounted for people coming from other parts of the world and 43 million comprising of people based in Italy, with 12% of that amount comprising of Italian tourists. According to the statistics, Florence registered 27% of the total inflow of tourists who used the application to proof its attractiveness, while the rest of the percentage was distributed across 282 towns in Italy. However, this application has a limitation in that it was developed only for a particular region (Tuscany region in Italy) and it displays just two languages; English and Italian(Katkuri et al., 2019).

2.2.2: Urban Sleuth AR application

Urban Sleuth is another AR app that was developed for touristic purposes (Katkuri et al., 2019; tom Dieck & Jung, 2018). It is a gaming app which targets users who love mysterious and adventurous trips. In a mixed research carried out by Herbst, Braun, McCall, and Broll (2008), a sample of 24 users (16 male and 8 females) were interviewed and issued questionnaires in order to collect information regarding their experience of using the Urban Sleuth app, which is an app that was created in the city of Cologne to enable users solve challenging puzzles by unifying a real and virtual environment that enable users to feel actively present. However, the results obtained from the study showed that to a lesser extent, the objectives of building the app such as; to make the game play take place within the city, and to foster temporal, physical and social presence were not completely met as most of the users interacted mainly with the technological aspects rather than the game itself, due to changing functionality across different platforms. Again, the fostering of temporal, physical and social presence was not accomplished as most of the participants recounted that they didn't have much interaction with the game due to its limited content and so they interacted more with the real world as they moved from one point to another. Even though this application has the potentials of providing its users with such exquisite experience, it has failed to provide a unique experience to all its users across different platforms and are limited to certain geographical areas. From the above analysis, it can be concluded that the Urban Sleuth is a very interesting app that gives its users very exquisite experiences, but it is limited as it was created specifically to be used in the cologne region in Germany.

2.2.3: Pokemon Go mobile AR application

According to a research carried out by Nayyar et al. (2018) Pokeman Go, which is another AR gaming application, was released in 2016 and it is believed to be one of the famous mobile multi-player AR based game which has gained millions of users across the globe. By using this application, Users walk around collecting points in the physical world by holding up their smartphone in an attempt to map and collect virtual images called "pocket monsters" situated at sightseeing locations such as monuments and other public places of interest, with the help of the phone camera (Rasche, Schlomann, & Mertens, 2017). This app was designed with the intention of helping players expand their knowledge about unfamiliar locations in a playful and interactive manner. In contrast, (Ocampo & Palaoag, 2019) using a qualitative research method, conducted interviews with some citizens and tourists in the Province of La Union using pokeman Go as the testing application. The feedback gotten from the respondent was that there were moments that the player's current position differed from that of the app due to inaccurate GPS signals.

Fig 3: Pokeman Go mobile application(Nayyar et al., 2018)

2.2.4: CityViewAR application

CityViewAR is another application that is famously used in the city of Canterbury in New Zealand. In a study carried out by(G. A. Lee, Dünser, Kim, & Billinghurst, 2012) tracing the history behind the creation of this application, it was concluded that due to the disastrous effects of the earthquake that took place in the city of Christchurch of Canterbury, a lot of properties were damaged and most of the structures gone. As a result of that, little or nothing was left to be saved for historic purposes. The CityViewAR application was therefore designed for the purpose of enabling tourists to see what used to exist in this city by augmenting the view as shown in the fig 4 below.

Fig 4: CityViewAR displaying virtual buildings with an AR view (G. A. Lee et al., 2012)

From the above analysis, it is seen that these mobile applications comprises of all hardware suitable for its smooth functioning such as a camera to assemble videos of the physical environment, a layout to illustrate the augmented view and a computer technology to cast the positioning of the camera so as to create assets and merge virtual images with the video (Manuri & Sanna, 2016). Therefore, it can be concluded that the above listed applications for tourism possess these characteristics as they all display content via the use of camera, with an embedded GPS for tracking. For instance, the Tuscany+ application displays information about restaurants, hotels, parking, and sightseeing locations in the town of Florence in Italy, while the CityviewAR application displays information about important historic events and structures that had existed in the city of Canterbury. However, they are all created to serve different

touristic purposes; the Tuscany+ application for navigating the Tuscany region in Italy, the cityviewAR for viewing historical structures that used to exist in the city of Canterbury, the Urban sleuth and Pokemon Go application for gaming purposes, aimed at helping users master the city of Cologne in Germany. In the same light, the already existing AR applications in other fields such as the MS Hololens, the Google Sky Maps, Voice Translator and the Google Glass, display 3D objects generated by computer technology, by use of high resolution cameras and GPS tracking devices.

