CONTEXT-AWARE ACCEPTANCE MODEL FOR SMART GLASS BASED AUGMENTED REALITY TOURISM

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UNIVERSITI KEBANGSAAN MALAYSIA

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MODEL PENERIMAAN KONTEKS-KESEDARAN UNTUK APLIKASI AUGMENTASI REALITI PELANCONGAN BUDAYA BERASASKAN KACA MATA

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TESIS YANG DIKEMUKAKAN UNTUK MEMPEROLEHI
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DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged.

06 August 2018

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P80535

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ABSTRAK

Dengan adanya kemajuan terkini dalam teknologi mudah alih dan teknologi boleh pakai, peluang dalam sektor pelancongan digital berada pada tahap tertinggi. Para penyelidik terdahulu telah mengkaji peluang untuk meningkatkan penerimaan dan penggunaan AR dalam kalangan pengguna. Walau bagaimanapun, penyelidikan mengenai penerimaan pengguna terhadap Augmentasi Realiti (AR) dalam konteks pelancongan budaya masih terhad. Penyelidikan AR terkini kurang memberi tumpuan terhadap kajian dan kerja empirikal yang menggabungkan dimensi yang khusus untuk pelancongan warisan budaya dan konteks tertentu kaca mata pintar. Oleh itu, kajian ini mencadangkan model penerimaan AR dalam konteks pelancongan warisan budaya dan kaca mata pintar yang mampu melaksanakan AR luar. Untuk memetakan keperluan dan mengetahui aspek yang mungkin menggalakkan pelancong untuk menggunakan AR, kaedah pensampelan kuota digunakan untuk mengumpul data 24 pelancong dan 4 pakar pembangunan aplikasi AR melalui teknik pemetaan afiniti. Untuk mengumpul maklumat mendalam mengenai dimensi luaran yang dihasilkan dalam kajian ini, 4 kumpulan tumpuan yang terdiri daripada pelancong dan 2 kumpulan tumpuan yang terdiri daripada pakar bagi setiap kumpulan telah ditemu bual. Hasil temu bual mendapati empat aspek utama yang perlu dimasukkan ke dalam penyelidikan berkaitan penerimaan AR adalah termasuk kualiti maklumat (IQ), daya tarikan visual (VA) dan kesediaan teknologi (TR) serta keadaan memudahkan (FC). Oleh itu, kajian ini akan menghasilkan model penerimaan untuk menkonsepsikan factor penting penggunaan AR serta bagaimana pengaruh pelancong terhadap tujuan penggunaan AR dan tujuan lawatan destinasi melalui kepercayaan mereka dan sikap terhadap AR. Kaedah penyelidikan kuantitatif berdasarkan statistik inferensi telah digunakan untuk pengumpulan data. Sampel dari 152 orang yang menggunakan aplikasi prototaip kaca mata pintar AR telah dikumpul di tapak Warisan Dunia UNESCO di Melaka berdasarkan cadangan model penerimaan. Kajian ini menganalisis hipotesis dengan model persamaan struktur (SEM) menggunakan SmartPls 3.0. Keputusan dari analisis menunjukkan bahawa instrumen yang digunakan boleh dipercayai dan menunjukkan kesemua item yang mengukur dimensi adalah berkorelasi. Hasil juga menunjukkan bahawa IQ, VA and TR didapati sebagai peramal tentang pengamatan kebolehgunaan. Di samping itu, IQ, VA dan FC dipengaruhi pengamatan kemudahan penggunaan. Pengamatan kemudahan penggunaan mempengaruhi pengamatan kebolehgunaan. Akhirnya, pengamatan kebolehgunaan dan pengamatan kemudahan pengguna mempengaruhi niat untuk menggunakan AR dan untuk melawat destinasi melalui sikap terhadap AR. Oleh itu, kajian ini membentangkan implikasi teoretikal dan praktikal dalam kajian kaca mata pintar AR, pelancongan pintar terutamanya dalam penggunaan AR.

ABSTRACT

Modern day technologies including wearables devices such as smart glasses have changed the way people interact with their surroundings. Such developments have resulted in increased popularity of augmented reality (AR) applications to project context-aware information on objects or users' immediate surroundings. In order to enhance the overall tourism experience, a number of recent works have highlighted the opportunities of using smartphone based outdoor AR or navigation AR systems. Due to the development of context-aware AR, tourists using such a technology can acquire valuable knowledge and experience. Recent context–aware AR research lack empirical studies and works that integrates dimensions which are specific to cultural heritage tourism and smart glass specific context. Hence, this work proposes an AR acceptance model in the context of cultural heritage tourism and smart glasses capable of performing outdoor augmented reality. To map the requirements and find out the aspects that might be encouraging tourists to actively utilize AR, a purposive quota sampling method is used to collect the data of 24 tourists and 4 AR application development experts through affinity mapping technique. To gather in-depth information about the resultant external dimensions in this research, five focus groups constituting 26 participants and 4 experts were organized. The thematic analysis of the data revealed four main aspects that should be incorporated into AR acceptance research, including information quality (IQ), visual appeal (VA) and technology readiness (TR) as well as facilitating conditions (FC). Thus, this study conceptualizes these crucial factors of AR usage as well as how these influence tourists AR usage intention and destination visit intention through their beliefs and AR attitude, in the form of an acceptance model. Quantitative research methods based on inferential statistics have been employed for data collection conducted. Samples from 152 tourists were collected in a field study conducted at UNESCO World Heritage sites in Malacca. This field study data was used to analyze the hypotheses with structural equation model (SEM) using SmartPls 3.0. Results from the analysis indicated the developed models convergent validity, discriminant validity and model fitness. The result also implied that IQ, VA and TR were found to be predictors of perceived usefulness. In addition, IQ, VA and FC affected perceived ease of use. This study therefore, contributes to the knowledge of three domains; augmented reality, cultural heritage tourism and technology acceptance by identifying specific tourist requirements and acceptance factors.

TABLE OF CONTENTS

			Page
DECLARATION			**iii**
ACKNOWLEDGEMENT			**iv**
ABSTRAK			**v**
ABSTRACT			**vi**
TABLE OF CONTENTS			**vii**
LIST OF TABLES			**x**
LIST OF ILLUSTRATIONS			**xi**
LIST OF ABBREVIATIONS			**xii**
CHAPTER I	**INTRODUCTION**		
1.1	Introduction		1
1.2	Research Background and Related Studies		2
1.3	Problem Statement		5
1.4	Research Questions		7
1.5	Objectives		7
1.6	Scope		8
1.7	Research Methodology		8
1.8	Significance of Study		10
1.9	Organization of Thesis		10
CHAPTER II	**LITERATURE REVIEW**		
2.1	Introduction		13
2.2	Context-Aware Augmented Reality		14
	2.2.1	Context-Awareness (CA)	14
	2.2.2	Augmented Reality (AR)	17
	2.2.3	Context-Awareness as a property of Augmented Reality	21
	2.2.4	Recent Developments in Augmented Reality	23
	2.2.5	Benefits of AR	33
	2.2.6	Challenges of AR	37
	2.2.7	AR in Industrial Settings	40
	2.2.8	Acceptance of AR in Tourism Settings	43
2.3	Cultural Heritage Tourism		46

	2.3.1	Definition of Cultural Tourism	47
	2.3.2	Definition of Heritage Tourism	48
	2.3.3	Towards Cultural Heritage Tourism	50
2.4	Theories and Models of Technology Acceptance		59
	2.4.1	Technology Acceptance Models (TAM)	59
	2.4.2	Technology Readiness Acceptance Model	65
	2.4.3	Augmented Reality Acceptance	69
2.5	Discussion and Problem Formulation		71
	2.5.1	Smart Glass AR Acceptance Challenges in the domain of Tourism	77
2.6	Conclusion		80
CHAPTER III	**METHODOLOGY**		
3.1	Introduction		81
3.2	Research Philosphy		81
3.3	Research Strategy		84
3.4	Research Approach And Design		86
	3.4.1	Inductive and Qualitative Research	86
	3.4.2	Deductive and Quantitative Approach	87
	3.4.3	Mixed Method Approach	88
3.5	User centered design approach		90
3.6	Research methodology		93
	3.6.1	Stage 1 : Model Development	95
	3.6.2	Stage 2 : Model Implementation	102
	3.6.3	Stage 3: Model Evaluation	106
3.7	Conclusion		113
CHAPTER IV	**CONTEXT-AWARE ACCEPTANCE MODEL DEVELOPMENT**		
4.1	Introduction		115
4.2	Findings of the preliminary analysis		115
	4.2.1	Annotation Design	116
	4.2.2	External Dimensions	118
	4.2.3	Perceptions	124
	4.2.4	AR Attitude and behavioral intention	126
4.3	The Research Model		129
4.4	Conclusion		132

CHAPTER V	**CONTEXT-AWARE ACCEPTANCE MODEL IMPLEMENTATION**		
5.1	Introduction		133
5.2	Development Platforms		133
	5.2.1	Smart Glass Hardware	134
	5.2.2	Development Software	135
5.3	Feature Mapping		139
	5.3.1	Requirement analysis	139
	5.3.2	Design Conceptualization	141
	5.3.3	UI Design	141
5.4	Prototype Development		143
5.5	Conclusion		148
CHAPTER VI	**CONTEXT-AWARE ACCEPTANCE MODEL EVALUATION AND VALIDATION**		
6.1	Introduction		149
6.3	Regression Analysis		161
	6.3.1	Measurement Model Analysis	161
CHAPTER VII	**CONCLUSION AND FUTURE WORK**		
7.1	Introduction		178
7.2	Discussion		178
7.3	Contribution Of The Research		186
	7.3.1	Theoretical contribution of the study	186
	7.3.2	Practical contribution of the study	187
7.4	Future Work		188
REFERENCES			**190**
Appendix A	Research Instructions for Focus Group Participants		208
Appendix B	Consent Form for the participation in the Field Study		209
Appendix C	Field Study Questionnaire		210
Appendix D	Screenshot from Smart PLS 3.0		214

LIST OF TABLES

Table No.		Page
2.1	Differences between smart glass AR and smart phone AR.	28
2.2	Five categories of people in relation to their readiness to accept new technologies.	63
2.3	Recent Works	72
3.1	Profile of the participants	91
3.2	Focus group questions	92
3.3	Key findings of the thematic analysis	93
4.1	Initial Theme Identification	106
4.2	Grouping of Themes	106
4.3	Findings of the Design	107
4.4	Key findings of the thematic analysis	121
5.1	Smart Glass Comparison	125
5.2	Feature Mapping Process	131
6.1	Initial Questionnaire	143
6.2	Revised Questionnaire	145
6.3	Respondent Age	147
6.4	Respondent Gender	148
6.5	Respondent Occupation	148
6.6	Respondent Education Background	149
6.7	Respondent Income	150
6.8	Respondent Marital Status	150
6.9	Smart Glass Use	151
6.10	Cronbach Alpha for all the items	152
6.11	Convergent Validity Criteria	153
6.12	Convergent Validity with all the items	153
6.13	Cross Loading with all the items	154
6.14	Convergent Validity after the deletion of items	155
6.15	Results of the Fornell-Larcker Criterion	156
6.16	Discriminant Validity Cross Loading	157
6.17	Discriminant Validity Heterotrait-Monotrait Ratio	158
6.18	Inner VIF Measures	159
6.19	Path Coefficients	160
6.20	Result of Hypothesis	162
6.21	R-Square Values	163
6.22	F-Square Effect Size Values	164
6.23	Mediation Analysis	165
6.24	SRMR Results	166
7.1	Hypothesis Test	174

LIST OF ILLUSTRATIONS

Figure No.		Page
1.1	Research Methodology	9
2.1	Outline of Literature Review	12
2.2	Tourists Arrival 2014-2016	50
2.3	Tourists Arrival 2015-2017	50
2.4	Technology Acceptance Model (TAM)	54
2.5	TRAM Model for AR Tourism	60
3.1	The User-Centred Design lifecycle	81
3.2	Research Process Flowchart	85
3.3	Adopted UCD approach for this research	86
3.4	Stages of Research	86
3.5	Literature Review Method	87
3.6	Affinity diagram	89
3.7	POI designs	89
3.8	Feature Mapping Process	95
3.9	Rapid Application Development Methodology	96
3.10	Sample size calculation with G Power	102
3.11	List of Experimental Tests	104
4.1	Model of acceptance for smart glass based cultural heritage AR applications.	122
5.1	Google Glass Development Kit (GDK) Code	127
5.2	Android Studio IDE	128
5.3	Inclusion of "beyondAR" library	129
5.4	Final Wireframe Design	133
5.5	UI design and flow	134
5.6	System Architecture of AR Module	135
5.7	First applications workflow	138
5.8	Second applications workflow	138
6.1	Steps of Evaluation Process	141
6.2	Result of SEM Analysis	160
6.3	Graphical Representation of Path Coefficients	161
6.4	Graphical Representation of R-Square Values	163
7.1	Research Model	171
7.2	Smart Glass Prototype System Architecture	172

LIST OF ABBREVIATIONS

AR	Augmented Reality
GPS	Geo Positioning System
CPU	Central Processing Unit
DOF	Depth Of Field
RAD	Rapid Application Development
SDK	Software Development Kit
GDK	Glass Development Kit
IDE	Integrated Development Environment
UI	User Interface
API	Application Programming Interface
IQ	Information Quality
VA	Visual Appeal
FC	Facilitating Conditions
UX	User Experience
UNESCO	The United Nations Educational, Scientific And Cultural Organization
POI	Point Of Interest
REST	Representational State Transfer
CR	Composite Reliability
AVE	Average Variance Extracted
HTMT	Heterotrait-Monotrait Ratio
SRMR	Standardized Root Mean Square Residual
TR	Technology Readiness
PU	Perceived Usefulness
ARA/ARATT	AR Attitude
ARU	AR Usage
PEOU	Perceived Ease Of Use
OPT	Optimism
PI	Personal Innovativeness
DV	Destination Visit
PLS	Partial Least Squares

VIF	Variance Inflation Factor
CI	Confidence Interval
HCI	Human Computer Interaction
UCD	User-Centered Design
UKM	University Kebangsaan Malaysia
TRAM	Technology Readiness And Acceptance Model
TAM	Technology Acceptance Model
SEM	Structural Equation Modeling
RIPP	Rapid Iterative Production Prototyping
AVE	Average Variance Extracted

CHAPTER I

INTRODUCTION

1.1 INTRODUCTION

The rise of new communication and information technologies has tremendously influenced how tourists interact with tourist attractions. Modern day technologies including wearables devices such as smart glasses have changed the way people interact with their surroundings. Such developments have resulted in increased popularity of augmented reality (AR) applications to project context-aware information on objects or users' immediate surroundings. In order to enhance the overall tourism experience, a number of recent works have highlighted the opportunities of using outdoor AR or navigation based AR systems. Due to the development of context-aware AR, tourists using such a technology can acquire valuable knowledge and experience without the need of any tourist guide. Hence, a variety of context-aware AR usage examples can be seen in the domain of tourism in general. Without examining the user acceptance and user behaviour, it becomes a difficult task to measure the potential of emerging technologies. Although recent works shed some light on the acceptance of smart phone based AR acceptance in tourism settings however, the investigation of potential factors effecting the user acceptance in the context of smart glasses based AR is limited. Surprisingly, in the recent past the market has not been able to produce many successful applications based on smart glass based AR. Therefore, this study is aimed at investigating the user acceptance factors for smart glass based context-aware in the domain of cultural heritage tourism, through an empirical study based on qualitative and quantitative research techniques. This introductory chapter presents the research background, problem statement, research objectives, research scope, research methodology, significance of the study and organization of the thesis.

