

The Next Frontier for Mobile Based Augmented Reality: An Evaluation of AR Uptake in India

K. Krishna Milan Rao, Nelvin Joseph, Praveen Dwarakanath

Abstract—Augmented and Virtual Realities is quickly becoming a hotbed of activity with millions of dollars being spent on R & D and companies such as Google and Microsoft rushing to stake their claim. Augmented reality (AR) is however marching ahead due to the spread of the ideal AR device – the smartphone. Despite its potential, there remains a deep digital divide between the Developed and Developing Countries. The Technological Acceptance Model (TAM) and Hofstede cultural dimensions also predict the behaviour intention to uptake AR in India will be large. This paper takes a quantified approach by collecting 340 survey responses to AR scenarios and analyzing them through statistics. The Survey responses show that the Intention to Use, Perceived Usefulness and Perceived Enjoyment dimensions are high among the urban population in India. This along with the exponential smartphone indicates that India is on the cusp of a boom in the AR sector.

Keywords—Mobile augmented reality, technology acceptance model, Hofstede, cultural dimensions, India.

I. INTRODUCTION

AUGMENTED REALITY is quickly becoming the next 'big' thing in the tech world. It is attracting millions of dollars in funding and the attention of tech giants such as Google and Microsoft [1], [2]. Augmented reality simply put is the technology which enhances/augments a real world environment with computer generated input such as graphics, sound, tactile feedback and GPS. It also aims to enhance the cognitive capability of users to interact with the augmented environment in real time. Augmented reality applications range from games, head up displays to educational and medical services [3], [4]. Augmented Reality based Gamification applications for education has also been introduced. Studies have shown a direct correlation between use of gamification strategies and increased student engagement [5]. Students were seen to engage actively with the content and this lead to an increase in positive attitude towards learning and an increase in productivity.

Augmented Reality applications have already made several commercial inroads with the release of GPS based games such as Ingress [6] and Head up Displays in premium automobiles and aircraft [7]. Augmented Reality technology has matured

over the last couple of years and it is now possible for commercial high quality AR services and applications to be introduced to the average consumer. It is also fast becoming an important tool for marketing and has shown positive brand association [8]. While the use of Augmented Reality apps has been on the rise, there is a divide in the uptake of the technology not only between developed and developing countries. There are several hurdles that remain to be cleared before AR applications can achieve mainstream success.

One of the innovations of the tech world – the smartphone – has opened up a path towards the spread of AR applications and services. Mobile computing systems such as Smartphones and Tablets contain all the hardware components for a Augmented reality Device – Processor, Camera and MEMS sensors (accelerometers, GPS chips and solid state compass) [9]. The explosive growth and penetration of smartphones have helped to increase the spread of Augmented Reality apps.

The falling prices and ubiquitous availability of Mobile Computing Systems such as smartphones have given an edge to Augmented Reality over technologies such as Virtual Reality that require expensive dedicated devices for operation and use. Moreover, the penetration of these portable devices in developing countries such as India is growing exponentially. India is expected to have around 500 million smartphone users and over 400 million wireless connections by 2017 [10]. These developments and will give Augmented Reality an edge in India and other developing countries over other technologies.

This paper investigates and predicts the rate of uptake of Augmented Reality technologies and applications in India.

II. RELATED INFORMATION

A. Factors which Affect Behaviours and Intention to Use Augmented Reality

The three major factors in the acceptance of any technology are Perceived Usefulness, Perceived Ease of Use and Perceived Enjoyment [11]. Perceived Usefulness is the degree to which the application or service helps the user to reach his goals and achieve success. Perceived Ease of Use is the degree to which the user finds the application or service to be intuitive. Perceived Enjoyment is the degree to which the user derives pleasure or satisfaction from the interaction with the service or application. These are the three yardsticks/constructs (derived from the Technology Acceptance Model, 1) that is used to predict the attitudes and behaviour of users towards a particular technology [12]. Another important parameter that needs to be taken into consideration when trying to improve the uptake rates of the

Nelvin Joseph is the Chief Technical Officer (CTO) of an Augmented Reality startup Empower Labs, Hyderabad, Telangana 500034 India (e-mail: nelvin.joseph@empowerlabs.ooo).

K. Krishna Milan Rao is the Chief Executive Officer (CEO) of an Augmented Reality startup Empower Labs, Hyderabad, Telangana 500034 India (corresponding author, e-mail: krishnamilan.rao@empowerlabs.ooo, krishnamilanrao@gmail.com).