2.3 Challenges and prospects of Augmented Reality Application to the Tourists

Despite the successes registered by the aforementioned AR applications developed for touristic purposes in previous studies, there are still some barriers that obstructs the full exploitation of the technology's prospects. However, these challenges are backed up by suggestions brought forth by other researchers, to enable the AR applications gain full acceptance in the tourism industry in future. These challenges and prospects are centered on technical requirements, user's acceptability and data availability.

2.3.1 Technical requirement of the AR applications

Most researchers spotlight the inability of AR apps to interact with other devices across mobile platforms (Kounavis et al., 2012; Manuri & Sanna, 2016; Nyurenberger, Luchina, Sewruikov, & Tikhomirova, 2019). According to them, despite the many frameworks on which the AR apps are developed, they still cannot be used on all operating systems. Ocampo and Palaoag (2019) affirms that the majority of AR applications are designed for iOS platforms and Apple mobile devices because of the ability of these devices to operate AR applications without the need for extra hardware requirements. Therefore, this limits tourists who have devices that run on other platforms like Android, to effectively make use of these applications. Another challenge most researchers agree on is the difficulty to connect their AR apps to cost-effective internet services. For instance Guttentag (2010) & Martínez, Skournetou, Hyppölä, Laukkanen, and Heikkilä (2014) identify lack of internet connectivity as the fundamental issue that poses a major challenge to tourists, given that it is often expensive for tourists to run their apps on roaming data. Ocampo and Palaoag (2019) throw more light on this point by reiterating that AR uses GPS and internet connection. Based on a study they carried out, using Pokemon Go as the trial application to test for the reliability of AR and GPS, they discovered that there were moments that the locations on the app and the physical location itself differed which is a big problem as it is misleading to the tourists. Similarly, Kounavis et al. (2012) went further to explain that not all cities or areas are completely submerged with Wi-Fi networks that provide free internet connections and so tourists are forced to use the current 3G/4G networks and data roaming which have high charges and quite expensive for tourists. Martínez et al. (2014) & Chatzopoulos, Bermejo, Huang, and Hui (2017) in their study about AR applications used for tourism, noted that another challenge faced by tourists using AR apps is the short battery life span of the devices. According to them, it is caused by the diversity of sensors involved in the applications, taking reference from devices that make use of the marker less AR applications which uses GPS, camera capturing and internet connection which are all energy consuming

components. However, T. H. Jung and tom Dieck (2017), in their findings, they concluded that AR has great possibilities of becoming a prevailing technological tool in tourism in the nearest future due to its functionality, which could be used both for indoor and outdoor purposes. Cai, Richter, and McKenna (2019) posit that tourists' intention to use virtual world stems from positive vibes, entertainment, relaxation, and the emotional attachment that comes with it. This experience is enriching when they share exciting content like images and adventures. Therefore, developers have to augment these applications to be user friendly in order to allow the users attain their goals. As such, future research in this specific area should be centered on the connection of frameworks and toolkits (Kounavis et al., 2012; Ocampo & Palaoag, 2019). Most researchers suggest that an interwoven platform framework needs to be developed to suit developers, service providers and users of these applications so as to achieve the purpose for creation (Akram & Kumar, 2017; Kounavis et al., 2012; Moorhouse & Jung, 2017). Martínez et al. (2014) propose that in order to facilitate the approval and acceptance of AR in tourism, some pertinent design issues need to be tackled by providing answers to the following questions: "Does the system work according to plan and does it deliver the right information to its user?" "Is there a complete exploitation of the AR applications?" "Does the AR application contribute to a better tourist experience?" According to them, if the above questions are duly taken into consideration and well answered by app developers in developing these applications, then the apps will be designed to suit the end users' requirements and thus, it would be fully embraced.

2.3.2 User's Acceptability

According to Chatzopoulos et al. (2017), most AR systems are limited to some particular areas that makes it impossible for any new update to be added by any regular user (tourists) since it requires a great programming skill to be able to navigate the system and make some adjustments. In this light, the users find it difficult accessing information on some of these applications since it lacks up-to-date information about certain destinations. In the research carried out by Ocampo and Palaoag (2019), most respondents comprising of citizens and tourists who use android face challenges of incompatibility since most of the AR applications are built for IOS devices. Therefore, Android users find it difficulty using these applications due to lack of compatibility. Akram and Kumar (2017) reiterates this point by confirming that there is a lack of refinement, learning abilities and this has killed the interest of the general population to adopt this technology as it is seen as a stunt. This poses a great difficulty as its target of reaching the mass market can't be fulfilled. Therefore, the research of Cai et al. (2019) Suggest that application developers should consider future movements in this sector like a movement from a much generalized tourist experience to a more personalized experience by providing tailor-made applications that will allow tourists enjoy these experiences and achieve the desired results.