1.2 RESEARCH BACKGROUND AND RELATED STUDIES

The rise of wearable devices, increasing availability of geo-referenced and user generated data and high speed networks spurs the need for context-aware applications, which provide the right information at the right moment, and at the right place. AR is one such technology, which allows interweaving digital data into physical spaces and through this aims at providing relevant information on the spot. While for many types of wearable applications context-awareness and adaptation may not be necessary, AR applications on the contrary depends on being adaptive to the physical context in which they are used (Kjeldskov & Graham 2003). At the very least, obtaining spatial information is a key requirement for AR systems. The need for more adaptive content as part of context-aware AR systems has already been recognized (Kooper & MacIntyre 2003; Langlotz et al. 2014). Initially, AR researchers addressed technical challenges in AR, however, in recent years AR research switched focus from basic tracking and rendering algorithms to human-centered issues in consumer and industrial contexts. Given the nature and definition of AR, location has been handled as major context source for AR but there are a multitude of other context factors that have an impact on the interaction with an AR system.

Geo-location (GPS) based applications for information search and gaming such as ‘Foursquare’ and ‘ARGH – Augmented Reality Ghost Hunter’ have slowly introduced AR into the tourism industry accelerating its public awareness through sharing on social media platforms (Crowley and Selvadurai, 2009; Gazzard, 2011). As of 2014, the majority of smart phones provided navigation based on GPS-map based systems, which are able to pinpoint the user’s exact location and therefore are able to provide a platform for AR overlays. AR has increasingly become an area of interest in technological developments not only for the current era of smart phones, but further for the use of wearable computing through largely researched devices such as Google’s Glass and Microsoft’s Hololens (Wrenn, 2012; Siluk, 2015). Augmented Reality Smart Glasses merge the real world with virtual information that is integrated in a user’s field of view (P. Rauschnabel et al. 2015). Several sensors capture physical information and augment them with virtual information that can be gathered from the internet or stored on the smart glasses memory, primarily accomplished through context aware data in the form of location, object, facial, and image-based recognition technologies. This virtual information is then displayed in real-time on a display, which, in brief, is a plastic screen in front of a user's eye(s). A user can see both the offline and the virtual and the real-world through these displays. Smart Glasses, such as Google Glass or Microsoft Hololens, have recently gained increased attention. Broadly speaking, smart glasses are a new wearable augmented reality (AR) device that captures and processes a user's physical environment and augments it with virtual elements (tom Dieck et al. 2016). Recent forecasts predict that smart glasses will substantially influence our media behavior, and market research institutes propose tremendous growth rates. For example, Technavio (2015) predicted growth rates of nearly 200 percent within the next five years, and Jupiter Research (2015) forecasted $53.2 billion retail revenue of smart glasses by 2019. Since smart glasses based AR is its infancy, recent research has identified a number of challenges with the implementation of smart glass based AR for consumer applications (Due 2014). One of the biggest challenge posed by smart glasses is its lack of user requirements knowledge (tom Dieck et al. 2016) and user acceptance and adoption (P. Rauschnabel et al. 2015; Sedarati & Baktash 2017). One of the potential area for smart glass AR to flourish is cultural heritage tourism (P. A. Rauschnabel et al. 2016; tom Dieck et al. 2016).

It was argued that the tourism industry in particular in cultural heritage areas has been facing many challenges due to its increasing competitiveness and efforts for sustainable development (Pantano and Servidio, 2010). Tourists are presented with an increased choice of information due to the development of technology and implementation of such in various sectors to enhance the overall tourist experience. However, it remains a challenge for many tourism businesses in cultural heritage areas to identify technological solutions and successfully implement them into their business strategy. Gretzel et al. (2009) discussed the implementation of information and communication technologies (ICT) for the community and cultural heritage development, while Paskaleva & Azorin (2010) supported the argument that destinations require to make use of the increasing digital environment in order to stay competitive in the global market. Ali and Frew (2014) noted that implementation of ICTs to enhance the tourism product has become a key research area for the sustainable development of destinations. Therefore, they argue that it is crucial for eTourism researchers to investigate how technology can be practically implemented to continuously develop tourism in a sustainable way. Although many cultural heritage destinations are trying to implement new types of technology for tourist attractions, such as mobile applications, they are often neglected by tourists and widely unused due to its limited transferability to other contexts as well as lack of awareness and limited benefit to the tourist. Since AR is able to overlay the physical environment using the digital space, it has long been regarded as potential method to provide easily accessible information for visitors (Noh et al. 2009; Choubassi et al. 2010; Marimon et al. 2010; Jung & tom Dieck 2016). While developing and implementing context-aware AR technology in the tourism domain results in high costs and effort due to unspecified tourist requirements, such applications are left with little benefit for the destination and the tourists. Hence identifying the tourist requirements for successful user acceptance at the cultural heritage destination is seen as a key challenge (Benckendorff et al. 2018; Chung et al. 2015a; Kourouthanassis P. E., Boletsis C., Bardaki C. 2014; tom Dieck & Jung 2015a).

Recent research in the domain of AR has made efforts at developing models of smart phone AR acceptance, revealing that researchers have applied various theoretical models. Among these models, the Technology Acceptance Model (TAM) has been the mostly widely applied to studies of mobile and wearable technology acceptance (F D Davis 1986). TAM is clearly the most accepted reference framework for investigating the formation of the technology acceptance process as it can successfully capture the two most robust acceptance dimensions, perceived usefulness (PU) and perceived ease of use (PEOU). These dimensions are derived from technology characteristics, suggesting that a person will be likely to accept a technology if it is useful and easy to use. However, understanding technology acceptance solely on the basis of these two variables is considered inadequate since it is also important to identify what factors influence a person's attitude to the technology. Rogers and Shoemaker (1971) argued that consumers who have high innovativeness levels adopt a new product earlier than do others. Innovativeness is seen as an indicator or measure of the tendency and willingness to embrace change and try new things (Hirunyawipada & Paswan 2006). Consumers who are highly innovative are expected to demand new products. Technology readiness, in the same vein, specifies the concept of consumer innovativeness in the context of high-tech technology acceptance. It indicates consumers' propensity to embrace and utilize technologies to carry out activities at home and work. In many recent works, the addition of technology readiness to TAM to form a new model called TRAM (J. S. C. Lin & Hsieh 2007) has created an opportunity to better understand how an individual's traits and general beliefs affect attitude toward technology. Past research, such as that of Chiu and Tseng (2010),Lam et al. (2008); Sophonthummapharn & Tesar (2007), Yi et al. (2006), and Lin and Hsieh (2007), has proven this factor's influence in technology acceptance. This, again, suggests that TAM is considered too simple to adequately explain consumer acceptance of technology. TAM is also questioned for its ability to explain technology acceptance in a non-work situation, such as a wearable AR application for cultural heritage tourists. In recent user acceptance literature for context-aware AR in the domain of cultural heritage both TAM (D. I. Han et al. 2017; tom Dieck & Jung 2015b) and TRAM (Chung et al. 2015b) have been implemented to identify the tourist requirement for smart phone AR. These works identify visual appeal, technology readiness, trust, system and information quality, cost, facilitating conditions and enjoyment as the major factors effecting the acceptance of smart phone AR at cultural heritage sites. For smart glass AR, very limited research has explored empirically the tourist requirements at cultural heritage sites. To the best of the researcher's knowledge, this is the first study which explores tourist requirement for outdoor smart glass based cultural heritage AR applications at UNESCO World Heritage sites.

1.3 PROBLEM STATEMENT

Modern day technologies including wearables devices such as smart glasses have changed the way people interact with their surroundings. Such developments have resulted in increased popularity of augmented reality (AR) applications to project context-aware information on objects or users' immediate surroundings. Recent forecasts predict that wearables, especially smart glasses will substantially influence our media behavior, and market research institutes propose tremendous growth rates of nearly 200 percent within the next five years (P. A. Rauschnabel et al. 2015a, 2016). These developments has enabled visitors to fully explore and appreciate cultural heritage sites and has made AR a popular method for enhancing users capability to appreciate the surroundings in real time (Benckendorff et al. 2018; Jovicic 2017; tom Dieck & Jung 2017).

Contrary to expectations, smart glass AR is not being actively used, and, as a new phenomenon, it is appearing more slowly than expected. Even though AR has been argued to hold high potential and usefulness in the tourism environment, use cases of successfully implemented and widely used smart glass AR applications are limited. One of the biggest challenge posed by smart glasses is its lack of user requirements knowledge (tom Dieck et al. 2016) and user acceptance and adoption (P. A. Rauschnabel & Ro 2015a; Sedarati & Baktash 2017). In cultural heritage tourism studies, empirical studies have not yet sufficiently researched why tourists use smart glass AR or how its use will affect visits to tourist destinations. The importance of understanding the user requirements and user acceptance in a context aware environment has been acknowledged in previous augmented reality studies, investigating its determinants and specific tourist requirements (Kourouthanassis P. E., Boletsis C., Bardaki C. 2014; tom Dieck et al. 2016).

TAM is clearly the most accepted reference framework for investigating the formation of the technology acceptance process as it can successfully capture the two most robust adoption dimensions that measures users perceptions; perceived usefulness (PU) and perceived ease of use (PEOU) (Olushola & Abiola 2017). While Dieck & Jung (2015b) have researched tourist acceptance on smart phone AR based on TAM, they found factors such as information quality to have major impact on user acceptance. To overcome the inconsistencies posed by TAM, Chung et al. (2015a) and Jung et al. (2015) also researched tourist acceptance on *smart phone* AR based on an integrated model TRAM emphasizing the importance of visual appeal and technology readiness but ignored the important information quality factor. These authors argued that the investigation of the tourist acceptance based on smart glass AR is very limited and requires further examination in regards to identifying the factors of acceptance and specific tourist requirements. Recent studies on smart glass acceptance in domains other than tourism (P. A. Rauschnabel et al. 2015, 2016) clearly highlights the importance of both; visual appeal/aesthetics and information quality along with other factors to enhance user acceptance. Preliminary studies conducted in this research also highlights the same issues, however, no work is found during the literature study which combines these dimensions together in the form of an acceptance model to measure user acceptance in cultural heritage and smart glass AR specific context. Therefore, to address the obvious gap in the literature, where no specific model exist with these dimensions for smart glass based cultural heritage tourism, this study aims to explore the important external dimensions and factors and create a user acceptance model for smart glass AR in the context of cultural heritage tourism.

1.4 RESEARCH QUESTIONS

Based on research gap presented and the premise set in the above section, this research should answer the following research questions.

- What theories and models can be critically explored to formulate a new acceptance model for smart glasses in the domain of cultural heritage tourism?
- Which important external dimensions can be bring a positive change in the perceptions, attitude and behaviour of the tourists.?
- What tools and methods are used to validate the new smartglass acceptance model?

1.5 OBJECTIVES

The main objective of this research is to identify the cultural heritage tourist's needs and develop a smart glass AR acceptance model for AR. A comprehensive literature review is conducted along a preliminary analysis based on qualitative approaches to identify the tourist requirements. These requirements are then mapped into a form of a smart glass AR acceptance model based on TAM and technology readiness. The developed model is validated by first implementing it in the form a smart glass based AR application prototype and then evaluated by conducting a field study at UNESCO World Heritage Site in Malacca. The specific objectives of this research were:

- To design a context aware technology acceptance model for smart glass based augmented reality cultural heritage applications.
- To develop a context-aware adaptive smart glasses application based on the designed model.
- To validate the model and user acceptance behavior through the developed adaptive augmented reality application.

1.6 SCOPE

The scope of this research involves the design, development and validation of a context-aware smart glasses acceptance model for cultural heritage applications. This research identifies user requirement and factors of user acceptance for cultural heritage tourists. The model is validated at UNESCO World Heritage site in Malacca in an outdoor environmental setting best suited for location based smart glass augmented reality applications. Both, male and female cultural heritage and tourism enthusiasts between the ages of 16 and 56 belonging to different walks of life have participated in the experiments conducted during the research. Common qualitative methods such as affinity mapping and focus group discussions are conducted to generate the user requirement and external dimensions for the proposed acceptance model. Similarly, quantitative methods based on PLS-SEM are used for validation of the acceptance model. The model is implemented on a google glass explorer edition smart glass device. Due to limited resources of the project some restrictions will be applied on the scope of this work. The complete and comprehensive implementation of the model in the form of a commercial multi-platform application cannot be fitted into the scope of this work.

1.7 RESEARCH METHODOLOGY

Research methodology is an essential part to employ the research methods in any study to understand its research issues. Originally called usability engineering (Nielsen, 1993), today the practice, philosophy and methodology of designing usable products is widely referred to as User-Centered Design (UCD). In the context of this study, the research methodology is adopted based on the UCD research methodology. The study involves the collection of both qualitative and quantitative data in a sequential exploratory manner. Therefore, the methodology of this research consists of three main research phases; identification of requirements, design solutions and evaluation. Phase 1 identifies the context of use, research gaps and issues through a thorough literature search and qualitative research experiments. Phase 2 utilizes this knowledge to map the requirements into an acceptance model for smart glasses based AR tourism applications. The model is then implemented into a smart glass AR application called "TouristicAR" which is later used for user evaluation studies. Finally phase 3 evaluates the user perceptions, attitude and behavior and validates the developed smart glasses based AR acceptance model. To better explain the flow of this research, the adopted UCD methodology is also divided into three main stages representing the three phases of the methodology; model development, model implementation and model evaluation (Figure 1.1).