Praveen Dwarakanath is the Co-Founder and Director of Accendere Knowledge Management Services Pvt. Ltd., Anna nagar West, Chennai 600101, India (e-mail: praveen@accendere.co.in).

technology is the aesthetics of the augmented reality apps. Aesthetics of an AR app has a positive influence on the Perceived Usefulness, Ease of Use and Enjoyment. It is particularly important as good aesthetics has been linked to the halo effect which is defined simply as the tendency through

which initial impressions influence the overall judgment of a product despite being offered contradicting evidence [13]. Aesthetics also takes special significance as smartphones screens are considerably smaller than desktops.

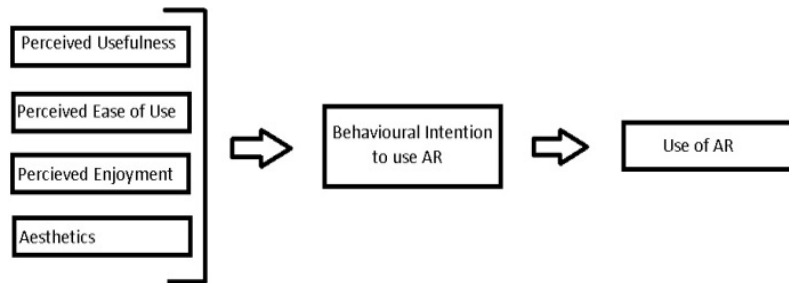


Fig. 1 Technology Acceptance Model

Fig. 1 shows the Technology Acceptance Model, with Perceived Usefulness, Perceived Ease of Use, Perceived Enjoyment and Aesthetics having an influence on the Behavioural Intention to use Augmented Reality Technology and Devices which drives the actual use of the products.

B. Hofstede Cultural Dimensions

While Perceived Usefulness, Ease of Use and Enjoyment along with the aesthetic quality of the Augmented Reality Experience have a major influence on its uptake and acceptance among users; another important part of the puzzle is the culture of a particular region and the smartphone penetration in the region.

Cultural differences often play a huge role in the adoption rates of technology even in the developed world. This is especially true of app based AR as it operates as part of an interlinked communities and widespread acceptance is crucial. Differences in adoption rates of AR between Eastern and Western developed countries have been investigated by other researchers. Geert Hofstede, a Dutch Social Psychologist has developed the Cultural Dimensions Theory which is used to compare the cultural dimensions of various countries. Hofstede et al. listed out the main cultural dimensions that can be used to characterize/compare the cultures and societies of various regions and countries [14]. The four main cultural dimensions are Masculinity/Femininity, Power Distance, Individualism/Collectivism and Uncertainty Avoidance.

Masculinity/Femininity – A high score (Masculine) on this dimension indicates that the society values competition and achievement more than caring for others and quality of life. A low score (Feminine) indicates that a particular society values caring for others and quality of life over other goals.

Power Distance is defined as the extent or degree to which inequality in power is regarded as normal within the society. Societies which score high on this dimension are said to have largely hierarchical order.

Individualism/Collectivism – A high score (Individualism) indicates a low interdependence among the members of society and vice versa. Users in cultures with low scores

(Collectivism) tend to place a lot of importance on the views and opinions of others and conform to social norms.

Uncertainty avoidance is the extent to which the culture views new or unexpected events as unfavourable and the level of risk they deem as acceptable. Such cultures may have lower uptake rates of new technologies initially due to their novelty.

The Masculinity/Femininity cultural dimension is said to influence both Perceived usefulness and Perceived Ease of Use. Typically Perceived Usefulness has been hypothesized to receive higher score in Masculine cultures and countries as they tend to focus on achievement of work goals and success [15]. Perceived Ease of Use has been hypothesized to receive higher scores in Feminine countries where individuals place higher importance on the availability of tech support [15].

Power distance is said to positively influence the perceived enjoyment of the user experience. Perceived Enjoyment has been hypothesized to be higher in those cultures with higher power distance. Reference [16] has shown that certain countries with higher power distances display preferences to various hedonic services and self-indulgence as opposed to low power distance countries. Probable reasons could be an overall comfort with regard to status and position in life.

