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Timothy Jung M. Claudia tom Dieck *Editors*

Augmented Reality and Virtual Reality

Empowering Human, Place and Business



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Empowering Human, Place and Business



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ISSN 2196-8705 ISSN 2196-8713 (electronic) Progress in IS ISBN 978-3-319-64026-6 ISBN 978-3-319-64027-3 (eBook) DOI 10.1007/978-3-319-64027-3

Library of Congress Control Number: 2017947444

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Preface

Organised by the Creative Augmented and Virtual Reality Hub at Manchester Metropolitan University, the 3rd International Conference on Augmented and Virtual Reality took place on the 23rd of February 2017 and brought together leading researchers and industry professionals from the area of augmented reality (AR) and virtual reality (VR). The conference theme of "Empowering human, place and business" invited speakers from various disciplines to share their experiences of these new and exciting technologies.

Paper presented focused on the areas of AR and VR in tourism, business, marketing & storytelling, health & defence, retail & fashion and design & development. We hope that this edited book will serve as a valuable source for future research and inform businesses about latest developments in the areas of AR and VR.

Manchester, UK

Dr. Timothy Jung Dr. M. Claudia tom Dieck

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Part I Augmented and Virtual Reality in Tourism

Identifying Tourist Requirements for Mobile AR Tourism Applications in Urban Heritage Tourism

Dai-In Han and Timothy Jung

Abstract While research for the employment of information and communication technology in urban tourism settings has been conducted for many years, studies to apply Augmented Reality (AR) to enhance the tourist experience have emerged in recent years. This paper aims to investigate tourist requirements for the development of mobile AR tourism applications in the urban heritage tourism context. Qualitative research incorporating two research stages were conducted in Dublin. The first stage included 26 pre-experience interviews with international tourists to explore tourist requirements, while the second stage was conducted in form of 5 focus groups including a total of 49 participants. The data was analysed through thematic analysis to compare and contrast research outcomes. The findings suggest that tourists would consider using mobile AR tourism applications, if meaningfully designed. Therefore, the user interface should be designed intuitively, while content was regarded the dominant factor for tourism purposes. The study outlines tourist requirements for mobile AR tourism applications, contrasting them to themes in mobile computing identified in preceding studies to confirm previously identified requirements and explore newly emerging elements and tourist perceptions that have developed in alignment with modern technology. Limitations and recommendations for further research are provided.

Keywords Mobile augmented reality \cdot Urban heritage tourism \cdot Tourist requirements \cdot Dublin

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[©] Springer International Publishing AG 2018 T. Jung and M.C. tom Dieck (eds.), *Augmented Reality and Virtual Reality*, Progress in IS, DOI 10.1007/978-3-319-64027-3_1

1 Introduction

As short trips to urban destinations have been increasing in popularity (Gospodini 2004), maintaining the inflow of tourists especially for heritage sites has become a challenge for a number of destinations. In alignment with technological developments, the implementation of ICTs in the tourism industry was argued to support the sustainability of urban heritage sites and increase their competitiveness in the global market. As a result, it is crucial to investigate how modern technology can be implemented meaningfully to enhance the tourist experience. Augmented Reality (AR) has become an area of interest for tourism, as it is able to overlay digital information in the immediate environment. This makes it an ideal tool to provide information in unknown locations if it can be developed meaningfully. Although research and public interest in AR for wearable devices has increased significantly (Siluk 2015), it is crucial to clearly understand requirements for current mobile AR-ready handsets before investigating forthcoming technology. While a number of studies to implement AR in tourism have been conducted, initial research has largely focused on functionalities (Fritz et al. 2005; Reitmayr and Schmalstieg 2003), while recent studies are shifting towards enhancing the tourist experience (Jung et al. 2015; Leue et al. 2015). Nonetheless, studies exploring requirements of AR applications from a tourist perspective are still limited. Therefore, this study will investigate tourist requirements for mobile AR tourism applications in the context of urban heritage tourism to design beneficial applications for tourists and encourage repeated use.