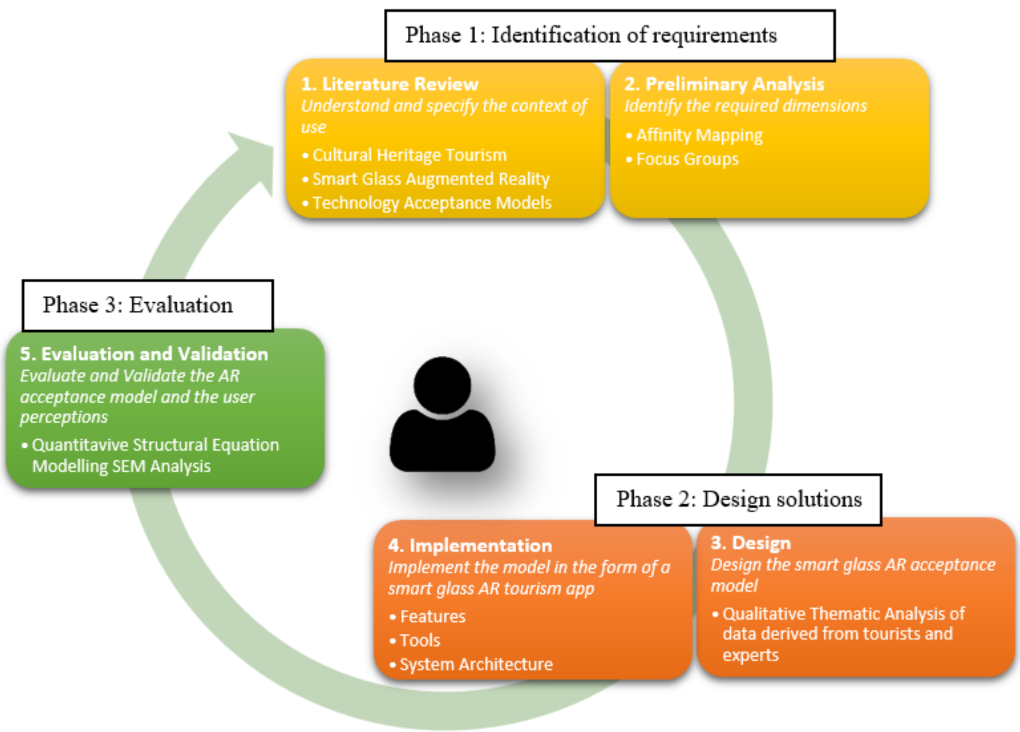

Figure 1.1 Research Methodology

1.8 SIGNIFICANCE OF STUDY

This study aims at exploring issues and identify user requirements in a rapidly growing smart glass market targeted at cultural tourism domain. Hence this study impacts theoretically and practically to the field of smart glass AR, cultural heritage tourism and user acceptance. Firstly, this study is significant to the knowledge body in the field of AR because it addresses the challenges and tourists' requirements related to smart glass AR. Secondly, this study is significant to the cultural heritage domain knowledge as it helps identifying new ways of sustainable tourism through the use of latest information communication technologies. Finally, this study also shows significance to the body of knowledge in the domain of technology acceptance as it helps identifying the external dimensions and their correlation with tourist perceptions, tourist attitude and behavior of the tourists. Professionals, tourism destination managements and smart glass application developers may also find this study significant since along with identifying tourist requirements, it also provides practical guidance on the design knowledge, the functionality selection and the development practices of smart glass AR applications for cultural heritage tourists.

1.9 ORGANIZATION OF THESIS

The current research consists of 7 chapters: 1. Introduction; 2. Literature Review; 3. Research Methodology; 4. Research Model Development; 5. Model Implementation; 6. Evaluation and Validation of the Model; and 7. Discussion and Conclusion. The study is structured to represent the original development of the research to help visualize the stepping-stones on which the study was built in order to achieve the overall study objective. This section will briefly present the purpose and content of each of the seven chapters.

Chapter 1 introduces the study, its purpose and justification. While AR has been argued to hold high potential and usefulness in the tourism environment, use cases of successfully implemented and widely used smart glass AR applications are limited.

Therefore, this study has the potential to serve as guideline for the researchers in the field for the development of smart glass AR tourism applications in the cultural heritage tourism context. By providing an insight into the background of Context-Aware Augmented Reality and Cultural Heritage Tourism and Technology Acceptance Models, it outlines the research gap and justification of the study. Furthermore, the aims of the study are introduced and discussed to provide milestones throughout the study leading to the overall outcome of the research.

Chapter 2 presents the study of literature in the fields of Context-Aware Augmented Reality, Cultural Heritage Tourism and Technology Acceptance. The chapter discusses the recent developments and challenges in the field of context-aware AR and its implementation in various industrial and tourism settings. Literature related to cultural heritage tourism identifies the role of ICT and AR technologies to support tourism activities and tourists' intention to visit a destination. A good amount of literature also discusses various technology acceptance models and recent models based on TAM and TR in the field of AR.

Chapter 3 focuses of the development of the research methodology. It reviews the research aims guiding this study and further provide a discussion of research philosophies and approaches implemented in the study. By discussing the research strategy and design, it follows with a detailed explanation and justification of the adopted research methodology. The research was divided into three research stages, 1) model development based on literature review and qualitative study findings, 2) model implementation 3) model evaluation with a quantitative study at the UNESCO world heritage site. All three phrases are individually discussed with regards to purpose, population, sample, data collection and data analysis.

Chapter 4 chapter presents the research model of this study and explains the model constructs that constitute the research model with the relevant hypotheses. The chapter starts with the discussion on the findings of the preliminary study conducted based on affinity mapping and focus group techniques. As a result of these findings, external dimensions and other constructs of the model are mapped based on the themes identified. A research model is developed based on the discussion on the findings of the preliminary analysis and literature.

Chapter 5 provides the steps to implement the model in the form of a TouristicAR prototype which can be used by the tourists. The prototype application represents the various factors highlighted in the developed acceptance model. The chapter discusses three main topics; 1. The hardware and software platforms used in this study, 2. Feature mapping process which shows how the requirements are analyzed and the application design is conceptualized and finally 3. The TouristicAR prototype development process using RAD methodology.

Chapter 6 discusses the evaluation and validation of the smart glass acceptance model through descriptive and inferential (multiple regression) statistical analysis techniques. The motivation behind choosing the multiple regression analysis was in its suitability for hypothesis testing and examining how exogenous (independent) variables can be employed to predict endogenous (dependent) variables. This chapter presents the evaluation of the developed smart glass AR acceptance model using industry standard software such as SPSS and Smart PLS 3.0. Instrument validation, demographic analysis and scale reliability analysis is performed using SPSS. The model is then analyzed for correlation analysis using SEM PLS. Convergent validity, discriminant validity and bootstrapping is performed to check for model fitness and analyze the relationships between different constructs and variables. Finally, a discussion is conducted on the findings of the results in the light of previous literature.

Finally, chapter 7 concludes the research by reviewing the research aims and discussing how each aim has been achieved throughout the study. In addition, the contributions of the research for academia and industry practitioners are presented. Furthermore, limitations of the thesis are discussed reflecting on the process of the overall study. Lastly, recommendations are provided with regards to future research, as well as recommendations for the implementation of smart glass AR tourism applications in cultural heritage destinations.

CHAPTER II

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter presents the study of literature in the fields of Context-Aware Augmented Reality, Cultural Heritage Tourism and Technology Acceptance. The chapter discusses the recent developments and challenges in the field of context-aware AR and its implementation in various industrial and tourism settings. Figure 2.1 below presents the outline of the literature review.

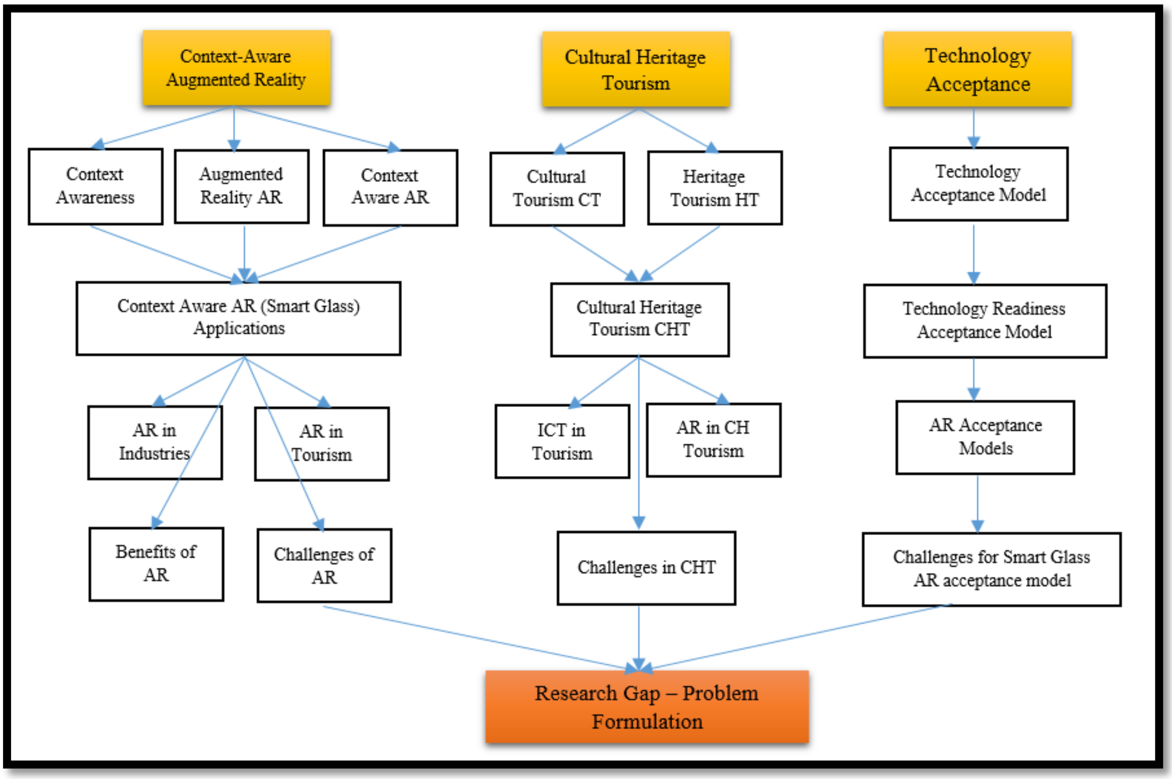

Figure 2.1 Outline of Literature Review

Literature related to cultural heritage tourism identifies the role of ICT and AR technologies to support tourism activities and tourists intention to visit a destination. A good amount of literature also discusses various technology acceptance models and recent models based on TAM and TR in the field of AR. Finally, at the end of this chapter a discussion on the critical analysis of the literature is presented.

2.2 CONTEXT-AWARE AUGMENTED REALITY

As information technology has been increasingly implemented across many industries, the search and access of information has shown a shift from presentation to user interaction and from collective to individually shaped information search (Thomsen 2002). One of the most promising areas of digital media that opened an additional area of interaction between users and applications by identifying their context is 'Augmented Reality' (AR), which has increasingly become an area of development in many industries since early 2000 (Nicas, 2016) . Regarded as a revolutionary kind of media-user interaction, context-aware augmented reality quickly became attractive for many industries, including the gaming, education, health, retail, as well as the tourism industry.

2.2.1 Context-Awareness (CA)

Context-aware systems are commonly used in the wide range of domains such as user interface adaptation, tour guides, multi-user systems, targeting advertisement, smart environment. This approach is gaining popularity in research and in the field of applied engineering year by year (Hong et al. 2009). The predecessor of the concept of context-aware systems, the ubiquitous computing systems firstly appeared in the Mark Weiser article in 1991 (Weiser 1991), more than 20 years ago. The author described it as a computer property, which adapts its behaviour in significant ways without requiring even a hint of artificial intelligence based on the surroundings. From this notion the first discussion about context-aware mobile computing has arisen. Afterwards it was firstly mentioned by Schilit and Theimer in 1994 (Schilit and Theimer, 1994). They summed up the knowledge of the term and gave the first complete definition of the context-aware computing notion:”The context-aware computing is the ability of mobile user’s applications to discover and react to changes in the environment they are situated in.”

Despite references to other types of context in the Schilit’s definition the researchers and developers were mostly focusing on location-aware systems at that period of time. Only location contextual information was used as the source for adaptation and application personalisation. For researchers and developers this limited the domain of possible context applications. Schmidt et al. pointed to the problem of the context definition being to narrow in his work ”There is more to context than location” paper (Schmidt et al. 1999). The unified definition of context-aware computing was offered by Dey, which covers a wider range of usage domains for the concept of context-awareness in applications (Dey et al. 1999). A system is context aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user’s task.” The author gave a more generalized definition of the term, which does not cover the context based system adaptation. For instance, an application which just shows the context of user’s environment (such as a weather forecast at user’s location) will fit this definition of context-aware system, although it does not react to the context it has collected about the environment. To sum up, this definition covers the context-aware computing systems, but does not really suit as the definition of context-aware applications.

a. Context-Aware applications

A software build with the property of context-awareness is called a context-aware application. Schilit et al. define context-aware applications as software being able to ”adapt [itself] according to its location of use, the collection of nearby people and objects, as well as changes to those objects over time” (Schilit et al. 1994). In other words, context-aware applications can recognize the environment dynamic characteristics and act upon them. Hence mobile devices can collect context data, process and afterwards make necessary adaptation of the system in order to serve the user in a more efficient way. The adaptation of the system can involve not only the user interface flexibility, but also changes in system behavior. Therefore a single application may look and serve the user differently depending on the collected context: hardware characteristics, environment, system state, user interaction with the system, etc.

In addition, the other goal of the context-aware adaptation is to provide the best user experience of the application with minimal user intervention. In brief, a context-aware application is aiming to take the maximum possible amount of work from user's side. And as a result, to make the use of device, technologies and systems more comfortable and easier. ”Context-aware systems are able to adapt their operations to the current context without explicit user intervention and thus aim at increasing usability and effectiveness by taking environmental context into account” (Baldauf et al. 2007).

The user location as contextual data on the applications running on a mobile device can be readily retrieved with the global positioning system (GPS). Hence users are freed from manually pointing their position on a map or entering an address. So the user is exempted from the hand-operated work of defining the context. In other words, the context-aware technology ”takes into account the human world and allows the computers themselves to vanish into the background” (Weiser 1991). Some illustrations of context-aware applications can be found in Subsection 2.1.2, particularly the Systems Interacted with Environment case. The applications described and discussed there have an adaptive interface depending on the changes in the environment they are in and interactions with it. In addition the result of Wai Yip Lum work is a successful example of a context-aware application. Lum et al. designed a content adaptation system for hypermedia (Lum & Lau 2002). A part of the system-decision engine is an adaptation based on device capabilities. The context is chosen based on the battery level, dimensions, Internet connection and other device parameters and characteristics. The decision engine provides an optimal version of the hypermedia content, which is renderable for particular client device and suitable for its network characteristics. This decision is derived by executing an algorithm based on a received from the device context data. This approach was widely taken into use as a server-side application for web mobile application generation. Currently, newer techniques, such as responsive design, and increased capabilities of the mobile devices made such idea irrelevant.