Social Influence to try and adopt Augmented Reality Technologies has been hypothesized to be higher in Collectivist Societies as opposed to those with Individualistic tendencies. Evidence has shown that word of mouth information flow is indeed higher in Collectivist societies and countries [16].

Some of the sticking points for users from surveys have been fear of Information flood, loss of autonomy and of the virtual replacing the real [17]. The survey presented to the audience a series of Augmented Reality situations set in the future and recorded their experience to it. The scenarios included Augmented Reality projected onto glasses while jogging, commercial services and advertisements shown on the Mobile Augmentation Device, a virtual mirror which enabled the user to try on clothes, fabrics and accessories in a hassle free manner by overlapping the image of the customer with those of the products [17].

The response of the mainly urban, well-educated youth in Finland (where the survey was conducted) was ambivalent. This clearly indicates that players in the Augmented Reality space must take into consideration fears and expectations of potential users. As a side note, these results could also be a consequence of a high Uncertainty Avoidance dimension of Finnish Society. This would cause a certain degree of mistrust for new unknown situations or experiences. Moreover, cultures with low power distance dimension like the Finnish culture [16] could also be a deterrent to the quick uptake of Augmented Reality.

According to [18] (Fig. 2), India has relatively large power distance and Masculinity of 77 and 56. India shows a moderate score of 48 for the Individualism dimension which indicates a society with mixed individualistic and collectivistic traits. India also has a low uncertainty avoidance which indicates that the society is tolerant of new and unexpected experiences and adapts/adjusts accordingly.

The High power distance and Masculinity cultural dimensions of India indicate the probability of higher Perceived Enjoyment and Perceived Usefulness respectively. The moderate Individualism score indicates that while word of mouth information exchange of AR would not be very high yet it would not be completely absent either. The Low Uncertainty Avoidance dimension also bodes well for the uptake of a relatively new technology such as AR.

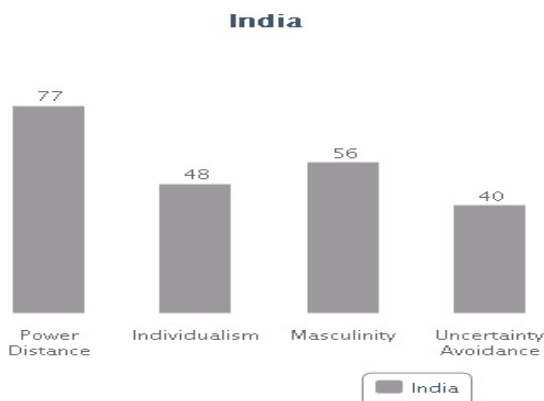


Fig. 2 Hofstede Cultural Dimensions – India [18]

When the cultural dimensions of India is compared with that of an Eastern culture such as that of Korea, it still scores higher on the Power Distance, Individualism & Masculinity dimensions and lower on the Uncertainty Avoidance dimension, indicating that quick AR uptake in India is definitely feasible

However, studies have shown that while all the factors are important in the usage and uptake of Augmented Reality, the aesthetics of the Augmented Reality apps has a strong influence on Perceived Enjoyment regardless of the cultural dimension of a particular society or culture [19], [20].

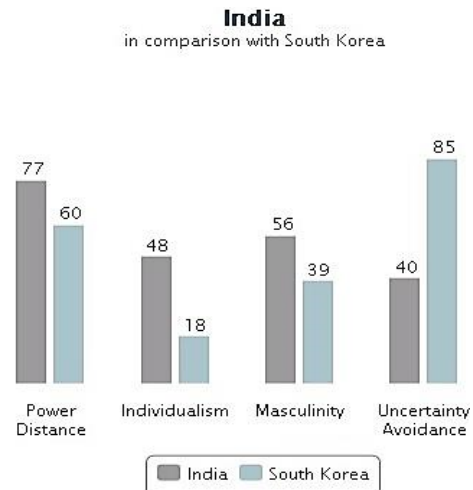


Fig. 3 Comparison of Cultural Dimensions – India vs South Korea [18]

III. RESEARCH METHOD

An online survey was conducted through Survey Monkey and subsequently responses were collected. The survey included three main parts. Part 1 collected information of the user along with information regarding smartphone and internet usage patterns. The second part included four scenarios to be evaluated and responses were recorded on a 5 point Likert scale from Strongly Agree to Strongly Disagree.