2 Definition of Augmented Reality

Augmented Reality (AR) has been researched and implemented in various industries such as gaming and retail and has gained increasing interest in the tourism industry in recent years (Nicas 2016). While many attempts have been made to provide a common definition, it was argued that AR is still regarded a developing technology, and therefore has not yet reached its full potential. As a result, the definition of AR has undergone a number of modifications depending on the context or method of implementation (Van Krevelen and Poelman 2010). Nonetheless, Stone et al. (2009) formulated base criteria to be included in AR that have been universally accepted. AR should therefore include a conjunction between the virtual and real environment, be able to interact with the immediate surrounding and register and connect real and virtual objects. Building on this concept, Rouse (2015) defined AR as the integration of digital information with live video on the user's environment in real time. Tourism has long been argued to be one of the logical adaptors of AR due to its ability to share and exchange location-based information in the immediate surrounding (Pang et al. 2006). Klubnikin (2016) in addition claimed that tourism applications were already the 7th most downloaded type of mobile apps, which could greatly facilitate the early adoption of AR-type applications in this industry.

3 AR Applications in Urban Heritage Tourism

Early studies of AR in tourism have largely focused on the functionalities and technical aspects, such as GPS-based AR technology to overlay information in the tourists' immediate environment (Feiner et al. 1997; Rekimoto 1997). Some of the implemented examples of AR in the tourism industry include the 'GUIDE' project by Grossmann et al. (2001) as well as developments by Davies et al. (2005), both of which are mobile AR systems providing location-based information. Since then, a number of researchers argued that AR was able to greatly benefit the tourism industry if it was meaningfully implemented (Hariharan et al. 2005). Subsequent studies attempted to expand on this idea by not only providing location-based information, but developing an application that could serve as a computerised tourist guide which tourists could interact with (Höllerer and Feiner 2004; Pang et al. 2006). In the urban heritage context, AR was seen as a potential tool to overcome the physical boundary of heritage attractions. Since AR is using the digital space to provide additional value, it was argued to support the sustainability of heritage sites. Pang et al. (2006) developed a case of an urban tourist guide application in Vienna, which was able to guide tourists to points of interest (POI) using GPS coordinates. Pang et al. (2006) expanded on the original idea of GPS-based AR, but included social functionalities that enabled the user to generate and share information with peers. In recent years, a number of studies have been conducted exploring the enhancement of the tourist experience using AR through handheld as well as wearable devices (Chung et al. 2015; Jung et al. 2015; Leue et al. 2015). Particularly in the urban heritage environment, AR has been studied to enhance the museum experience by reinterpreting the tourist product (Damala et al. 2008). In this regard, a number of studies have been conducted to examine the acceptance of tourists using handheld as well as wearable devices in the urban heritage context (Jung and Leue 2015). It was found that tourists generally had a positive response on the use of AR for the enhancement of the urban heritage tourism experience. Challenges were noted for AR applications in the outdoor environment, such as in the application 'Paris, Then and Now', in which tourists are able to 'time-travel' and experience sights of Paris how it used to be 100 years ago, for 2000 spots around the city. Uncontrollable external factors, such as changing weather conditions and people in the immediate surrounding would provide issues in the interaction. Fritz et al. (2005) argued that the tourism industry required continuous development and implementation of technology in order to attract visitors and stay competitive in the global market. However, regarding mobile AR applications, it was pointed out that AR systems still required improvement to create meaningful tourist experiences (Lee et al. 2015; tom Dieck and Jung 2015). Nonetheless, as mobile technology is being developed rapidly, it is crucial to understand tourist requirements in order to utilise functionalities such as AR in a meaningful way to encourage repeated use.

4 User Requirements in Mobile Computing

Since identification of requirements for AR applications in the literature was limited, the mobile computing context was regarded to provide the closest indication of requirements that could be aligned with mobile AR applications. The requirements created a knowledge base for the design of interview questions and were contrasted to primary research outcomes. This could determine which requirements were still valid and identify emerging requirements for mobile AR applications in the urban heritage tourism context. 'Simplicity' referring to the user interface (UI) was repeatedly noted in the literature as a key requirement (Dantas et al. 2009; Gebauer et al. 2010; Gafni 2008; Karahasanović et al. 2009; Ngai and Gunasekaran 2007; Pulli et al. 2007). It was argued that the UI should be easy to navigate and understandable for anyone. Required information should be promptly accessible and relevant to the user (Delagi 2010; Dinh et al. 2013; Herskovic et al. 2011; Kenteris et al. 2009; Wang and Liao 2007).