2.3.3 Data Availability

In a research carried out by Ocampo and Palaoag (2019), they discovered that most of the AR applications that run on mobile devices such as smartphones issue very little information about a

tourist's destination and emphasis is only laid on general information. It was noticed that the required information that could help a tourist better prepare for navigating the desired sight is lacking on the AR app. For instance, cost of transportation, feeding, and accommodation is not updated on the apps which could be very misleading to the tourist. Han et al. (2013) posit that many tourists still prefer the traditional sources of tourism like travel books and other media sources which is causing adoption and acceptance of these application very difficult. Martínez et al. (2014) argue that aspects of information misuse, information overcrowding for marketing purposes and data privacy could also be a hindrance to the full adoption of these applications by tourists. According to them, too much information about shopping destinations is updated in the apps which is of little interest to the tourists and a user can be easily tracked due to the presence of a client-server application that sends signals to third party servers for tracking and analysis. However, some researchers identify content personalization to be a solution) (Buhalis et al., 2019; T. Jung et al., 2015). According to them, developers should tailor these applications according to the specific needs of different tourist groups. For instance, Cai et al. (2019) assert that tourists' reasons for engaging in the use of the virtual world is derived from the amusement, refreshment and leisure that it gives. Therefore, developers should customize the format in which these apps are build-up, so as to facilitate the exploitation of its content by the designated user. Also, as most of the AR applications function only with the help of internet connection, Kounavis et al. (2012) Suggest that creating offline AR mobile application will be a good remedy to allow tourists avoid extra charges on roaming data and provide them with a wonderful experience. According to them, creating an AR app that does not need internet connection in order to function, will be of great use to the tourists since it will help to cut off the charges on roaming data which is quite expensive for the tourists. By analyzing the points gotten from the previous studies, it was noticed that AR applications are of great importance to tourists and this technology stands the chance of gaining full recognition and acceptance in the future, if the developers of these applications will take into consideration the suggestions brought forth.

As earlier mentioned, the knowledge of AR in the other disciplines was brought into this study to help situate the use of AR within the broader ambit of extant literature on AR. From the above discussions, it has been observed that many AR applications in use in tourism are borrowed from other disciplines to improve the touristic experience. For instance, the introduction of autism glass for patients with disabilities to aid them integrate in the society and enjoy a touristic experience like every other normal person (Mayordomo-Martínez et al., 2019). Microsoft Hololens was adapted in tourism as a smart glass to merge information in the virtual world through a translucent object to end users field of view (Cranmer, tom Dieck, & Fountoulaki, 2020). The Google's sky map is already being used for astro-tourism or space travel which is a very fertile field that renders various possibilities of attracting people's interest in the unknown, both the old and the young(Jiwaji, 2016).voice translator is also in use and it is very instrumental for tourism because of its abilities to translate different languages which is very beneficial for tourists (Nyurenberger et al., 2019).Other applications like the HeART app used to view 3D anatomy of the human heart and the Fetch Lunch Rush apps are designed for specific tasks and so it wouldn't be effective for touristic purposes.

CONCLUSION AND RECOMMENDATION FOR FURTHER RESEARCH

3.1: Conclusion

This paper was focused on answering three specific questions;

- ➤ What is AR and what are some existing application fields of AR?
- ➤ Does the existing AR applications for tourism meet tourists' demands?
- ➤ What are some of the challenges tourists face while using these already existing applications and what are the prospects of these AR applications for the tourism industry?

Firstly, several definitions from different researchers are given and the common idea expressed in all of these definitions is that AR applications are an upgraded technology that combines images in the physical world and those of the virtual world, assembled with the help of computers, to make meaning to its end users. A detailed explanation concerning the functionality of these applications in other fields is given, as well as some benefits that these applications provide for these disciplines. In the medical field, it was noticed that these AR applications are very beneficial for trainees and inexperience surgeons because it gives them the possibility to operate on a surgical simulation system. Therefore, they are guided on identifying areas of interest on the human anatomy via virtual images displayed on the screen, which reduces the occurrence of errors in operations in real life (Hsieh, Lee and Nurs, 2018). In the educational sector, it was discovered that instead of using the traditional teaching methods, AR applications are installed in the students' devices, therefore, granting them access to the material in time, which has greatly improved the students' anxiety to learn (Uzunboylu, and Yıldız, 2016). In the marketing field, it was observed that AR applications help save time and provide readily available information and displays 3D product images in different colours, shapes and sizes that facilitate consumers' in making their choices (Pantano, Rese & Baier, 2017). Applications like Ms Hololens, Google sky map, Google Glass and voice translator, used in other domains were identified as also applicable for tourism based on the fact that they also display content via the help of sensors, tracking devices and HD cameras implanted in them to help guide users choice. Others like the HeART application and the Magic Mirror were considered not applicable because they are designed for specific illustrations such as displaying an extended virtual shelf with items on it that couldn't fit on a physical shelf and viewing a 3D anatomy of the image of the heart.