The Scenarios in the survey are replicated in verbatim as follows:

A. Scenario 1- Augmented Shopping App

You do not usually buy clothes online. However, your friends introduced you to a new app which they say completely changes things. You find a couple of jeans and accessories that are appealing and select them on the app. You click on a button in the app named the virtual mirror. The app switches on the front camera. Somehow magically the items you choose appear on your body and you can check whether the products suit you.

B. Scenario 2 - Traffic Gamification App

Games are primarily played for leisure. However, they can also be modified in such a way that you can even cure Alzheimer's disease! The results of such games have found that its users were able to match or outperform algorithmically computed solutions. Imagine the following scenario. You are sitting in your car stuck in a traffic jam on your way home from work. You stumble upon a game in the app store and start playing the game. The game uses your inputs to arrive at a solution to reduce the traffic congestion.

C. Scenario 3- Augmented Furniture App

Imagine the following scenario. You are trying to buy furniture for your house. You are having a hard time figuring out if the item you have picked fits in with the décor of the house. You try an app which uses the main camera and 'enhances' the image by placing the item in a location of your

choice at your house.

D.Scenario 4- Augmented Reality Educational App

Imagine the following scenario. You are preparing for a biology exam on the various organs and tissues of the body. Instead of using your textbook, you and your friend use an app which utilizes the camera of your smartphone and it projects the image of tissues and organs onto the body of your friend which you can then closely examine in three hundred and sixty degrees.

The questions in part two were designed according to previous research. Four sets of questions related to Intention to Use "I would like to try", Perceived Usefulness "It would help me/save time" and Perceived Enjoyment "I would enjoy". Perceived Ease of Use and Aesthetics could not be determined from the scenarios and were thus omitted from the survey.

IV. RESULTS AND ANALYSIS

A total of 346 survey responses were collected by creating an online survey form via survey monkey and spreading the link through the internet. Six responses were deleted due to incomplete information.

The 340 survey responses were divided into two groups – 273 Responses from India and 67 Responses from the Rest of the World (ROW). The responses from the Rest of the World included the following Countries – USA, UK, New Zealand, and Italy.

The large majority of the survey audience was in their 20s and the average age of the respondents from India and the rest of the world is 27.51 years and 27.53 years respectively.

Overwhelming majorities (90.6%) of the respondents were from urban areas and 98% of the respondents owned smartphones. 73.6% of the respondents had fast mobile internet connections – either 4G or 3G services. A further 21.4 % of the population used a mix of 3G and 2G services.

An overwhelming 6.1 % of respondents both from India and the Rest of the World considered technology to be a necessity not a luxury

The scenarios were presented to the survey audience after which they were asked to answer three evaluative questions; in order to determine 'Intention to try', Perceived Usefulness and Perceived Enjoyment' on a 5 point Likert scale ranging from Strongly Agree to Strongly Disagree. Strongly agree, Agree, Neutral, Disagree and Strongly Disagree were given values of 5,4,3,2 and 1 respectively.

The Means and Standard deviations of the three evaluative questions presented after each scenario is given in Table I for survey responses from India and in Table II for survey responses from the rest of the world.

The Mean values of the responses to the three evaluative questions in all the four scenarios show values from 3.6 to 4.4; indicating that respondents showed positive 'Intention to Use', 'Perceived Usefulness' and 'Perceived Enjoyment'

The standard deviation in all scenario responses except one did not cross a value of 1.

A t test was then conducted to determine whether the null hypothesis H was correct. Null hypothesis: The responses

from the evaluative questions have similar means in both responses from India and the Rest of the World.

The t values were determined by using the following formula for each of the three evaluative questions answered by Respondents from India and Respondents from the Rest of the World.

In Fig. 4, X_1 and X_2 are the means of the evaluative questions (from all four scenarios) from India and the Rest of the World respectively.

n_1 and n_2 are the number of responses from respondents in India and from respondents in the Rest of the World respectively.

s_{X1} and s_{X2} are the standard deviation of the responses from India and Rest of the World respectively.

$$t = \frac{X_1 - X_2}{s_{X1X2} \cdot \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

where

$$s_{X1X2} = \sqrt{\frac{(n_1 - 1)s_{X1}^2 + (n_2 - 1)s_{X2}^2}{n_1 + n_2 - 2}}$$