Therefore, content should be 'context-aware' to provide relevant information instantly (Dantas et al. 2009; Delagi 2010; Dinh et al. 2013; Gebauer et al. 2010; Herskovic et al. 2011; Karahasanović et al. 2009). This would avoid the overload of information, as large amounts of irrelevant content was believed to result in a slow down of the software (Delagi 2010; Dinh et al. 2013; Gafni 2008; Gebauer et al. 2010; Kenteris et al. 2009; Pulli et al. 2007; Wang and Liao 2007). In contrast, 'personalised content' was largely expected of mobile applications to access information efficiently (An et al. 2008; Gafni 2008; Herskovic et al. 2011; Karahasanović et al. 2009; Kenteris et al. 2009; Swallows et al. 2007; Wang and Liao 2007). Future applications should be accessible regardless of time and place, as users were increasingly mobile (Delagi 2010; Dinh et al. 2013; Gebauer et al. 2010; Herskovic et al. 2011; Kenteris et al. 2009; Wang and Liao 2007). 'Privacy' was furthermore regarded as a key requirement that would continue to be relevant for future applications (Dantas et al. 2009; Delagi 2010; Dinh et al. 2013; Gafni 2008; Herskovic et al. 2011; Karahasanović et al. 2009). 'Social functions' were revealed to be increasingly significant, as a large number of users were using social platforms such as Facebook and Twitter on a daily basis (An et al. 2008; Herskovic et al. 2011; Karahasanović et al. 2009). A number of studies additionally outlined reliability issues of mobile applications, which were largely performance-based, but could also be determined by the provision of reliable and trustworthy information (Dantas et al. 2009; Dinh et al. 2013; Herskovic et al. 2011; Kenteris et al. 2009; Wang and Liao 2007). Table 1 shows the identified user requirements in the mobile computing context.

Requirement	Authors
Simplicity	Dantas et al. (2009), Gafni (2008), Gebauer et al. (2010), Karahasanović et al. (2009), Ngai and Gunasekaran (2007), Pulli et al. (2007)
Relevant and updated information	Delagi (2010), Dinh et al. (2013), Gafni (2008), Herskovic et al. (2011), Kenteris et al. (2009), Wang and Liao (2007)
Speed	Delagi (2010), Dinh et al. (2013), Gafni (2008), Gebauer et al. (2010), Kenteris et al. (2009), Pulli et al. (2007), Wang and Liao (2007)
Safety and security (Privacy)	Dantas et al. (2009), Delagi (2010), Dinh et al. (2013), Gafni (2008), Karahasanović et al. (2009)
Accessibility	Delagi (2010), Dinh et al. (2013), Gebauer et al. (2010), Herskovic et al. (2011), Kenteris et al. (2009), Wang and Liao (2007)
Social functions	An et al. (2008), Herskovic et al. (2011), Karahasanović et al. (2009)
Personalisation	An et al. (2008), Gafni (2008), Karahasanović et al. (2009), Kenteris et al. (2009), Herskovic et al. (2011), Swallows et al. (2007), Wang and Liao (2007)
Power efficiency	Delagi (2010), Kenteris et al. (2009)
Context-awareness	Dantas et al. (2009), Delagi (2010), Dinh et al. (2013), Gebauer et al. (2010), Herskovic et al. (2011), Karahasanović et al. (2009)
Reliability	Dantas et al. (2009), Dinh et al. 2013, Herskovic et al. (2011), Kenteris et al. (2009), Wang and Liao (2007)

Table 1 User Requirements in the Mobile Computing Context

5 Methods

For the purpose of this study, Dublin was selected as research site representing an urban heritage tourism context. To identify tourist requirements, two separate qualitative research were conducted. The initial interviews were regarded as 'pre-AR experience study', while the second qualitative research was seen as 'post-AR experience study'. Due to the limited research in this context at the time of study, an inductive research method was considered suitable for this research. According to Creswell (2007), qualitative data collection is the preferred research method to explore unknown areas. The research population was selected as international tourists visiting Dublin. Therefore, it was aimed to incorporate the main market segments according to the 2010 Annual Report of Failté Ireland in the sample, including tourists from France, Germany, Spain, USA and the UK. The first research stage was conducted in two separate interview sessions including tourists from Ireland (n = 4), UK (n = 8), USA (n = 3), Germany (n = 4), France (n = 3)and Spain (n = 2) through a convenience sampling method. The research was conducted in two city center hotels in Dublin. The majority of research participants were female, while most interviewees were students and young professionals the age group of 22-30. As participants had limited knowledge of AR at the time of study, three AR application samples were provided including text, image and video overlays as well as a GPS-based AR application sample. Nonetheless, it was crucial that participants had absolute freedom to answer the interview questions to their own discretion, as the aim of the first research phase was the initial identification of tourist requirements. All interviews were digitally recorded for transcribing and analysing purposes. Two pilot interviews were conducted prior to the data collection to assess the clarity and expected responses of interview questions. A total of 26 tourist interviews were conducted in February and April 2013, with interviews ranging from 15.30 min to 48.19 min. The first research stage was designed in form of semi-structured interviews to identify tourist requirements and contrast them to user requirements identified in the literature of mobile computing to investigate whether newly emerging requirements were evident for mobile AR tourism applications in the urban heritage tourism context. Additionally, it aimed to establish an understanding of tourists' user behavior of mobile tourism applications.