2.2.2 Augmented Reality (AR)

As Augmented Reality has been researched, many attempts have been made to give a proper definition (Ronald Azuma 2004; Bimber & Raskar 2005). However, while it is not a new technology, it is still considered to be in its infant stage, and has not yet been fully developed, which has lead to a constant modification to define AR properly depending on the implementation method and area (Krevelen & Poelman 2010). However, a universally accepted definition has been formulated by (Stone et al. 2008), as a means to provide functionalities to supplement or enhance the real environment. Therefore, it should include the following specifications:

Create a conjunction between virtual and the real environment

Be able to utilise and interact with in real time

Register and align virtual as well as real objects connected to each other

A more recent definition has been formulated as the integration of digital information with live video on the user's environment in real time (Rouse, 2015). While the definition has become more specific according to technological advancements, the core has remained as an enhancement of the real environment by computer-generated content, which is up to date mostly supplemented with graphical content (Kalawsky et al. 2000). Azuma (2004) furthermore classified early AR devices into three subparts, which have remained relevant for current devices alike. Each system should include a scene generator, a display device and a tracking-sensing device in order to successfully harmonise with the real environment.

Although the concept of AR is closely related to Virtual Reality (VR), its main difference was defined by the interaction with virtual information and objects in a real-time setting (Höllerer & Feiner 2004). The user can experience the real environment in an enhanced way mainly through a visual sense, but also through auditorial enrichments. In the development of ‘Mixed Reality’, which AR is a part of, many other terms have been given to this technological concept including ‘ubiquitous computing’, ‘augmented reality’, ‘wearable computing’, and ‘tangible computing’, which are all based on the perception of combining virtual information with the real-world environment (Bolter et al. 2006). Utilising such 'Mixed Reality' applications, it gave users a new way of understanding of interacting with the physical environment (Dourish, 2006). The 21st century is regarded as one of communication and information exchange, requiring people to exchange information faster and more efficiently than ever before. With the help of mobile devices, it has enabled people to use technology for everyday life purposes, making it part of culture and lifestyle (Fritz et al. 2005).

Sutherland (1965) came up with the concept of the 'Ultimate Display', which should provide the user with additional relevant information for specific jobs. Other display enhancements have been studied for a variety of industries (Zhou et al. 2008). The Head-Up Display (HUD) for aircraft assembly and navigation purposes has been found to be one of the most dominating and earliest implementations of AR (Kalawsky et al. 2000), which enhances the real world with a graphical information overlay, such as navigation routes in the sky for orientation assistance. However, real world enhancements have been argued to not only be possible with visual supplements, but also using auditory enrichments to provide 3D sounds to the setting for the improvement of spatial awareness (Vincenzi et al. 2003). There is a need to continuously develop interaction equipment as peoples' expectations are constantly rising. Although AR was initially regarded and utilised for a number of restricted industries, it has been introduced and utilised in public especially for industries such as gaming and tourism (Fritz et al. 2005). By using AR, users are expected to process larger amounts of information in a shorter period of time in order to help in the decision making process (Stone et al. 2009). Therefore, Ahmad et al. (2005) concluded that AR systems should be designed to be light and mobile, enabling anyone to use it for everyday purposes, such as in private mobile devices. The information could be displayed on the device itself and provide the user with additional visual as well as auditory content based on the surrounding of the user. Google was believed to provide the first device of an AR capable wearable display for public use with their Project Glass concept. It was expected to be launched in 2014, but was withdrawn before the launch (Rivington 2013). Although, it was argued that Glass does not yet provide AR overlays, it was considered to be the first form of wearable computing that had the potential of being widely adopted (Gorman, 2013). AR systems should be widely available so that it is usable indoors as well as outdoors in any set of environment without location based limitations. However, there are still challenges to overcome in order to reach that stage of development. Further requirements and challenges will be discussed in section 3.5, investigating the current state of AR development.

Researchers have identified AR as a promising type of technology for public use, which connects the user's spatial dimension with information to enhance the overall user experience (Pang et al. 2006). Furthermore, users were thought to be able to share and exchange location based information, which makes it especially attractive for the tourism industry (Thomsen 2002). Today's mobile applications are plentiful that many applications that enhance tourism products exist already, making tourism applications the 7th most downloaded type of mobile apps (Klubnikin, 2016). The flexibility to access required information anytime and anywhere opens up new possibilities for the users' immediate surrounding. Höllerer & Feiner (2004) expect the development of mobile AR to become accessible anywhere in the world without the restrictions of place and time, which would enable people to access desired information and integrate it in the real environment. Although AR has been increasingly studied since early 2000, the technology has yet to overcome challenges, as it has not yet been implemented seamlessly into current mobile applications. Nonetheless, it is continuously researched and enhanced, and academics expect it to be able to utilise for everyday purposes in the near future.

a. Augmented Reality Applications

Even though the term 'Augmented Reality' was first defined in 1990 by Boeing researcher Tom Caudell (Cassella, 2009), the first 3D display enhancing the real environment was designed by Sutherland (1968), as the first head-worn display enhancing the environment with graphical information. Hereafter, many studies in the mobile and commercial field were conducted in order to enhance the interaction of computer-generated graphical information in the real environment (R. Azuma et al. 2001). By 1970, tracking devices were implemented into the AR content, which provided the foundation for the VR concept. Although the US Air Force was already conducting research on heads-up displays for fighter jets (Furness, 1986), Boeing's studies of display overlays provided the first definition of AR. The idea of AR, which originated from the study by (Caudell & Mizell 1992) to support aircraft assembly for construction workers, was soon considered to have the potential for a much wider area (Ronald Azuma 2004). Nonetheless, AR systems could not be implemented into modern technology until the mid-1990s, when mobile devices became powerful enough to serve as AR platforms.

So far, there have been many studies conducted with regards to AR implementation in a number of fields. However, most studies were concerned with technological issues and implementation challenges. Although there has been prior research regarding the impact of AR on performance, such as testing the userexperience based on AR enhancements, it was focused mainly on the visual improvements and did not consider multisensory types of AR enhancement (Swan & Gabbard 2005). Stone et al. (2009) stated that AR interfaces should be able to augment more than just graphical overlays, and use more enhancements including visual, auditory and touch senses. They concluded that not only visual enhancements via Head-Mounted Displays could enhance users' performance, but also other modalities, such as auditory to improve accuracy, and decrease information processing time. While studies in AR continue to increase, AR in the industry has accelerated through investments of major businesses such as Microsoft Hololens and Google Glass in recent years, as well as the increase of tech start-ups expanding the technology to create new markets and frontiers (Nield, 2015). According to Sullivan (2015), a total of USD 3.15 billion has been raised by such start-ups in equity financing just within a year. The trend of AR and VR has triggered many big players in the industry to venture into new areas to make it accessible for the public (Sullivan, 2015). Similarly, the film industry has tapped into the market with Michael Bay, the producer of major motion pictures such as Transformers, as well as other producers experimenting with AR comics to be released in the near future (Kamen, 2015). Another major industry that has recently been exploring context-aware AR applications is cultural heritage tourism with a number of research identifying the consumer acceptance parameters (Benckendorff et al. 2018; Jung & tom Dieck 2016; tom Dieck & Jung 2017).

2.2.3 Context-Awareness as a property of Augmented Reality

The rise of wearable and mobile devices, increasing availability of geo-referenced and user generated data and high speed networks spurs the need for context-aware applications, which provide the right information at the right moment, and at the right place. AR is one such technology, which allows interweaving digital data into physical spaces and through this aims at providing relevant information on the spot. While for many types of wearable applications context-awareness and adaptation are still optional, AR applications on the contrary depends on being adaptive to the physical context in which they are used (Kjeldskov & Graham 2003). At the very least, obtaining spatial information is a key requirement for AR systems. The need for more adaptive content as part of context-aware AR systems has already been recognised (Kooper & MacIntyre 2003; Langlotz et al. 2014).

AR applications are usually grouped into three components: A tracking component, a rendering component, and an interaction component. All of these components can be considered as essential. The tracking component determines the device or user position in six DOF, which is required for visual registration between digital content and the physical surrounding. Based on tracking data the scene (e.g., 3D models and camera images representing the physical world) is composed in the rendering component. Finally, the interaction component allows the user to interact with the physical or digital information when using the system.

Initially, AR researchers addressed technical challenges in AR, however, in recent years AR research switched focus from basic tracking and rendering algorithms to human-centered issues in consumer and industrial contexts. Given the nature and definition of AR, location has been handled as major context source for AR but there are a multitude of other context factors that have an impact on the interaction with an AR system. Generally, context can be seen as being any information used to characterize the situation of an entity. An entity is a person, place or object that is considered relevant to the interaction between a user and an application, including the user and the application themselves. Similarly, context-awareness is defined as the facility to establish context".

Over the last years AR moved more out of the lab environments into the real world. Also, companies have started to roll out AR apps to consumers, which are downloaded by millions of users and used in a multitude of mobile contexts. For example AR Browsers, applications browsing digital information that is registered to places or objects using an AR view, are used among other purposes for navigation in indoor and outdoor environments, marketing purposes mobile games or exploring the environment as part of city guides. As AR is increasingly used in real-world environments there is a need to better understand the particularities of AR interfaces in different contexts going beyond location. These particularities are often based on the tight spatial link between the interactive system and the physical environment and its implications on visualization and interaction techniques for AR applications. This link is also one key factor, which distinguishes AR applications from other (potentially context-aware) interfaces for Mobile and Ubiquitous Computing. Hence, it is worthwhile to study the role of context specifically for AR and to highlight distinct characteristics that are unique to AR.

There is only limited research that investigates the design and development of context-aware AR browsers in tourism context. One of the most relevant study pertaining to this area was described in (Kourouthanassis et al. 2014) . The main aim of the project was the development of an AR browser (CorfuAR) that delivered personalized content to tourists by automatically selecting and presenting content that matches tourists preferences. The filtering of content was based on three user profiles (thematic-based, entertainment-based and action-driven) adopted from the World Tourism Organization tourists segmentation approach.

The main problem with development of context-aware AR is that it is extremely challenging to identify and measure context (Zhu et al. 2015). Even if context is measured and captured, it is difficult to make inferences about its influence on interaction or intent. There is still an on-going debate what is the exact range and nature of the contextual parameters an AR system has to adapt to Langlotz et al. (2014), which mimics the more wide debate about the relevance of context parameters in context-aware literature (Bellotti & Edwards 2001; Dourish 2004; Greenberg 2001; Oulasvirta et al. 2005; Schmidt et al. 1999). On wearable devices all available context has to be taken into consideration for context aware adaptation processes. Brusilovsky pointed that the environment has to be taken into account as well as the user's characteristics (Brusilovsky, 2001). In case of modern smart glass based systems this statement is valid especially for other systems, since these devices have a huge variety of sensors, which can be utilized as environment meters. Moreover, these devices are often found in conditions of diverse surrounding due to their mobility. Three general classes of context-aware adaptation suitable for wearable smart glass applications are determined based on; the information organization, information presentation and the interaction between the user and the system (Ro et al. 2018).

2.2.4 Recent Developments in Augmented Reality

As the development and implementation of AR systems became more feasible, researchers have attempted to develop practical solutions according to the context of implementation (Haller et al. 2007). With respect to current technological developments, AR systems were divided into ‘mobile AR’ and ‘wearable AR’. It was found that both systems are practical in their own way and would be utilized for different settings (Tang et al. 2003). However, as wearable devices in the form of smart glasses are now emerging to a central part of consumer market, wearable AR will be the focus of this study.

a. Mobile AR

Using mobile AR enables the user to detect and focus on a target, which can be involved into the task, providing more freedom in involving the environment (Wagner and Schmalstieg, 2003). However, Yeh and Wickens (2000) argued that by involving a wider area, it could result into a decrease of productiveness, as the user is directed to a specific area. Furthermore, Wang & Dunston (2004) stated that hand-held mobile displays, such as smart phones, could result to be more inefficient due to the time loss to constantly shift the user’s attention to the display and outside environment. Nonetheless, to date, hand-held displays are considered as one of the suitable device for AE, as hand-held devices have already been developed sufficiently in terms of access and everyday use (Wagner and Schmalstieg, 2003). GPS systems and electronic compasses are furthermore already in most of mobile devices today. Therefore, just as smart phones have become an increasing part of everyday life, it is anticipated that more AR applications will be used in the near future.

i. Mobile Marker-based AR

Although mobile AR is still in an early stage of development, marker-based AR has been largely discussed as one of the most stable forms of AR systems (Wagner et al. 2005). Early marker-based sysyems were typically built on a 2-dimensional QR code (Quick Response Code), which would provide the user with additional information mostly in form of a website link by simply scanning it (Walsh 2009). Such codes have become internationally recognised and standardised, which have supported the public awareness and popularity of QR codes globally (Liu et al. 2008). Being first developed in the car manufacturing industry in Japan to support the building process, it has quickly become popular in various other industries such as in tourism. It has been increasingly used for the promotion of destinations as well as private businesses, such as restaurants and pubs (Canadi et al. 2010). In the Pitney Bowes Report (2012), people from Europe as well as the U.S. were interviewed regarding their awareness and use of QR codes, out of which 15% of the people were aware and already using QR-codes on a regular basis. This trend was recognised to increase with more demand by smart phones users in the United States (Pitney Bowes Report, 2012). Schadler and McCarthy (2012) argued that by 2016, the number of smart phone users would exceed one billion globally, which would significantly contribute to the use of new applications, such as QR codes and other AR applications. Placing the QR code anywhere in form of posters, or even into buildings, it serves as a bridge to close the gap between the physical and digital space being instantly connected to digital information (Pitney Bowes Report, 2012). However, recent developments have moved away from relying on QR codes as triggers for marker-based AR experiences. Instead, alternative recognising softwares are used to overlay computer-generated content onto the real environment. Limitless Computing Inc. announced the development of a cloud-based solution called 'SightSpace Pro', which is able to project designed 3D models in form of real-life buildings on the real environment (Graham, 2016). However, the fashion industry has made an alternative approach to marker-based AR through facial recognition softwares in which the user's facial features are tracked by the insight camera of the mobile device and make-up products can be directly augmented on the user's face on the camera (Jaekel, 2016).