Fig. 4 Formula for obtaining t values

TABLE I
MEANS (M) AND STANDARD DEVIATION (SD) OF SCENARIO SPECIFIC EVALUATIVE QUESTION RESPONSES BY RESPONDENTS IN INDIA

N = 273		Intention to Use		Perceived Usefulness		Perceived Enjoyment	
Survey Responses - India							
SCENARIOS	M	SD	M	SD	M	SD	
Augmented Shopping App	4.081	1.104	3.849	0.969	3.985	0.950	
Traffic Gamification App	4.077	0.862	3.746	0.950	3.926	0.867	
Augmented Furniture App	4.200	0.816	4.062	0.856	4.100	0.841	
Augmented Reality Educational App	4.082	0.940	4.083	0.916	4.029	0.919	

N is the number of survey questions response

TABLE II
MEANS (M) AND STANDARD DEVIATION (SD) OF SCENARIO SPECIFIC EVALUATIVE QUESTION RESPONSES BY RESPONDENTS IN REST OF THE WORLD

N = 67		Intention to Use		Perceived Usefulness		Perceived Enjoyment	
Survey Responses – Rest of the World							
SCENARIOS	M	SD	M	SD	M	SD	
Augmented Shopping App	3.940	0.895	3.895	0.812	4.059	0.730	
Traffic Gamification App	3.850	0.965	3.439	0.955	3.666	0.893	
Augmented Furniture App	4.333	0.745	4.014	0.855	4.104	0.755	
Augmented Reality Educational App	4.149	0.901	4.164	0.939	4.089	0.909	

N is the number of survey questions response

t1, t2 and t3 all correspond to the t test values calculated between the responses from India and the Rest of the world for the evaluative questions concerning 'Intention to try', 'Perceived Usefulness' and 'Perceived Enjoyment' in specific scenarios.

The values of t_1 , t_2 and t_3 for each scenario are given in Table III. The values of n_1 and n_2 were 273 and 67 respectively.

The calculated t values in Table III were examined with respect to the degrees of freedom and it was found that the t values pertaining to all the scenarios except the Traffic Gamification App Scenario do not cross the 60% confidence barrier; thereby proving that the null hypothesis is correct. This signifies that there is no significant difference between the responses to the three evaluative questions in three of the scenarios when comparing India and the Rest of the World.

In the case of the Traffic Gamification App Scenario, it is seen that the mean values for the three evaluative questions are lesser in the case of responses from the Rest of the World as compared to India. This indicates that the urban youth in India have positive intentions towards Augmented Reality Gamification based applications and services. This result of the survey takes special significance as it indicates that though India is a developing country; it has immense potential for the acceptance and uptake of Augmented Reality among the urban youth of the country.

TABLE III
T TEST VALUES OF SCENARIO SPECIFIC EVALUATIVE QUESTION RESPONSES – INDIA VS REST OF THE WORLD

	$N_1 = 273$	Intention to Use T_1	Perceived Usefulness T_2	Perceived Enjoyment T_3
$N_2 = 67$				
SCENARIOS				
Augmented Shopping App		0.972	0.359	0.597
Traffic Gamification App		1.891	2.374	2.194
Augmented Furniture App		0.993	0.4127	0.035
Augmented Reality Educational App		0.528	0.647	0.481

N_1 and N_2 is the number of survey question responses of India and Rest of the World respectively

The survey indicates that the Technology Acceptance Model for Augmented Reality shows strong potential in India with high mean values for Intention to try, Perceived Usefulness and Perceived Enjoyment. These are benchmarks which predict the uptake rates of technology in a particular culture, society and country. In addition, smartphone penetration in India is increasingly exponentially and as evidenced by this survey, almost all the respondents in urban India possessed a smartphone with mobile internet connectivity.

Certain concerns regarding privacy of Augmented Reality apps and spreading awareness of the term 'Augmented Reality' need to be addressed.

82.5% of all respondents considered their privacy to be a major concern and it sends a clear signal to AR developers about the need to secure user security and privacy.

22.9% of all respondents had heard about the term 'Virtual reality' but not 'Augmented Reality'. Stakeholders need to spread awareness about Augmented Reality and its potential.