A second qualitative research was conducted in form of focus groups, as suggested by Adami (2005) and Halcomb and Andrew (2005). For the purpose of data completeness and trustworthiness of findings, it was suggested that conducting focus groups in addition to interviews was more inclusive compared to using the same data collection method for a second study (Lambert and Loiselle 2008; Plack 2006). After the initial investigation of tourist requirements, a mobile AR application demonstrator was developed based on the requirements identified in the tourist interviews. This allowed the investigation of tourist requirements in focus groups after experiencing a potential mobile AR tourism application in the urban heritage tourism context. A total of five focus groups were conducted with nine to ten participants per group from November 4-6, 2013. The semi-structured focus group questions were designed to encourage discussion among participants with regards to the mobile AR tourism application demonstrator and for the identification of tourist requirements after the experience. Tourists from the young British market were selected as the target population for the focus groups, as a target market for mobile AR tourism applications was still largely undefined and dependent on the context of implementation (Bulearca and Tamarjan 2010). The young market was considered suitable for the study purpose, as they were generally believed to have a high exposure to modern technology. Furthermore, as the aim was the investigation of tourist requirements, it was crucial that participants did not have to go through a learning process on how to interact with the mobile application, but could instead focus on application requirements. In addition, Bulearca and Tamarjan (2010) argued that consumers between 18 to 30 years would be the first market to be targeted by AR applications. As a result, most focus group participants were from the population of the British young market and between 21 to 29 years old. Two application demonstrators were prepared. One was based on story-telling image enhancements inside of the General Post Office (GPO) in Dublin, while another was prepared outdoors using GPS-based AR to project information on the immediate surrounding. Participants were equipped with three mobile devices and given fifteen minutes to experience both applications before the focus groups were conducted. All focus groups were digitally recorded and lasted an average of 25 min. The interview and focus group data was analysed using thematic analysis, which was argued to be one of the most commonly utilised analysis methods of qualitative studies (Boyatzis, 1998). After identifying themes from the literature, they were compared and contrasted to the requirements from the initial tourist interviews to provide an updated list of themes, which was used to develop the mobile AR application demonstrator. In the subsequent 'post-AR experience study', themes were confirmed and modified after tourists experienced the demonstrator and analysed by contrasting them to requirements identified in the tourist interviews.

6 Findings and Discussion

The semi-structured interviews and focus groups were designed to identify tourist requirements for mobile AR tourism applications in the context of urban heritage tourism. The following will discuss themes that emerged as tourist requirements from the interviews and focus groups by contrasting them to the literature. Overall, a large number of user requirements that were identified in the literature in the context of mobile computing were still significant for today's mobile applications. As a majority of them was applicable for mobile devices in general and not context specific, they reoccurred in the primary research of this study.