ii. Mobile GPS-based AR

The second system of AR has evolved in GPS-based AR, which works under the criterion that the mobile device includes a GPS function (Reitmayr & Schmalstieg 2003). However, (Walsh 2011) argued that this type of AR is not suited for indoor environments due to the limited GPS range, as opposed to its promising potential in outdoor environments, making it particularly interesting for tourism purposes. Nonetheless, it needs to be acknowledged that VR and markerbased AR have been developed and improved steadily up to date, whereas GPSbased AR has been found to pose a higher challenge to overcome (Rohs, 2007). Due to its complexity, the impact of mobile GPS-based AR in the public space has been limited as Marimon, et al. (2010) pointed out. One of the biggest challenges was identified as the inaccuracy of GPS systems in mobile devices, being able to pinpoint locations only up to 20 metres accuracy (Reitmayr & Drummond 2007). However, due to the promising opportunities that would benefit from accurate mobile GPS systems, alternative approaches have been sought to increase its accuracy with minimal increase of the cost (Brachmann, 2016). In the past it was considered extremely difficult to use mobile GPS systems for AR applications that require the exact coordinates to project the overlay accurately and provide enhanced experiences (Flintham et al. 2003). As a result, graphical enhancements were not aligned properly, making overlays float in mid-air rather than being fixed to a specific object, which has been challenging particularly for mobile AR games. Beer (2011) argued that one way of compromising was the use of multiple elements, such as a combination of GPS, magnetic compass and acceleration sensor. Alternative solutions have been studied, such as the use of ground-based sensors that would improve the GPS accuracy significantly. However, the cost of implementing such systems has slowed down development (Brachmann, 2016). In the meantime, alternative sensor technologies and their usability have been studied, such as iBeacons and the 'Aware' device which uses Bluetooth sensors in order to send information through smart phones to the user (Naziri, 2015). While it does not use GPS and therefore relies on a bluetooth beacon, it suggests a workable alternative for many use cases, such as shopping malls or for locating objects. A company known as Nextome has recently patented a similar bluetooth technology that allows the mapping of indoor environments which are difficult to reach through GPS signals, using bluetooth transmitters (Mastrolonardo, 2016). GPS-based AR's biggest market to date was identified as the automotive industry, where cars are equipped with windshields that are able to overlay navigation information based on GPS coordinates directly on the windshield (Ponomarev, 2015). However, Limer (2015) suggested that an improvement in the mobile antenna could increase GPS accuracy by a degree, which would allow the meaningful implementation of overlays. (Henrysson & Ollila 2004) similarly argued that GPS-based AR was expected to prosper once the main difficulties were overcome (Henrysson & Ollila 2004). Such technologies are expected to provide a platform to develop tourist AR applications using mobile GPS functions and enhance the overall tourist experience (Burigat 2005).

b. Wearable AR

In the development of AR and, the use of wearable computing as the next phase of AR devices has been increasingly discussed in industry and academia. According to the study investigating pilot reactions by (Wang & Dunston 2004), it was found that head-mounted displays (HMDs) reduced the necessity of reorientation and lead to shorter task completion times. Therefore, it was found that more simple tasks could be accomplished without facing great challenges. However, Yeh and Wickens (2000) stated that due to the overlapping view of information in direct eye sight, it could also disturb from the real environment. This criticism was also highlighted by Chapman et al. (2009), arguing that headmounted displays are not ready to be effectively utilised. Chapman et al. (2009) envisioned wearable displays that could be used for everyday life in form of a pair of glasses with a stable display to match any outdoor condition.

By investigating early developments of HMD, two types were identified, 'video-see-through' and 'optical-see-through' displays (Bonsor, 2001). Video-see-through displays completely block out the user's external sight and therefore, he is exposed to video cameras attached to the goggles, which screens the environment in real-time.

Being investigated over time, these types of displays became known as VR headsets, such as Facebook's Oculus Rift, and Samsung Gear VR headset, also powered by Oculus Rift (Lamkin, 2016). Optical-see-through displays on the other hand are embedded with reflective mirrors, which enable the user to see the real world directly. However, as augmented images could not be overlayed properly onto the real-world setting (Chapman et al. 2009), Microsoft's Hololens provided a promising alternative of a hybrid method between Virtual Reality and AR (Lamkin, 2016). The past hype of Google's project glass is the most imminent example of HMDs in the form of Smart Glasses entering the consumer market apart from early developments to implement AR into contact lenses (Rivington 2013). In the context of this study it is important to understand and formulate a thorough definition of smart glass augmented reality.

i. Smart Glasses

In this study AR Smart Glasses are defined as wearable Augmented Reality (AR) devices that are worn like regular glasses and capable of providing basic AR functionalities to the users (tourists). Augmented Reality Smart Glasses merge the real world with virtual information that is integrated in a user's field of view. Several sensors capture physical information and augment them with virtual information that can be gathered from the internet or stored on the smart glasses memory, primarily accomplished through context aware data in the form of location, object, facial, and image-based recognition technologies. This virtual information is then displayed in real-time on a display, which, in brief, is a plastic screen in front of a user's eye(s). A user can see both the offline and the virtual and the real-world through these displays.

Smart Glasses, such as Google Glass or Microsoft Hololens, have recently gained increased attention. Broadly speaking, smart glasses are a new wearable augmented reality (AR) device that captures and processes a user's physical environment and augments it with virtual elements. Recent forecasts predict that smart glasses will substantially influence our media behavior, and market research institutes propose tremendous growth rates. For example, Technavio (2015) predicted growth rates of nearly 200 percent within the next five years, and Jupiter Research (2015) forecasted $53.2 billion retail revenue of smart glasses by 2019.

In line with these forecasts, new startups specializing in smart glasses have been founded. As a final point, consumers and media discuss the advantages and potential concerns of this technology for individuals, and societies as a whole. Although there is a huge potential for smart glasses to create value for consumers, companies, and societies as a whole, surprisingly little research has been published. Not surprisingly, academics and managers alike call for early market knowledge to tackle the challenges posed by smart glasses and better understand the mechanisms that drive this promising technology (Olsson et al. 2012; P. Rauschnabel et al. 2015; P. A. Rauschnabel & Ro 2015a). In comparison to smart phones, smart glasses also offer high quality visual support for users. Table 2.1 presents some basic differences between the two modes of AR.

Table 2.1 Differences between smart glass AR and smart phone AR.

Source: TechSee Augmented Vision

Criteria	Smart glasses	Smart phones
Hands-free	Fully Hands-free	Limited
Field of view	Limited	Unobstructed
Mobility	Sensitive, cumbersome, often heavy and requires packing and un-packing	Light, Standard hardware for mobility, simple to use
Battery life	Short, often not replaceable	Long, often replaceable.
Connectivity requirements	Normally requires uninterrupted and high bandwidth	Standard connectivity, works well with lower bandwidths
Ability to communicate	Limited	Natural
AR Quality	3D	2D
Maturity	Immature, less stable	Mature, widely used
Price	Highly priced	Wide range of prices available. Often cheap.

ii. Limitations of Smart Glasses

The smart glass market is still in its infant phase, and although promising devices are slowly emerging, it is arguable how long it will take until consumers will accept the technology and understand its benefits (Curtis 2015; Haque 2015). Tim Sweeny, developer of the Unreal game engine claimed that AR would replace the screen in the near future, as a mobile solution that can be overlaid in any environment (Orland 2015). Sweeny argued that AR would eventually surpass even VR, as it provides far less limitations in terms of wearability, space and use cases (Orland 2015). Researchers are investigating whether wearable glasses could overcome privacy concerns despite its criticism by encrypting messages and content only visible to the eye of the recipient (Andrabi et al. 2015). Furthermore, it can be seen that wearable technology is becoming more than simply a gimmick, as the Pentagon recently announced to team up with Apple and Boeing to develop wearable technology for federal defense systems (Reuters 2015). Although promising, the smart glasses and wearable AR devices face many challenges the require the attention of the researchers in the near future. This work categorizes these challenges in the following categories.

Health issues

One potentially problematic issue is the effect of smart glasses on the eye and the body as such. Smart glasses are wearable computers; but, unlike all other wearables, the technology is fixed in front of the eye and, thus, adapted to the eye's properties. Apps are being developed that enable one to use the glasses to look at things in order to control them. This is possible because some of the glasses (e.g., Google Glass) can recognize eye movements and, thus, the viewing direction. So, the potential for managing and controlling the outside digital world through the eye is vast. But a number of professional, optician-related questions arise.

In the 1970s, one of the pioneers of wearable technology, Steve Mann, found that intense use of his prototype smart glasses led to disturbed vision. Mann learned that, when he (also) saw the world through the video lens attached to his helmet, it subsequently disturbed his normal vision. The camera's position in relation to the eye is crucial; and, right now, no one knows what the effects of prolonged use might be. Mann experienced dizziness and difficulty with concentration (Mann 2013b). For some time now, researchers in the field of virtual reality glasses have been investigating how normal vision and behavior are affected by the prolonged use of eye-sensitive technology, and they have found that the brain and the eye adapt quickly and, therefore, might be affected by prolonged use (Mann 2013a). The same might be the case with prolonged use of smart glasses (Ackerman 2013).

More generally, there is a risk of Computer Vision Syndrome (Blehm et al. 2005), which results from looking for a long time at a point closely in front of the eye. If the eye is tense for a long time, the eye muscles become locked and cannot relax again for some time. The result may be visual disorders, and long sight becomes weak. Google Glass hired Eli Peli, Professor of Ophthalmology at Harvard Medical School, to help design the technology, so that these and other possible eye problems might be avoided. But, as things stand today, there are numerous unanswered optical questions.

Privacy and Security issues

As digitization increases, it becomes easier for everyone to monitor each other. One of the main barriers against the sale and use of intelligent glasses is, undoubtedly, people's discomfort with the idea of constantly being able to be filmed and uploaded onto the Internet – possibly, for commercial use or deployed by countries in their surveillance. With regard to this discomfort, there are several points. First, it is still quite unclear, in terms of the present legislation in both the USA and Europe, what the attitude is to smart glasses and the possibility of constant, video-filmed surveillance. In fact, this phenomenon has been given its own name: Sousveillance (Mann et al. 2002), which is not so much about being monitored from the top but by like-minded people: person-to-person monitoring. This English/French term Sousveillance is an alternative to Surveillance and means “to look from below” rather than “to look from the top”.

Currently, Google has announced that they will not develop facial recognition programs, but commentators believe it is only a matter of time before apps come on the market. Facebook has already progressed quite far with face recognition (the DeepFace program), and Google Glass will also soon be able to identify people (and their relationships, geography, age, etc.). This is a serious challenge to any kind of privacy. The key regulatory issue is, in part, about whether and how it is legal to be filmed without being aware of it and accepting it and, in part, about how data will subsequently be stored and who has access to that data. Video and photos taken with Google Glass are tied to Google accounts, such as Gmail and Google+, and any data is uploaded to Google's servers, so that Google has access to that data. Therefore, a number of critics suggest that Google's greatest interest is not so much in selling "a pair of glasses" as in becoming the all-powerful IT infrastructure in which Google owns data about every aspect of our lives (Morozov 2013).

This would mean that Google could potentially sell this so-called big data information in a commercial context and to states, which could begin to predict our needs and, possibly, illegal behavior. Services in Google, such as Google Now, can predict user behavior: e.g., by reading calendars and email and by correlating the information with e.g. news, time and geography. This makes Google the potential "operating system for our lives" (Ahmed 2012) - which is only boosted by Google Glass. There is still a need for new interpretation and the development of detailed legislation for these new technologies. Nevertheless, when the first hand-held, analogue cameras came out on the market, they were met with the same criticism. At that time, people demanded that they should be banned, for example, on beaches. Today, there are already many other options for the same type of behavior: e.g., cheap, anonymous small cameras one can hang around one's neck or put on one's clothes, so no one can see them. Basically, the broad issue of surveillance and digital development is not something that relates specifically to smart glasses (Hon, 2013; Clepic, 2013) but generally to technological development and the vast quantity of digital footprints that almost everyone currently leaves behind (Atrey, Kankanhalli, & Cavallaro, 2013; Kitchin, 2014). Soon, for example, we will also see small drones flying around with (surveillance) cameras. New, relevant legislation needs to be developed across nations.

Interaction issues

The glasses move even more the boundaries for interaction between people – boundaries that are currently becoming more and more technologically mediated. For example, many young people today have no problem in listening to music with a single earplug in one ear, while they look at their phone and interact with friends. They are partly present in a constantly augmented reality in which a digital layer of information from a mobile phone flows over physical reality. As new technological products appear, new sets of rules are constantly being debated.

When users have the glasses on, they can make themselves relevant as interactive participants, because they are looking up and seem involved even though, in reality, they may actually be involved in some other digital activity. On the other hand, people look down and away, when they use a telephone, thus making themselves irrelevant as prospective speakers. But the difference is more subtle: when using a mobile phone, users turn their heads away completely; when using the glasses, users only move their eyes. In both cases, technology intrudes into interaction (Lyons 2005).

By turning away their face and gaze, users generally indicate that they are not available for conversation at that particular moment. In this way, the phone has been used as a tool to guard against losing face: the user is never alone and lonely and never devoid of interaction because he/she can always take out the mobile phone and check emails and other “important” matters. The user is never totally “naked” in front of other people; she/he always has the opportunity to save face and insert distance into the interaction. The same kind of face-saving function will also probably be witnessed in the use of smart glasses, producing some kind of new alone togetherness (Turkle 2012).

Smart Glass Technology Acceptance issues

Mat Honan, a prominent Google Glass wearer, describes all the difficulties that he, as a first-time user, has encountered in social situations, in that the glasses are “pretty great as long as you are not around other people” (Honan 2013). But he learned that people basically do not like him when he wears them. These issues will probably change when there are many more glasses on the market. Google is doing its best to create awareness and has developed a social etiquette based on Do’s and Don’ts and 10 Google Glass Myths (Google, 2014). Basically, new technologies and products are always put to use long before the establishment of any new rules of behavior, norms and specific codes of social etiquette (McLuhan 1964). Thus, the most urgent sociological question is whether and how a new form of behavior regulation and some common moral standards will be developed: in short, a new social etiquette for the use of smart glasses in general.

When the first smartphones was launched on the market, they were both a class marker and an identity marker. An iPhone is rather expensive, and only the wealthy can afford it. So far, the same is true of Google Glass. They can be looked at as class markers, which differentiate between rich and poor. The worst dystopias, as I see it, draw a picture of "Them versus Us": between cyborgs, who are technologically connected (à la Schwarzenegger in Terminator), and "authentic", "real" people. A cyborg is short for Cybernetic organism, which in popular terms refers to people who improve their abilities with the use of connected technology – also, called transhumanism (Farrell 2012). Science-fiction examples of this phenomenon include RoboCop and Terminator, but the term is also used more prosaically and has acquired a new meaning with the advent of smart glasses. There is now an entire organization working to stop cyborgs with smart glasses: stopthecyborgs.org. So, in purely sociological terms, it becomes a question of how smart glasses can and will be demystified over the course of time and what cultural practices will support this process. However, along the way, there are also challenges with psychological, philosophical and interactional issues.