V. CONCLUSIONS

The results of the survey indicated that the values of

'Intention to Try', 'Perceived Usefulness' and 'Perceived Enjoyment' in urban areas of India were at par with those from developed countries such as the USA and UK. Hofstede's research on cultural dimensions also show that India has high power distance, high masculinity and low uncertainty avoidance as compared to even developed eastern countries such as South Korea. Earlier research has shown evidence that cultures and countries with high power distance, high masculinity, and low uncertainty avoidance embraced new technologies much quicker than those cultures or countries at the opposite end of the spectrum. The survey results as well as favourable Hofstede cultural dimensions for technology acceptance and the exponential increase smartphone penetration in India cement the prediction that India is on the cusp of an Augmented Reality revolution. Stakeholders would be wise to take notice and invest in the radical new field of Augmented Reality.

ACKNOWLEDGMENTS

K. Krishna Milan Rao, Nelvin Joseph and Praveen Dwarakanath thank Karthick Chandra Isola and Geo George Philip for their help in carrying out and analysis of the research work.

REFERENCES

- [1] Ben Popper, "Google leads \$542 million funding of mysterious augmented reality firm Magic Leap", The Verge, 21 October 2014.
- [2] Microsoft Channel, YouTube (4), 23 January 2015.
- [3] Maier, Patrick; Tönnis, Marcus; Klinker, Gudron. Augmented Reality for teaching spatial relations, Conference of the International Journal of Arts & Sciences (Toronto 2009).
- [4] Mountney P, Giannarou S, Elson D, Yang GZ (2009). "Optical biopsy mapping for minimally invasive cancer screening". Medical Image Computing and Computer-assisted Intervention 12 (Pt 1): 483–90. PMID 20426023.
- [5] K. M. Kapp, The Gamification of Learning and Instruction: Game-based Methods and Strategies for Training and Education, Pfeiffer, 2012.
- [6] Gregory, Myk (2014-07-22). "Ingress: A Game, Lifestyle and Social Network in One!" When In Manila. Retrieved 2014-08-07.
- [7] "Airbus A318 approved for Head Up Display". Airbus.com. 2007-12-03.
- [8] John Mccarthy, "Infographic: Major brands and tech firms to look out for in virtual and augmented reality", The Drum, 22 October 2015.
- [9] Metz, Rachel. Augmented Reality Is Finally Getting Real Technology Review, 2 August 2012.
- [10] Harshith Mallya, "With 3rd largest smartphone market in the world, India to reach 314 million mobile internet users by 2017", Your Story, 21 July 2015. (<http://yourstory.com/2015/07/mobile-internet-report-2015/>).
- [11] Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS quarterly, 13(3): 319-340.
- [12] Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1992). Extrinsic and intrinsic motivation to use computers in the workplace. Journal of Applied Social Psychology, 22(1): 1111-1132.
- [13] Al Sokkar, A., & Law, E. (2013). Validating an episodic UX model on online shopping decision making: a survey study with B2C e-commerce. In Proceedings of the 5th ACM SIGCHI symposium on Engineering interactive computing systems, 297-306.
- [14] Hofstede, G. (2000). Culture's consequences: Comparing values, behaviors, institutions, and organizations across nations. London: Sage Publications.
- [15] Venkatesh, V., & Morris, M. G. (2000). Why don't men ever stop to ask for directions? Gender, social influence, and their role in technology acceptance and usage behavior. MIS quarterly, 24(1): 115-139.

- [16] Harris, P., Rettie, R., & Cheung, C. K. (2005). Adoption and usage of m-commerce: a crosscultural comparison of Hong Kong and the United Kingdom. *Journal of Electronic Commerce Research*, 6(3): 210-224.
- [17] Thomas Olssona, Tuula Kärkkäinen, Else Lagerstama and Leena Ventä-Olkkonenb, "User evaluation of mobile augmented reality scenarios", *Journal of Ambient Intelligence and Smart Environments* 4 (2012) 29-47.
- [18] Hofstede, Geert (1991). *Cultures and Organizations: Software of the Mind*. London: McGraw-Hill. ISBN 9780077074746, (<http://geert-hofstede.com/india.html>).
- [19] Lee, H., Chung, N., and Jung, T. (2015). "Examining the Cultural Differences in Acceptance of Mobile Augmented Reality: Comparison of South Korea and Ireland", In Tussyadiah, I. and Inversini, A. (eds), *Information and Communication Technologies in Tourism*, Springer International Publishing, Wien, New York, pp. 477-49.
- [20] Li, Y. M., & Yeh, Y. S. (2010) "Increasing trust in mobile commerce through design aesthetics. *Computers in Human Behavior*", 26(4): 673-684.