6.1 Simplicity

In the tourist interviews, it was found that designing a simple user interface in mobile AR tourism applications was crucial, as a large number of consumers had never been in touch with AR functions. To encourage fast adoption, it was revealed that a 'step by step' guide could be useful that would guide the tourist through the initial interaction with the application. However, it was pointed out that interaction with future mobile applications required to be increasingly natural to reduce the need for a learning process. While 'Ease of use' was largely discussed in the literature as a crucial theme (Choi and Lee 2012; Dantas et al. 2009; Gafni 2008; Gebauer et al. 2010; Pulli et al. 2007), tourist interviews as well as focus groups showed that 'simplicity' and 'ease of use' were largely expected in mobile applications. The focus group findings further revealed a shift in the wording of 'simplicity' to 'intuitive', arguing that natural interaction was key in future mobile applications. Schinke et al. (2010) recommended in this regard that intuitive design would facilitate the rapid adoption by users. Choi and Lee (2012) similarly argued that applications that did not require a learning process would encourage repeated use. This could specifically be achieved for mobile AR applications, as they were based on currently used handheld mobile devices. Similar adoption rates are expected after a wide adoption of wearable computing, as consumers would already be familiar with utilising such devices on a daily basis. Morrison et al. (2011) further revealed that using mobile AR applications had to be non-disturbing for the user as well as for people in close vicinity, which was confirmed in the tourist interviews. It was found that using AR to project information in the immediate surrounding disclosed practical issues that will be further discussed in 'Privacy and Security'.

6.2 Information Filter

'Personalisation' was previously identified as a crucial user requirement in mobile computing (Huang and Bian 2009; Xu et al. 2008) and confirmed in the tourist interviews as well as focus groups, as participants argued that tourists were not all interested in the same content. In order to avoid information overload and provide relevant information for the user, being able to filter and tailor the information according to the tourist's needs was regarded crucial. Limiting augmented information was previously revealed to have been discussed in motor vehicles, as it was debated how much information would be suitable for drivers to avoid distraction (van Krevelen and Poelman 2010). Alternatively, Marimon et al. (2010) proposed a user interface that would project additional information on request, while keeping the initial content to a minimum. With regards to content type, focus group participants argued that one of the most important content to provide in mobile AR tourism applications in the urban environment was information on public transportation. While current tourism applications are able to offer this type of information, it was not yet mentioned in the literature. However, it can be seen that public transportation is increasingly important, as current map-based applications are able to include information on public transportation options to reach certain POIs. However, it needs to be acknowledged that focus group participants were from the British young market. Therefore, the need for information on public transportation might have been more dominant compared to other market segments that would have more disposable income available on their travels.

6.3 Social Function

A social aspect was regarded an increasingly expected feature in mobile applications. Not only for tourism applications, but also for gaming, social elements are believed to encourage repeated use and enjoyment while using mobile applications. Roberts (2013) therefore suggested linking tourism applications to established social media platforms that would enable users to share and comment on peer-generated content, which was confirmed in the tourist interviews. It was argued that tourists were using social platforms such as Facebook and Twitter on a daily basis, and therefore being able to access them through the tourist application would greatly enhance convenience and encourage its use. In contrast to the findings from the literature (Dantas et al. 2009; Gafni 2008), primary research particularly from focus groups revealed that privacy concerns in this regard were not considered a key requirement anymore. Focus groups participants argued that using social media to share content had gotten people used to publicise private information. Furthermore, it was revealed that sharing and seeing peer-generated content would be beneficial for potential visitors that were looking for first-hand information, which could also encourage positive word-of-mouth for the tourist attraction and destination. The interviews findings revealed that reviews and ratings by other tourists were highly valued before visiting a destination, confirming literature outcomes (Johnson et al. 2012). Gretzel and Yoo (2008) investigated the impact of reviews and ratings on the buying decision and suggested that it would greatly facilitate the decision making process of tourists, particularly for single travelers and women. While interview participants argued that their own research was equally important, many interviewees nonetheless suggested including a functionality to review and comment on tourist attractions. Similarly, Johnson et al. (2012) argued that users were often influenced by peer reviews not only for tourism products, but also for tangible products. Therefore, Gretzel and Yoo (2008) recommended including such functionalities in mobile tourism applications in order to encourage user engagement with the application.