2.2.5 Benefits of AR

It has been found that AR provides many benefits for various industries due to its mixed environment or computer enhancement of real world setting (Regenbrecht et al. 2005; Reinhart & Patron 2003; Shin and Dunston, 2008). While millions of users will be able to experience VR in the near future, Nicas (2016) argued that AR requires more time to overcome current challenges. However, AR benefits are expected to yield higher returns compared to VR due to the nature of interacting with the real environment. While a lot of hype has spread around the consumer market in recent years, Rossi (2016) believes that AR will impact on enterprises along with general public in the coming years, particularly because wearable technologies are now opening up more possibilities.

a. Economic Benefits

While AR has become an increasingly discussed topic in recent technological advancements, excitement has particularly increased with major companies in the digital market, such as Google, Facebook and Microsoft making big investments in this area. Although it is surprising how little AR has been used so far to generate revenue (News 3.0, 2013), Facebook has recently purchased Oculus for USD 2 billion followed by Google's USD 542 million investment in Magic Leap and Microsoft's HoloLens (Merel, 2015). Although the numbers are still not sufficient to be analysed meaningfully, AR and VR show high potential in many areas and is regarded to create significant economic as well as non-economic benefits for businesses and stakeholders in various industry sectors. While AR is still seen by many businesses as gimmick and has been used for promotional purposes only, Digi-Capital forecasts the revenues generated from AR/VR technology to reach USD 150 billion by 2020, with AR generating around USD 120 billion and VR the remaining USD 30 billion (Digi-Capital, 2015). The division is not surprising considering that VR was originally developed for the 3D and gaming market as a 'sit-down' experience due to the safety issues arising while moving with a fully closed headset. AR on the other hand is expected to ride the wave of the current smart phone and mobile device market, which has an enormous market range and therefore provides significantly more potential use cases for implementation. It is believed that AR will not only serve to grab peoples' attention in the future, but as a mainstream technological tool that will alter the way people interact with technology and their surrounding (Business Wire, 2013). Clark (2015) forecasts a similar trend suggesting that the AR/VR hardware market will reach USD 4 billion by 2018. Ahonen (2012) furthermore predicted users to adopt AR naturally with the increasing market penetration of smart phones and expects AR users to exceed 1 billion by 2020. CCS Insight (2015) released a report stating that 2.5 million devices will be sold this year that are capable of running AR applications. The number is expected to increase to 24 million devices that are AR/VR ready being sold by 2018, which would make AR and VR a mainstream technology. While early forecasts were argued to be too optimistic, Clark (2015) claims that with the involvement of major companies such as Google and Samsung, AR and VR technology would be at a tipping point to be accepted and used by the public.

Currently, developers spend significant parts of their budgets on AR technology. Ingram (2013) argues that about USD 670 million is currently spent on the development and research of AR and is expected to increase to USD 2.5 billion within the next five years. Investments in AR are increasing in many industry sectors, as more people see the potential that this technology has to offer. With a connection to a cloud based database it could potentially be able to grant access to information immediately and anywhere in the world. While AR has mainly been used for promotional activities to enhance brand image and social capital, businesses that have implemented AR are now seeking to further develop the technology and encourage customers to a purchase decision targeting economic benefits (News 3.0, 2013). Although Google Glass was not successfully launched, businesses have realised the potential benefits that AR can provide. In the meantime, Google is heavily investing into its own VR headset, Google Cardboard, by partnering with Magic Leap to create AR and VR experiences (Conditt, 2016). While Google is putting more resources into researching and developing AR and VR systems, it has recently announced the collaboration with Lenovo to create an AR technology called Project Tango, which enables developers to scan the immediate surrounding and overlay 3D objects to create applications, such as AR games (Takahashi, 2016). Therefore, Clark (2015) argues that those who will embrace AR in the next two years will gain a major competitive advantage.

b. Socio-cultural Benefits

While the potential economic impacts of AR start to be evident, the opinion of non-economic impacts varies. In general, as AR applications enhance the real environment they are believed to provide the user with more information and enhance the life and experience of people (Oldershaw, 2012). As the augmented overlay communicates visually as well as auditory with the real environment, it gives the user a chance to interact with or process any kind of given information immediately (Pan et al. 2006). By interacting with AR systems, the user is expected to be able to focus on priorities, while not being distracted by other factors in the immediate environment. Such applications come particularly handy for industries, which require people to process a lot of information while being able to freely utilise their hands for other operations (Tang et al. 2003).

Previous research in the manufacturing and assembly industry has found that people using AR applications were less likely to do errors during operation and could better recall information that needed to be processed (Tang et al. 2003). Vincenzi et al. (2003) supported this point arguing that the use of AR platforms could be taught to users, as it relies on cognitive psychology, and would boost productivity and efficiency once properly implemented. Henceforth, it would require less effort to complete a given task, as the application would automatically provide any necessary information. Furthermore, the frequency of switching the user’s attention are greatly reduced, as all required information could be screened as an overlay to the user’s convenience. Milham et al. (2001) argued that the environment of AR is already embedded by the real world and did not require to be separately designed. This implies that such technology could be easily implemented into society for everyone to utilise. Additionally, by providing information according to the physical world, AR could improve users’ spatial cognition, especially for new and complex environments, which closely relate to navigation technology (Wang & Dunston 2004). Applications in this regard have been developed and studied in AR games, such as ‘String’ that uses AR to put the gamer in a real life setting intending to enhance the gaming experience (String Labs Ltd, 2012).

An application in tourism includes Wikitude, which overlays AR information into the tourist’s immediate surrounding, and provides navigation assistance to aid tourists’s way finding (Wikitude, 2012). Such applications are expected to continue being developed and improved. A specific example of AR impact in society was outlined by Ioannidis et al. (2014) arguing that museums today face the challenge of competing against other entertainment industries, which has a financial as well as an educational and cultural impact on society. In order to make stories in museums more attractive, an EU-funded project has been tested in the Acropolis museum in Athens, Greece, which involves the visitor in an interactive story by using AR on tablet devices (Ioannidis et al. 2014). Through employment of AR devices it aims to bring museum visits back to life by educating visitors interactively. Nessi (2014) on the other hand believes that AR has already started to make an impact on the way people see their surrounding. Since it has been introduced in various industries, including gaming, education, medicine and marketing, it is believed that AR will mainly provide instant information on the things people see and interact with on a daily basis (Nessi, 2014).

As technology advances, Havens (2013) further argues that the use of AR with wearable computing will change the way humans behave. With the help of wearable computing, both hands would be available to complete tasks while checking E-Mails, or other forms of interacting with the technology. Furthermore, using AR to access information instantly would enable users to personalise information according to their preference. Wang and Dunston (2004) argued that most of the time spent on operation was typically used for processing given information and understanding a task, rather than utilising the time for the actual job itself. Therefore, they stated that the use of AR would benefit task performance, as it provides the user with necessary information, improving the process which could ultimately result in increased productivity. While Havens (2013) highlights that information accessibility has been important for many years particularly after the development of the Internet, the effective processing of information has been limited. Using AR would therefore assist in the processing of existing information to screen only what is relevant and of interest to the user.

While AR is believed to provide many benefits, others fear the security impact that AR applications as well as AR enabled hardware will cause (Gorgone, 2013). Particularly personalized information and the invasion of others' personal space are issues that are concerning and developers need to address before releasing devices, such as the Google Glass wearable hardware (Pomfret, 2012). Google's Glass project is based on capturing and sharing the world through someone else's eyes (Tab Worldmedia, 2012), which will be pushed by the interest for social media and social acceptance of AR technology. According to Gorgone (2013), smart phones were one of the first devices to trigger concerns for privacy which has become a challenge for coming technological developments such as smart glasses.

2.2.6 Challenges of AR

In this study many challenges for AR are identified. While early studies in AR have focused mainly on the interaction between the real and virtual environment, McGrurity and Tuceryan (1999) state that most difficulties refer back to registration errors that originate from a media-user interaction. Early AR studies therefore tackled mostly with technical challenges posed by AR however with the rapid advancement in technology development recently, newer studies are more focused towards AR challenges towards user acceptance. In this study therefore, AR challenges are divided into two broader categories namely; technical challenges and user related or human computer interaction challenges.

a. Technical Challenges

Tracking and registration are two of the most challenging processes to implement successfully in smart phone AR and constitute a research area on their own. While there are many methods to determine the current position of the mobile device, state-of-theart software and hardware can deliver only limited accuracy when it comes to large outdoor environments (Langlotz et al. 2014). To utilise AR applications in outdoor environments, additional challenges were identified, such as different lighting and temperature conditions through direct sunlight, night, snow, and rainfall (Höllerer and Feiner, 2004). However, the correct registration of the user's immediate environment remained one of the most significant issues (Liarokapis 2006). Nicas (2016) argued that this persisted to be a challenge, as current AR devices were still not sensible enough in their registration process to logically overlay computer-generated content. As AR systems need to interact accurately with the user's immediate surrounding, it is necessary that the environment is able to create a tracking surface to enable data to be accessed and implemented into it. However, this challenge needs to be overcome first in order to commercialize AR systems and spread its use. This issue was attempted to be overcome by methods, such as saving a picture of the environmental setting in the device, which it could interact with, or by creating visual markers to map the environment (Höllerer and Feiner, 2004). Nonetheless, tracking in the unprepared environment is still being researched. A large source of dynamic registration errors are system delays (Azuma et al. 2001).

Techniques like pre calculation, temporal stream matching (in video seethrough such as live broadcasts), and prediction of future viewpoints may solve some delay. System latency can also be scheduled to reduce errors through careful system design, and pre-rendered images may be shifted at the last instant to compensate for pan-tilt motions. Similarly, image warping may correct delays in 6DOF motion (both translation and rotation). One difficult registration problem is accurate depth perception. Stereoscopic displays help, but additional problems including accommodation convergence conflicts or low resolution and dim displays cause object to appear further away than they should be (Drascic and Milgram, 1996). Correct occlusion ameliorates some depth problems (Rolland and Fuchs, 2000), as does consistent registration for different eyepoint locations (Vaissie and Rolland, 2000).

Sensor-based approaches are mainly limited due to the cumulative error from incoming GPS, accelerometer and gyroscope data. Additionally, computer vision algorithms are still very inaccurate and resource intensive when it comes to large and unprepared outdoor environments. AR requires hyper-sensitive sensors and the tolerance for positioning errors is very small (Turunen et al. 2010). The lack of accurate registration and tracking of the mobile device results in lack of seamless integration of virtual and physical spaces. This problem is especially exacerbated when it comes to cultural heritage environments, as it may confuse users and lead to wrong decisions. Moreover problems related to increased processing power, faster battery drainage, types of display technologies and techniques also pose great technical challenges in the field of AR especially wearable AR based on smart glasses.

b. User related Challenges

With the advancement in the AR technological capabilities in recent times, one of the major challenges for AR at the moment is identified in the perception and user acceptance (Olsson & Salo 2011). Contrary to expectations, AR is not being actively used, and, as a new phenomenon, it is appearing more slowly than expected. In addition, studies related to AR in a tourism context have dealt only with the importance of AR utilization, AR characteristics, technological understanding, and AR development strategies (Fritz et al. 2005; D.-I. Han et al. 2013; Yovcheva et al. 2012). In tourism studies, empirical studies have not yet sufficiently researched why people use AR or how its use will affect visits to tourist destinations. With respect to this phenomenon, the reasons for users trying to avoid using AR can be seen in three aspects based on studies considering information technology (IT) acceptance (Gelderman, Ghijsen, & van Diemen, 2011; Gu, Lee, & Suh, 2009; Y.-K. Lee et al. 2012). In other words, depending on whether the personal aspect of AR is ready for use, whether use of the technology is sensational and whether the environment is available to use AR, users may develop a positive attitude toward AR at any public setting because they enjoyed it. Therefore, identification of the right factors which support general as well as scenario based AR applications is a major challenge.

Delivering useful and usable content is another massive challenge for the overall acceptance of augmented reality. The amount of user-generated content and geotagged media increases exponentially every day, however, the density of available information is spatially unequal. Popular city areas are cluttered with virtual annotations, while sub-urban or rural areas may lack interesting content (Langlotz et al. 2014). An additional concern is the availability of different types of data. Currently, AR databases rely heavily on textual content (Langlotz et al. 2014). While multimedia, such as videos, images, animations and 3D models have a significant potential to enhance tourists experiences, there is still lack of such content that is widely available to use within AR browsers. Yovcheva et al. (2012) stated that visual issues still existed that would simply overload the display with information and be counter-productive as the view becomes unclear. They suggested the user to be able to display only one content at a time in order to avoid this problem seen in applications, such as Junaio, Augmented Reality UK and Localscope. Julier et al. (2003) on the other hand proposed a distance-based solution to this problem, which would only present information in the immediate surrounding, however, this conflicts with content that is not distance-related. An important additional challenge is the suitable presentation of content once it is available. Despite the huge availability of AR annotations in cultural heritage destinations, several empirical studies have indicated that information delivered through AR applications is difficult to understand and use. Selection of useful and relevant content, as well as suitable visual forms of representation for wearable AR require systems that are aware of the context (context-aware) in which they are used.

2.2.7 AR in Industrial Settings

AR has been discussed to have the potential to be successfully implemented in many industries, which convinced academics to increasingly investigate this area over the last decade (Bimber & Raskar 2005). While studies in AR originated from industrial purposes, such as manufacturing and construction, today's use cases of AR for the consumer market are increasing rapidly. This section will investigate early use cases of AR in the industry, followed by the current employment of AR for public use.

One of the earliest implementations of AR was the assembly industry for Boeing by utilising AR technology to support the building procedure of aircrafts especially for cable arrangements (Barfield & Caudell 2001). However, it has also been used for a similar purpose in the car manufacturing industry (Reiners et al. 1998). (Ruffner & Fulbrook 2007) further discussed the implementation in watchtower controls for the airplane industry, where via near-eye displays, additional information could be screened for better navigating the approaching aircrafts at night. It was found that most companies implemented this technology to create prototypes particularly for modern machinery assembly, as in the research project 'AVIRKA', but also the WebShaman Digiloop system by Halttunen and Tuikka (2000), the Fata Morgana system by Klinker et al. (2002), and Spacedesign system by Fiorentino et al. (2002). Another area to implement AR technology is for military purposes (Wagner and Schmalstieg, 2003). As one could augment the real environment with visual and auditory enhancements, it was seen highly valuable for training purposes, being able to reconstruct real situations without having to educate people in training rooms using only verbal examples (Hughes et al. 2005). 'Battlefield Augmented Reality System' (BARS) is just one of many utilised military systems that have developed since AR was first introduced to increase the effectiveness of training methods (Juhnke et al. 2010).