Secondly, some applications like Tuscany+, Pokemon Go, Urban Sleuth and CityViewAR specifically designed for tourism were discussed. We find that these AR applications are enhanced with different sensors such as integrated GPS, compasses and cameras for tracking and registering of three dimensional objects (T. Jung et al., 2015). The presence of this components on the mobile devices makes it easy for tourists to get acquainted with unfamiliar destinations by using the applications in a very interactive and relaxing manner. Again, the fact that these applications are designed with the possibility of carrying on translations is also of great benefit to the tourists.

Thirdly, this paper reveals a couple of challenges that tourists face while using AR applications amongst which are a lack of a universal AR app for all destinations as there exists many different AR applications for different destinations (Nyurenberger et al., 2019). Another challenge identified is the inability of AR apps to interact with other devices across different mobile platforms as most of the AR applications are designed for iOS platforms and Apple mobile devices, therefore posing a problem to users who have devices that run on android systems from fully utilizing these applications (Ocampo & Palaoag, 2019). Internet connection is another challenge that is discussed in the paper as most of these applications need internet to function and considering that not all areas are fully covered with WI-FI connection, tourists will have to spend on roaming data which is quite expensive. Inadequate information is another challenge addressed in this paper. It was discovered that most of the apps that run on mobile devices such as smartphones issue very little information about a destination and most of the information on the apps are not updated like cost of transportation. This poses a serious problem to a tourist visiting an area especially for the first time (Ocampo & Palaoag, 2019). However, the following propositions were made for the technoloy to be fully accepted and exploited in the future. Being a technology which is fast advancing, the suggestion that an interwoven platform framework should be developed to suit developers, service providers and users of these applications so as to achieve the purpose for creation (Cai et al., 2019). Another suggestion that is discussed is that of creating offline AR applications so as to help tourists to cut the extra charges spent on roaming data (Kounavis et al., 2012). Creating a customized AR application instead of a generalized one is another point raised (Cai et al., 2019). This will help secure the data and information of the tourists who like to keep their information on their adventures private. From the above discussed topics, there is evidence that AR technology is a very promising tool for expanding the tourism industry, if all the aforementioned challenges are well handled by the app developers and service providers.

3.2: Recommendations for Future research

This study has numerous limitations and recommendations for further studies. Firstly, it was noticed that most of the papers that were reviewed used mostly quantitative methods and done just for particular regions without the opening to generalize the findings. In order to test the authenticity of the results, it is recommended to use an additional qualitative approach to generate data that will be used to confirm the results gotten from past research. Some tourists who use these AR applications could be interviewed to get firsthand information about their perceptions and experiences with these applications. Application developers could also be interviewed to get their experiences on the difficulties they face while designing a software that links different platforms to enable all users to have access to these applications. These interviews could be carried out by means of using well-structured questions aimed at addressing all aspects of the application's functionality, so as to get every detailed information about these applications.

Secondly, there was a limited amount of information about the specific AR applications in tourism reviewed in this study. Therefore, it is recommended that one or two of these applications could be

focused on in future research, to have an in-depth knowledge about the functionality of the specific AR application and the possibility of adapting its features or attributes to be used in other cities or countries since most of the applications were designed to serve particular cities. Applications like the Ms Hololens and Google Glass which are mobile wearable devices could be customized to limit the rate of updating data on the cloud which intrudes into users' privacy. Also, applications like the Fetch Lunch Rush which is designed to help students build up basic statistical skills by finding and providing answers to statistical problems, could be tailored like a treasure hunting application for different locations so as to enable tourists to pick up interest in knowing about different places by participating on the treasure hunt. This will boost the touristic experience.

Thirdly, it was observed that most of the articles used, still made mention of 3G networks which suggests the use of a less effective network. Therefore, it is recommended that researchers should carryout extensive studies on these applications used for tourism and focus more on the current 4G and 5G networks.

Furthermore, it was discovered that little or nothing was mentioned about tourists with disabilities. Therefore, it is recommended that tourists with special needs should be taken into consideration when developing some of these applications so as not to exclude anyone from having a feel of these experience. Applications with special effects could be designed to help them fit in, so that patients with a difficulty in hearing, seeing and talking could easily interact with the application and have the same feeling like any normal person with all senses intact.

Again, another issue that was realized was that of lack of implementation of AR systems especially in healthcare due to its heavy cost. Hence, NGOs and government bodies in charge of health care services could work in collaboration with medical facilities who carry on most of these demanding procedures that are vital for life, in implementing these applications so as to firstly reduce the high cost and secondly, to enhance the treatment offered to patient and also educate and encourage the older generations on the benefits of using these applications.

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