6.4 Privacy and Security

'Privacy' has long been argued to remain a key requirement in the literature (Dantas et al. 2009; Delagi 2010; Dinh et al. 2013; Herskovic et al. 2011; Karahasanović et al. 2009; Mallat et al. 2009). However, tourist interview and focus group outcomes showed contradicting findings. The majority of participants in the interviews and focus groups argued that secure systems and procedures were established by companies and trustworthy. Therefore, tourists generally did not have any concerns regarding data privacy. While privacy was still argued to be important, it was not considered a key requirement for mobile AR tourism applications. Nonetheless, tourists argued that for the purpose of mobile transactions, privacy was seen to be necessary for secure payments. While studies conducted a few years ago still regarded privacy as a key requirement (Zoellner et al. 2009), online information transparency and peer-generated content has since been widely adopted. However, with the development of wearable technology, privacy issues seemed to be at the forefront of discussion once more (Mallat et al. 2009). Therefore, Carmigniani et al. (2011) suggested designing AR interactions in a way that would not violate other people's privacy in the immediate surrounding. While privacy concerns seemed to be decreasing, mobile AR applications on handheld devices posed a practicality issue during the interaction. After focus group participants experienced the mobile AR tourism application demonstrator, it was pointed out that a key concern was 'security' while using the mobile device outdoors in uncontrolled environments. The impracticality of pointing the device camera at certain POIs for an extended period of time to access information was believed to induce risks of theft. As an alternative solution, focus group participants suggested designing the application in a way that would allow storing of information without having to continue holding the device at a designated angle.

6.5 Navigation

With regards to in-app navigation systems, tourist interview and focus group outcomes suggested a map-based navigation system similar to Google Maps. As tourists were familiar with using Google Maps (Shi et al. 2010), it was argued that navigation in unknown environments was a key requirement for tourism applications. While applications such as TripAdvisor that would provide reviews and ratings of tourist attractions were optional, tourist interviewees revealed that maps were among the mostly used applications for tourists, as people were constantly requiring way-finding assistance to POIs. In this regard, focus group participants claimed that a map-based functionality was an expected requirement for any future tourism applications involving new technology such as AR. The benefit of map-based applications was revealed to be the possibility to pinpoint the user's location and provide clear way-finding instructions. However, similar to literature findings (Gafni 2008), tourists argued that information on such map-based applications should be personalised and provide an information filtering option to avoid information overload while being guided.

6.6 Language

Interview and focus group participants were increasingly concerned about the convenience for international tourists. Therefore, including language functionalities in future mobile applications were regarded a key benefit for a large number of tourists. These could be developed in form of translating functions to instantly translate signs, words and phrases, or through offering the application in various languages. Focus group participants argued that international travel was becoming more affordable. As a result, future applications should be usable for a wider demographic market. While language options were mentioned in the literature before (Gannes 2013; Marimon et al. 2010; Schinke et al. 2010), they were not discussed to a great extent. However, primary research outcomes revealed that there is an increasing need to investigate the implementation of multiple language options in future mobile tourism applications. In this regard, tourist interviewees suggested a translating option as the most convenient language function for international tourists, as it would not require downloading or carrying a separate dictionary. Instead, phrases and words could be tailored to a specific tourism context or

interest. Applications such as 'Word Lens' that can instantly translate languages were being developed for Google Glass (Gannes 2013). However, such functions are still limited and require further investigation to be meaningfully adopted in daily life. Nonetheless, it could revolutionise the way people interact with their surroundings, particularly for tourism purposes.

6.7 Information Quality

Literature findings as well as primary research outcomes revealed that content was the most influential and benefitting element in mobile tourism applications (Damala et al. 2008). Mobile AR tourism applications have been developed in various contexts that supported this view. Bruns et al. (2007) developed a mobile AR application in the museum context that would provide an interactive experience through the use of multimedia, while Huang et al. (2009) suggested a mobile AR application that would enable the virtual reconstruction of heritage sites in outdoor environments to provide an enhanced view of the past for the user. Zoellner et al. (2009) claimed that for such applications in the urban heritage context, it was crucial that the provided information was scientifically accurate in order to be beneficial for tourists. Van Krevelen and Poelman (2010) agreed, saying that the quality and accessibility of information was the key determinant for the success of mobile AR applications. Olsson and Salo (2011) further added that content should be personalised and relevant for the user, while assuring a smooth interactive experience. Morrison et al. (2011) similarly stated that future AR applications needed to be developed in alignment to each specific context to be beneficial for users. This would further facilitate the projection of information relevant to the user (van Krevelen and Poelman 2010). While content was considered key in the literature and by research participants, tourists noted that regularly maintaining the application to assure a smooth user experience was crucial to encourage regular use by tourists. This was particularly applicable for updating accessible content to project latest changes in the environment. Application maintenance was claimed to highly influence the user's perception of the application and a lack of it could be detrimental for the adoption of new applications (Gafni 2008). It was revealed that the importance of AR as functionality in mobile tourism applications was secondary to its content, and therefore regarded merely a tool that would serve as content communicator in the application. Therefore, content quality was confirmed to be the crucial determinant for mobile AR tourism applications. Nonetheless, it was pointed out that a suitable balance between content and function was necessary to provide a memorable user experience. Increasing the amount of available content was argued to pose a risk of exponentially increasing the size of the application. Therefore, to avoid long downloading times of the application, Internet access was revealed to be crucial.