According to Hamilton & Holmquist (2005), the range of impact was getting wider with the development of technology and modern weaponry, which made it harder to train people in real environments. Therefore, Hamilton and Holmquist (2005) claimed that with the use of AR systems, it would be possible to simulate the destructive power and reconstruct real life situations, giving training sessions a much higher purpose. Additionally, (Stone et al. 2008) discussed the utilisation of AR technology in the military for landmine detection and disposal, as their study proved that locating and disposing of such hazards could be highly improved through AR. (Maad et al. 2007) on the other hand presented a CYBERII application in the finance industry, where the market and dealer are 3D animated, giving traders an enhanced setting to operate in.

AR has also been studied extensively in the medical industry. (Carson 2015) discussed the use in medical education, utilising AR to simulate body organs and body anatomy for surgery purposes. Another possibility in the surgical area is the assistance of the doctor with additional information on the patient, such as for the support of daily routines, being able to see information on the patients' status while doing regular check-ups in the hospital. The public use of AR was largely initiated by the gaming industry as one of the few areas where AR has already been utilised and publicised to a certain extend (Geiger et al. 2007 ; Bernardes et al. 2008). GPS-based games, such as 'Foursquare' (Ebling & Cáceres 2010) and early AR games such as 'ARQuake' are just two of the increasing number of AR games on the market (Piekarski & Thomas 2002). Another AR game is 'Frequency 1550', which was developed in 2005, and enhances the physical environment to create a different perception of the surrounding while letting players interact with and become part of the game (De Souza E Silva & Delacruz 2006). This type was referred to as 'Hybrid Reality Gaming' (HRG), and was defined as a mobile-based technology, enabling multiplayer options in different surroundings and exchange of information among players while being played outdoors (e Silva and Delacruz, 2006).

With regards to recent advances in the gaming industry, the recently launched mobile AR game 'Pokémon Go', designed by Niantic allows the user to collect Pokémons in the real surrounding using their mobile device's GPS and camera to pinpoint the user's location and track Pokémon. Furthermore, AR allows the user to see and project them into the real environment, by using the camera on the mobile device (David, 2016). AR has already made an impact on the way people shop. Cases, such as 'TryLive' allow the user to try on virtual glasses and test the look online through a website without having to physically be in a shop (Total Immersion, 2013). Another example includes the 3D modelling of furniture in the own apartment through AR overlay to get a first glimpse of how a particular piece of furniture would fit into the room (Black, 2013). Klubnikin (2015) argued that AR was able to impact on the shopping experience in various ways. From virtual shops only accessible on AR applications, such as ‘Yihaodian’, to characters moving across the screen to navigate visitors through venues, mobile AR applications are expected to make an impact on the customer experience. Lego X introduced a marketing campaign back in 2010 in order to show the potential buyer what the Lego model would look like once completed, using an AR monitor to point at the Lego box (Klubnikin, 2015). On the other hand, Coxworth (2015) discussed a wearable AR device for cycling. Due to safety concerns for using smart phones while riding a bicycle, ‘Insenth’, a Chinese tech manufacturer has developed ‘Senth IN1’, a set of wearable AR glasses that enables the wearer to access the music library, take photos and navigate without using their hands or losing sight of the road (Coxworth, 2015).

AR will provide social benefits and alter habits of how people interact with and experience customer service. While information can be tailored to specific needs and preferences, the invasion of privacy and access of personal data was argued to be a challenge to overcome (Hyman, 2013). Another issue was noted in the amount of virtual spam and unauthorized advertising that AR could encourage for open source networks (Zacharias, 2010). However, as more people are exposed to AR and use the technology, the enhanced experience and benefits are expected to surmount such issues. This is particularly attractive for the tourism industry, as it can be used outdoors in any kind of setting once further developed.

2.2.8 Acceptance of AR in Tourism Settings

After AR was first introduced in tourism in the late 1990s, it has been increasingly investigated in the tourism industry, as it was able to enhance the immediate surrounding in indoor as well as outdoor environments. However, while many studies have been conducted with regards to user interfaces and the overlay of information, AR has limited successful implementation cases in the tourism industry. Although today’s tourists are better informed than ever before, Pang et al. (2006)) claimed that tourists in general had little knowledge of their immediate surrounding. The first AR prototype for tourism purposes was found by Feiner et al. (1997), who invented a graphical tour guide for Columbia university campus visitors. Works by Feiner et al. (1997), Suomela et al. (1992) and Thomas et al. (1998) were among the first to examine the benefits of AR in the tourism industry. (Pang et al. 2006) stated that AR interfaces were widely considered for navigation and information access, which was first introduced by Rekimoto (1997) as the ‘Navicam’, and has triggered many studies ever since. Regarding the implementation of AR in the tourism industry, a few notable examples include the ‘GUIDE’ project by Davies et al. (2005), which provides tourists in Lancaster with location-based information, and the ‘Nexus’ project by Rothermel and Leonhardi (2001), which generates a world model to provide location based data. Such location-based systems, which can be used to access information in the immediate surrounding, would greatly benefit the tourism industry (Hariharan et al. 2005).

The use of AR devices has long been argued to have the potential to create the next generation of computerized tourist guide (Pang et al. 2006). Höllerer & Feiner (2004) described a user-interface, which should not only be able to pinpoint the user’s location, but also provide background information of the area that might be of interest. Such applications aimed to not only offer information like a travel book, but to present it in an overlaid manner in the immediate environment which the user would be able to interact with (Höllerer and Feiner, 2004). However, those applications are still being modified in order to improve their efficiency to make them functional. Pang et al. (2006) provided an example for an cultural tourist guide application, which was based on the city of Vienna and is able to guide the user to certain locations via GPS navigation. It was designed to be multi-user friendly, allowing various users to share information, while supporting functions for social networking. Fritz et al. (2005) further argued that the tourism industry required constant investigation into new technology, preferably for mobile use, in order to continue attracting visitors, which is challenging for many tourism destinations globally. As of 2013, the majority of smart phones provide navigation on GPS-map based systems, which is able to pinpoint the user’s exact location. Furthermore, Yovcheva et al. (2012) stated that mobile phones are able to access up to date content, are flexibly to deliver text, image and video data and can provide additional information on their map-based systems.

With the increasing use of the Internet for tourism purposes, such as conducting research on a destination before travelling and making holiday arrangements, the tourism product has become more transparent, empowering tourists to access information on the destination prior to the actual trip. However, the possibility to interact with the destination using technology has been limited. With the introduction of mobile AR applications, Lu and Smith (2008) argued that tourists were able to interact with a tourism product prior to the trip as well as on site. Recently, more studies are being conducted to test tourists' reaction of mobile AR systems as well as wearable computing in the tourism context (Chung et al. 2015; Jung et al. 2015; Leue et al. 2015). While AR browsers in tourism have been investigated to some extend (Yovcheva et al. 2014), current studies focus on the enhancement of the tourist experience rather than usability issues as in early studies of AR in tourism. Other applications of AR have been tested in museums to serve as virtual tourist guide and enhance the way visitors see, experience and interact with exhibitions, enabling the visitor to interpret art pieces in various ways (Damala et al. 2008). Jung and Leue (2015) conducted a study of using Google Glass at Manchester Art Gallery to explore the reactions as well as potential use cases of wearable technology for indoor tourism products. In their study it was revealed that visitors in general had a good response and positive perception towards using wearable technology to access information. However, it was pointed out that Google Glass was not yet ready to be utilised flawlessly and therefore required further development in order to enhance the visitor experience. A similar outcome was evident in other studies suggesting that AR systems still needed improvement before it could be utilised meaningfully in the tourism environment (Lee et al. 2015; tom Dieck and Jung, 2015).

AR has long been praised for its potential to support educational purposes due to its nature of providing a dynamic experience and hands-on interaction (Horn, 2006). It was found that using technologies such as Google Glass in museums had a positive effect on the visitor's learning outcomes (Leue et al. 2015). Previous findings showed similar outcomes in the wearable market, suggesting wearable technologies to be ideal for assisting human learning (Brown, 2015). Especially for visitor attractions that are linked to a heritage or religious site, regulations for maintaining the site often restrict the use of information boards and signs, which can alter or affect the heritage site negatively.

2.3 CULTURAL HERITAGE TOURISM

Tourism has been considered the world's largest industry for many years and is continuously growing (Mill and Morrison, 1985; Hall and Page, 2000; Ghosh et al. 2003; Page, 2014; Navickas and Malakauskaite, 2015). According to the UNWTO (2009), tourism ranked as the fourth largest industry for export worldwide after fuels, chemicals and automotive products. While many attempts have been made to define tourism, many studies were found to be rather subjective and therefore did not provide a meaningful explanation. For instance, Smith (2003) defined tourism as a leisure activity to visit a place away from home in order to experience change. However, tourism has become much more than a leisure activity, such as travel for business, health and educational purposes, or simply for visiting friends and family members (Hall and Page, 2000). From the definitions that attempted to explain tourism, Hall's (2000) definition was found to incorporate a range of elements that were highlighted by other authors, such as tourism involving a temporary travel activity to and from a destination, resulting in a variety of impacts on the visiting destination. Although not all purposes for travel were discussed, Hall (2000) pointed out that the context of tourism was mostly in leisure, while business travel was continuously growing. As there are many forms of tourism, (Richards 1996) stated that culture is one of the main origins of tourism, as it was implied that all facilities and services that are offered at a destination are a reflection of its image and environment. In contrast, McCarthy (1994) claimed that tourism development should strengthen cultural identity and heritage, considering the opposite effect of tourism on a destination's culture. Nonetheless, the way and reason for travel has increased significantly, as more opportunities in transport and infrastructure have provided increasing possibilities for people to travel. While travel was considered a luxury many years ago, it is now considered a very common activity.

Cultural tourism has been increasingly investigated for its potential to tackle seasonality in tourism destinations (Cuccia & Rizzo 2011). According to statistics by Europa Nostra (2006), more than 50% of tourism in Europe was driven by cultural tourism services. Furthermore, the Italian Statistics Office (ISTAT) claimed that in 2005, cultural tourism was responsible for 33.5% of total tourist arrivals in Italy, scoring the highest mark in the overall ranking (Cuccia & Rizzo 2011). Girard (2008) argued that cultural tourism had become more than just a market niche over the past decade as it has been often viewed as a separate sector in tourism. While it has been debated whether cultural tourism provides more advantages or disadvantages to a destination, Faulkenberry et al. (2000), Tosum, (2002) and Cooper et al. (2008) concluded that cultural tourism could serve as a tool to revive local traditions with a positive effect on society as a whole.

2.3.1 Definition of Cultural Tourism

Cultural tourism has been defined in various ways depending on the perspective of stakeholders. The International Council of Monuments and Sites (ICOMOS), categorised the definitions largely into four areas, 'tourism-derived', 'motivational', 'experiential', and 'operational'. McKercher and Cross (2002) supported tourism-derived definitions of cultural tourism due to the relation to the tourist market. In their view, it involves developing and maintaining cultural sites for tourists to build a connection between people and the cultural heritage of the destination. However, the tourism-derived definition implies that the tourist is generally interested in a destination's culture and cultural events. As this definition is quite broad, Smith (2003) argued that it required sub categories, such as heritage tourism, arts tourism and ethnic tourism in order to get a clearer picture of cultural tourism as a whole. The 'motivational' definition of cultural tourism focuses on the people rather than the destination. It is based on Gnoth (1997) arguing that people are motivated or 'pushed' by their own desires to pursue a specific activity of experience, while at the same time being 'pulled' by a particular offer of a destination or attraction. Similarly, Lord (1999) defined cultural tourism as visits by tourists outside of the host community or region who are motivated by their own interest in a particular field. However, regardless of the motivation, tourists are involved in the culture of the visiting destination and therefore the 'push' and 'pull' factors are always inclusive. As an additional definition of cultural tourism, ICOMOS discussed the experiential and operational perspective. The experiential view is closely related to the motivational perspective, as tourists seek to consume culture in form of experiences through interacting with customs, traditions and heritage of a destination (McKercher and Cross, 2002). The operational definition on the other hand regards cultural tourism as a form of 'activity' that tourists conduct, such as visiting museums and historical buildings and attending performances and festivals to experience culture. This implies that tourists actively participate in the experience, rather than just passively ‘visiting’ the destination. As this study is based in the context of cultural heritage tourism, it is crucial to review the meaning and development of heritage tourism before discussing the cultural heritage environment. Therefore, the following sections will aim to provide an overview of heritage and heritage tourism from an academic point of view by investigating the definition and development of heritage tourism.

2.3.2 Definition of Heritage Tourism

To clearly understand the context of cultural heritage tourism, it is crucial to investigate the meaning of ‘heritage’ as a tourism product. The Center for Heritage and Society in the University of Massachusetts Amherst (2013) defined heritage as all kinds of inherited traditions, monuments, objects, and culture. However, while ‘culture’ is more focused on the actual attributes, ‘heritage’ further relates to the meanings and activities that people, especially tourists interpret in them (UMassAmherst, 2013). Timothy and Boyd (2003) on the other hand classify heritage into tangible immovable resources, such as buildings and natural areas, tangible movable resources such as objects, and intangibles such as values, customs, lifestyles and cultural events. Others categorised heritage into natural heritage, such as natural parks, living cultural heritage, such as food and customs, built heritage, such as historic cities and castles, industrial heritage, as in coal mines and textiles, personal heritage, such as cemeteries and religious sites and dark heritage, like places of death and pain. However, no matter how heritage is categorized, Timothy (2011) pointed out that people need to have a common understanding of ‘heritage’ to prevent any misuse for political or economic reasons.