6.8 Accessibility

The instant access of information has become increasingly important, as consumers have become more mobile, and therefore require information to be accessible independent of time and space (Dinh et al. 2013). However, tourist interview and focus groups participants claimed that Wi-Fi access in urban destinations was still too limited to be accessed anywhere at the tourists' convenience. While urban heritage destinations such as Dublin provide a free Wi-Fi service accessible for tourists, it was argued that such would provide limited speeds and access points, and therefore could not be utilised meaningfully. Instead, some tourists revealed to buy roaming packages before the trip that would grant access to the Internet at their convenience. Focus group participants agreed claiming that limited Internet access was a major issue for the young tourist market, as instant access of information was frequently required during a trip. Tourist interview participants therefore suggested providing an offline option in tourism applications that would not depend on the Internet to access content. However, Papagiannakis et al. (2008) pointed out that an offline application design would ultimately increase the size of the application depending on the amount of available content. Furthermore, Munch (2010) argued that such options would increase the loading time and could result in performance issues for the application. Therefore, it was discouraged particularly for tourism applications, as content in tourism applications was regarded a crucial selling point. Additionally, it was emphasised that mobile AR tourism applications required a network connection to instantly provide relevant information. Papagiannakis et al. (2008) further claimed that access to a stable Internet connection was crucial for mobile AR applications, as it would influence the speed of the application. While tourists had a split opinion whether or not to pay for Internet access during their trip, all participants agreed that Internet access was crucial for tourists to instantly search for information. Hill et al. (2010) and Zoellner et al. (2009) therefore claimed that limited Wi-Fi access would result in a negative impact on user adoption of mobile AR applications. Nonetheless, both alternatives would require constant monitoring and updated content to assure a continuous user benefit and enhanced user experience through the application.

7 Conclusions, Limitations and Recommendations

The study was conducted in the context of urban heritage tourism, selecting Dublin as the research site. While wearable devices are increasingly studied and developed for the consumer market recently (Curtis 2015), this study was based on handheld mobile devices that were considered the mobile standard of the time of study. While it can be seen that industry and academics are increasingly shifting to investigate wearable devices for tourism purposes (Leue et al. 2015), it was regarded significant to examine tourist requirements for mobile AR applications based on current

devices before moving to the wearable market. On the one hand, wearable devices were not vet widely implemented, limiting the adoption of potential users, on the other hand, tourist requirements identified in this study were largely of generic nature and therefore regarded transferable to wearable devices respectively. Furthermore, Curtis (2015) claimed that it was still unknown when wearable devices would be widely adopted to provide a platform for AR use cases. However, it was regarded to have high potential in the tourism industry, as wearable AR technology was able to replace the handheld screen, opening more opportunities for the tourism industry (Orland 2015). Adoption of wearable AR would not only depend on the content and interaction with the application as proposed in this study, but are expected to largely depend on social norms respectively, as studies in the area of 'Fashnology' indicate (Chuah et al. 2016; Rauschnabel et al. 2016). Nonetheless, it remains crucial that mobile AR tourism applications are able to enhance the tourist experience in a meaningful way to encourage repeated use. Therefore, the study outcomes are believed to add to the current knowledge of implementing AR in the urban heritage tourism context and valuable for further research in the area of mobile application development for tourism purposes.