Academics and industry practitioners have employed a number of definitions of heritage tourism depending largely on historic aspects of a tourist attraction (Timothy, 2011). Although Timothy (2011) argues that most people have a common understanding of heritage tourism, a more specific definition is highly context dependent. Li et al. (2008) claim that heritage tourism needs to take sociopsychological issues into consideration, and therefore cannot disregard tourist motivations and behavioural intentions. In general, heritage tourism suggests a tourism activity that lets the tourist experience and learn about a destination's culture (Li, 2003). Orbasli (2000) further adds that the motivation to visit heritage attractions lie in the product offered to the tourist. On the other hand, heritage sites should also appeal to the local community by being sustainable to enhance the heritage of the community that can make an impact on people's visit as well as to the citizen of the destination. In order to understand the development of heritage cities, it is important to consider the meaning behind heritage tourism. Heritage Tourism was further defined by the WTO (2001) as being connected to forms of natural and human heritage, such as arts and traditions in another region or country. This implies that heritage is highly connected to the values and intentions of the society that determine which aspects of the past are considered worth keeping, as values of society change over time. Therefore, the value of heritage needs to be considered to understand the motivation behind heritage tourism. The value of heritage has been defined as 'world', 'regional' and 'personal' value. World heritage, which is often referred to, as 'heritage tourism' is considered neutral, while regional and personal heritage is defined by the emotional value attached to it by a distinct group (Fowler, 1989). According to Li (2003), heritage tourism caters to the experiential consumption of the destination, which is formed by historical and archaeological sites, buildings and other facilities that have a cultural meaning to the community. In the study of (Poria et al. 2003) on the other hand, it was argued that heritage and the impact of heritage sites highly depend on the motivations and perceptions of tourists and the image of their own heritage which forms their behavioural intentions. Therefore, it naturally results into heritage sites having different values for tourists and inhabitants as a result of each individual's perception. While cultural tourism, heritage tourism and cultural heritage tourism are often used interchangeably in practice, review of the literature showed that they have different academic definitions. It was concluded that cultural tourism is based on experiential tourism through performed and visual arts and festivals, whereas heritage tourism seeks experiential tourism by becoming part of the natural or historical place.

2.3.3 Towards Cultural Heritage Tourism

Early studies in cultural tourism were initiated by Ashworth (1989), in which it was highlighted that definitions in cultural tourism were inconsistent. Bandarin and Van Oers (2014) argue that cultural heritage and urban heritage cannot be seen as separate entities, but are rather as continuously developing form of heritage. Urban culture is seen as the cultural and social practices, behaviours and assets of the urban environment. Furthermore, it is the result of connecting cultural and natural values in the urban setting, such as the built environment, as well as social, cultural and economical practices and values (Bandarin and Van Oers, 2014). As discussed earlier, heritage has received increasing attention as a driver for economic growth (De Noronha Vaz et al. 2012). Therefore, there is a need to investigate the question of preservation and sustainable development in order to sustainably develop heritage to continuously drive economic growth in urban destinations. As culture plays a significant role in urban environments, both economically and non-economically, the preservation and promotion of cultural heritage in urban destinations provides many opportunities, such as creating jobs and promoting cultural diversity, which have been recognised by a number of destinations (Anexo, 2015).

Cultural heritage destinations such as Dublin and Venice are considered to be the attraction themselves compared to other destinations that prosper through the impact of specific tourist attractions. Therefore, the impact on the destination is often of socio-economic nature, reflecting the conflict between tourism and social and economic concerns. Van Der Borg et al. (1996) investigated visitor to resident ratios in order to measure the impact of tourism in cultural heritage destinations around Europe. It could be seen that the pressure on the historical centre of Venice with a visitor to resident ratio of 89.4 was much higher compared to Amsterdam with an index of 5.9. However, the numbers are to be interpreted with care, as they do not only represent the amount of tourists in the destination, but are also affected by the number of residents and the resulting economic and residential stability in the city. Nonetheless, such indices highlight the relative importance of tourism in cultural heritage destinations and can be used to identify potential challenges in the destination, such as seasonality and tourism supply issues. However, it is evident that the number of tourists interested in cultural heritage destinations is steadily growing, affecting the living standard of residents as well as the tourist experience. Therefore, Aas et al. (2005) argued that it is vital to properly employ tourism management policies in cultural heritage destinations. In the case of the Turkish cultural heritage site Izmir, site management involves a cooperative approach between the public and private sectors to attract tourists. However, the inflow of tourists needs to be efficiently managed through infrastructural development and coordination to sustain the heritage sites (Günlü et al. 2009). The Australian Heritage Commission for instance provides guidelines for the successful management of heritage sites in Australia, such as understanding the significance of the heritage site, forming partnerships between private and public sectors, creating a quality visitor experience, developing indigenous tourism, and planning sustainable businesses (Australian Heritage Commission, 2001). Such measures should be taken into consideration to align the needs of tourists with the local community in the cultural heritage destination. In order to understand the impact of tourism in cultural heritage destinations, the following section will provide a definition of cultural heritage tourism.

a. Conservation of Cultural Heritage Tourism

Cultural heritage includes heritage structures, places, traditions and other important properties as well as tangible and intangible assets that have distinguished elements that have encapsulated the nation's spirit and character. Cultural heritage is a legacy of a state, a cultural group and above all, generally of all human beings. Conservation of the cultural heritage is important. The primary basis of conservation includes the protection of the heritage resources. Conservation comes to the fore when efforts are made to prevent the decay of the heritage resources over time (Tunbridge & Ashworth, 1996). It emphasizes the utilization of the heritage assets in a way that they can be appreciated and used for recreational purpose while at the same time striving to sustain the core value of the heritage for future generations (Pearce & Ozdemiroglu, 2002).

Timothy and Boyd (2003) have stated that in developing countries, heritage is usually listed and protected at the national level by the government agencies. Meanwhile, in the developed nations, the trend is more towards quasi-public forms of guardianship through the various associations and conservation groups. There are several international agencies that operate beyond the national realm that serves as guardians of the world's heritage conservation bodies which are in charge for the listing and protection of the heritage goods. Moreover, the most widely recognized agency is UNESCO, whose World Heritage Listing (WHL) strives to guard and bestow international prestige on properties or sites of unique historic, cultural and natural values worldwide.

b. Development of Cultural Heritage Tourism

Since 2010, the UN General Assembly has acknowledged culture as factor for the sustainable development in cultural environments, making a significant contribution towards strategic cultural planning and sustainable cultural heritage development for tourism. As the number of World Heritage cities increased, it has become more important to explore ways to conserve cultural heritage sites in alignment with sustainable tourism development through innovative practices and management. Many theories and themes exist regarding why cultural heritage tourism has started to develop. The global economic influence has been pointed out as one of the major reasons of tourism development in cities (Nasser 2003). While economic impact is a common determinant for destination growth, local communities in cities face the challenge of staying competitive in the destination, which is increasingly dominated by international organizations. Although international investments encourage competitiveness and development of the destination, Gibson et al. (2005) acknowledge the challenges for local communities particularly to embrace the sustainability of the destination's local heritage. Law (1993) identified four factors that affected the development process from the 19th century, decline of the manufacturing industry, creation of a new economy to tackle unemployment, the perception of tourism and potential industry, and the potential effect of tourism towards revitalisation and regeneration of areas. It was repeatedly mentioned in the literature that the development of tourism sites is cyclic. Therefore, cultural heritage destinations also undergo a lifecycle through the dynamics of tourism (Kuo & Chen 2009; McElroy 2006). As tourists visiting the place start to increase, investments are made into infrastructure, services and advertisement (Russo 2002). While the economy starts to flourish, the city experiences the take-off stage in its lifecycle until the maturity stage is reached. A Common issue remains that international corporations dominate such destinations while local services continuously decline. Russo (2002) argues that the interpretation of such a lifecycle implies that the problem needs to be tackled at the tourism expansion stage. Therefore, destination managers should put proper policies and regulations in place to ensure the sustainable development of cultural heritage destinations and aid the local community. However, apart from the influence of international corporations, cultural heritage destinations face a number of challenges that still need to be overcome.

c. Cultural Heritage tourism in Malaysia

Competition to attract tourists is taking place throughout the world at a very rapid rate. This phenomenon is increasingly significant in the region of Southeast Asia. Malaysia's entry into the tourism industry is relatively recent, compared to neighbouring countries such as Thailand and Singapore, the two major Southeast Asian destinations (Hitchcock et al. 1999; Din, 1997; Khalifah and Tahir, 1995; Jenkins, 1994). Prior to 1970, tourism was developed indiscriminately and was centred largely on Kuala Lumpur and Penang Island. The official stand towards tourism then was one of relying on market forces to fuel private investments, and tourism was accordingly a 'low priority' sector in the national development plans (Kadir, 1997:102). Priority was not granted to tourism mainly due to the country's reliance upon the export of traditional primary commodities such as rubber, tin, palm oil, and petroleum.

Cultural Heritage (CH) tourism has emerged as a potential form of alternative tourism for both foreign and domestic tourists in Malaysia. In every Malaysian National Plan since independence, the related ministry has identified potential tourism products to be developed and promoted, and CH tourism has been identified in the last two Malaysia Plans (8MP and 9MP). The identification of potential tourism products has mainly attempted to increase the number of available attractions, and in so doing, to ensure the continuity in tourism development through increasing tourist flows to the country (Tourism Malaysia, 2002).

Today, CH has become a significant factor in the development of national tourism. In fact, cultural-based attractions were amongst the earliest products to be promoted by the related authorities, but over time other kinds of attractions were given priority according to market preferences. The unique characteristics of a community based on multi-ethnic societies have led to an attractive collection of CH resources. These CH items and expressions include traditional arts and crafts, cuisines, community fairs and bazaars, cottage industries, buildings and monuments, traditional games, and religious and social ceremonies. In 2011 UNESCO listed two very prominent Malaysian cultural heritage sites in their World Heritage Site (WHS) list. The listing of Melaka and George Town as a WHS respectively has developed a cultural tourism industry that could give economic benefits not just to the local industry and its environs, but also to Malaysia as a whole.

d. Challenges of Cultural Heritage Tourism

Cultural heritage tourism development has been largely influenced by means and methods to maintain and sustainably develop heritage sites in and around the cultural area. However, the situation of traditional monuments and buildings representing historical events varies significantly. While some buildings have been reconstructed to serve a different function and are well maintained, others have completely lost their purpose and have been left in poor condition. Pendlebury et al. (2009) argue that even today, many cultural heritage sites particularly in developing countries are not maintained properly and are constantly declining either actively through tearing down and establishing new buildings or by passively not putting any effort into maintenance. Such is the case of Istanbul that was on the verge of losing its UNESCO World Heritage title in 2010 due to poor maintenance of its historical architecture (Head, 2010). The areas that benefit from conservation on the other hand are mostly related to economic purposes attracting visitors. If this trend continues, it is expected to result into many destinations losing their origin and heritage.

Gospodini (2004) discusses the implications of cultural heritage destinations in Europe that face the challenge that the tourist trend is shifting from sand and sun tourism to a cultural approach to travel, which is a high-selling point for many European and south East Asian destinations. Therefore, Gospodini (2004) argues that cities that are especially attractive tourist spots need considerable management in order to deal with the pressure on its capacity that is associated with high visitor numbers. On the other hand, it is important that other parts of the city are maintained effectively to sustain cultural heritage sites. Tweed & Sutherland (2007) point out an additional concern in their study of European heritage cities as the amount of pollution that is brought in with the increasing number of tourists, although the economic benefit of cultural tourism was equally realized.

In the context of Malaysian cultural heritage one of the challenges in the recent times is lower number of tourists visiting cultural heritage sites in Malaysia. The Malaysian tourism agency website mentions this challenge in their latest stat release (MyTourismData 2018). Figure 2.2 and 2.3 below presents the tourist arrival details in the past few years extracted from tourism Malaysia website. The figures clearly show a decline in the number of tourists visiting Malaysia drastically and report only 17.3 million tourist arrival in the year of 2017 compared to 26 million in 2016. One solution that has proven to have a positive impact on the sustainable development of cultural heritage destinations is the use of Information and Communication Technology (ICT) and AR. Moreover in very recent works, Chung et al. (2015b, 2017), Jung et al. (2015) have shown the positive effect on ICT and AR on tourists visit destination.

Tourist Arrivals & Receipts to Malaysia by Year

YEAR	ARRIVALS	RECEIPTS (RM)
2016	26.76 million	82.1 Billion
2015	25.72 million	69.1 Billion
2014	27.44 million	72.0 Billion

Figure 2.2 Tourists Arrival 2014-2016

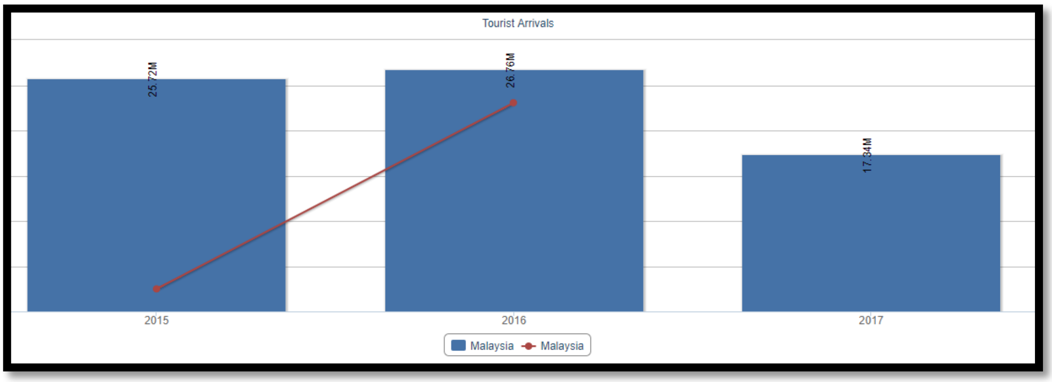

Figure 2.3 Tourists Arrival 2015-2017

e. ICT in Cultural Heritage Tourism and its Challenges

A number of authors including De Noronha Vaz et al. (2012) argued that there is a risk of cultural heritage tourism development becoming unsustainable in the future. One area that has significantly contributed towards sustainable tourism and the tourism economy is the implementation of modern Information and Communication Technology (ICT). Shanker (2008) argues that ICT has mainly contributed through the accessibility and sharing of information between various sectors to communicate through channels using the Internet and mobile services. It has been widely used in the extend and reach of marketing activities affecting the tourism experience due to its limited geographical boundaries. According to Collins et al. (2004), particularly small heritage sites often lack sufficient technical as well as economical resources to be developed sustainably. While heritage tourism management aims to conserve heritage sites in a meaningful manner, Hasse & Milne (2005) argue that communities are often excluded in the determining process and the handling of issues related to their heritage. Therefore, Gretzel et al. (2009) discuss the implementation of ICTs for the community and its heritage development, while Paskaleva & Azorin (2010) support the argument of destinations requiring to be represented in the increasing digital environment in order to stay competitive in the global market. (Shanker 2008) further outlines challenges and effects of ICT for the economic and social development being highly dependent on the ability to create and share information globally, while enabling access to information. Mitsche et al. (2008) on the other hand discuss the use of ICT for interpretation and marketing purposes of heritage sites that is communicated on cultural attraction and destination websites and outline potential effects it has on visitor interpretations. While