The study revealed that 'simplicity', which was regarded a key requirement in the literature for many years, was reworded to 'intuitive interaction'. In comparison, literature studying the Technology Acceptance Model (TAM) describes 'simplicity' as 'perceived ease of use', referring to the human-computer interaction (Davis 1989). According to the study outcomes, mobile AR applications should focus on a UI design that would enable tourists to interact with the application naturally without having to go through a learning process. While the TAM model further outlines the importance of 'perceived usefulness' (Venkatesh et al. 2012), research outcomes revealed in this regard that accessible content should be personalised and user-relevant to facilitate the access to required information and avoid information overload. It was expected that this would also positively influence application speed and performance. In addition, tourists largely expected implementing a social function in mobile AR tourism applications. Similar indications were noted in the TAM literature, suggesting that social and cultural factors influenced user's acceptance of new technology (Lewis et al. 2003). As privacy was not regarded a key requirement any longer, sharing information was generally seen as beneficial for tourism applications. In contrast, security issues were regarded a higher priority due to the impractical interaction with current mobile AR-ready handheld devices. While using AR applications was believed to potentially provide new opportunities such as for navigating purposes, regular maintenance of content was crucial to increase trustworthiness and encourage repeated use of the application. Particularly for new developments of AR applications, reliable and updated content was revealed being a key determinant of quality. Therefore, mobile AR tourism applications required being accessible independent of time and space. This demanded a stable and sufficient Internet access to provide requested information instantly. An Internet dependent mobile AR tourism application was argued to be more beneficial for tourists, despite requiring an active and stable Internet connection, due to the instant provision of information. In addition, it would allow reducing the size of the application, which would positively impact on the speed and user interaction, providing an enhanced tourist experience.

This study has a number of limitations and recommendations for further research. While this research was designed in two stages including a pre- and post-experience study in form of interviews and focus groups, it needs to be acknowledged that both methods are of qualitative nature. Therefore, the study proposes a limitation to generalise its findings. Furthermore, interview participants had limited knowledge of AR at the time of study. Therefore, AR examples were provided to support the understanding of interviewees. Although it was attempted to ensure that participants had as much freedom as possible to answer questions, occasional explanations were required to assist the understanding of AR. Nonetheless, a second research stage was conducted to reduce this limitation. Finally, the limitation in the sample population needs to be acknowledged, as the majority of research participants were female and in the age group of 22–30. A more balanced sample could have provided a modified list of requirements particularly including various age groups.

The research outcomes suggest that tourists are increasingly expecting methods to access information instantly. While this study provides an indication of tourist requirements for mobile AR tourism applications in urban heritage tourism, further research is recommended for the implementation of information and communication technology for the enhancement of the tourist experience. Therefore, it is suggested that demographic segments are explored separately, as tourists are increasingly looking for a tailored tourist experience. Dublin was selected as the study context for this research. However, comparative studies investigating other urban heritage sites would provide an insight into the reliability of findings as well as potentially identify additional requirements. In particular, contrasting urban heritage sites in Europe to Asia could reveal new insights, as cultural differences are expected to influence the way tourists interact with their devices and their surroundings. As studies are increasingly conducted on the adoption and usefulness of wearable AR devices, further studies for user requirements using wearable devices are required. In this regard, it is recommended to investigate not only generic content and function requirements, but in alignment with consumer behavior in a variety of contexts. Although this study was based on handheld mobile devices, a trend towards exploring wearable computing for the consumer market could be observed. While wearable devices have not yet been widely adopted, it is believed that the awareness and adoption of AR will increase significantly with the further development and utilisation of wearable technology.

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How can Tourist Attractions Profit from Augmented Reality?

Eleanor E. Cranmer, M. Claudia tom Dieck and Timothy Jung

Abstract The benefits, value and potential of Augmented Reality (AR) are widely researched. However, the value of AR is most commonly discussed in relation to enhancing the tourist experience, rather than generating revenue or economic returns. Although AR promises to add value to the visitor experience and generate associated benefits, the financial implications and revenue model for AR implementation remain uncertain and therefore too much of a financial risk for most tourist organisations, typically Small to Medium Sized Enterprises (SMEs) characterised by limited funding. Thus, using the case of UNESCO recognised Geevor Tin Mine Museum, in Cornwall, UK, this study identifies ways in which tourism organisations can profit from AR implementation. Fifty semi-structured interviews with Geevor stakeholders, analysed using content analysis reveal a number of ways AR can be introduced to increase revenue generation and profits, therefore filling a gap in research and minimising the risk for managers and practitioners considering AR implementation.

Keywords Augmented reality · Tourism · Revenue model · Business model

1 Introduction

Throughout the 20th Century the emergence of new adaptive and interactive technologies changed the tourism industry completely (Buhalis and Law 2008). Technologies have revolutionised travel behaviours, such as decision making and

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© Springer International Publishing AG 2018

T. Jung and M.C. tom Dieck (eds.), Augmented Reality and Virtual Reality,

Progress in IS, DOI 10.1007/978-3-319-64027-3_2