Understanding User Motivation for Augmented Reality Applications on Smartphones

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Abstract

The convergence of technologies has broadened the scope of applications possible today that were not realisable until just a few years ago. Augmented Reality (AR) is one such technology that has been actualised recently owing to the rapid evolution and adoption of smartphone technologies. Built on ubiquitous devices like smartphones, the adoption of multimodal & multi-use technologies like AR has not been correspondingly fast. This study's scope is to investigate the why and the how of the AR adoption process. Existing technology adoption models, although quite extensive, were formulated and used in a decade where technology-user interaction was one-dimensional in nature. However, owing to the increasing complexity of recent technologies, this interaction between the technology and the user has become immensely dynamic and complex as well, highlighting the insufficiency of current models to understand AR adoption better. Therefore, an exploratory study is undertaken to identify the user motivation to use AR applications on their smartphones to develop a holistic perspective of this process. This study conducted 18 in-depth interviews with smartphone AR users to understand their motivation, perception, attitude and usage of AR applications. The findings of the study suggest that apart from the already identified constructs in various technology adoption models, there are 5 key concepts that play important roles in this process, namely - 1) hedonistic or utilitarian projected attributes on the technology by the user, 2) context of interaction between the user and technology, 3) goal of the interaction, 4) motivators and 5) inhibitors that influence the interaction. Furthermore, this study identifies 4 major user motivations that push or pull a user to interact and continually use a technology - 1) to control, 2) to belong, 3) to escape, and 4) to explore. The findings of this study present a macro-perspective in the technology adoption process of AR applications on smartphones. It also proposes to adopt a social constructionist standpoint of technology adoption where both technology and users actively influence the adoption process of respective technology. Although a key limitation of this study is its immediate practical implications as this study does not aid in decision making, it, nevertheless, presents a stepping stone in understanding complex technologies better.

Keywords: Augmented reality, smartphones, user motivations, technology adoption

1. Introduction

Augmented reality (AR) as a technology specialises in adding on to our realities in a myriad of ways. With a history that spans over five decades, this technology has gone through multiple iterations of improvements to eventually bring it in the grasp of our palms. First conceptualised as an ‘experience theatre’ in the early 1960s and demonstrated as a prototype technology in the latter half of the same decade, the technology today has advanced beyond the level of just simulating virtual experiences in the real world (Carmigniani et al., 2010). Its applications include interfaces that allow engineers to visualise the individual components of their product without breaking it apart or ones that promote impactful learning in classrooms by moving beyond conventional diagrams. Additionally, it also aids consumer decision making by presenting a virtual sample of the product right in their living rooms or enhance our gaming experiences by making them more interactive. It is actively shaping and defining the innumerable possibilities offered by our increasingly convergent realities. From bulky and inefficient prototype demonstrations to useful regular applications, the technology has seen numerous cycles of evolution in its bid to perfect itself for regular consumption (Carmigniani et al., 2010).

The technical definition of augmented reality was first put forward by Ronald Azuma after a thirty year period of sluggish growth. He defined it as a variation of the virtual environment that allows co-existence of virtual and physical objects in real-time, registered in 3D (Azuma, 1997). With its objective centred around supplementing the real world with digital information, Azuma et al. (2001) state that the augmentation to our sensory perception can happen through either sight, hearing, smell, touch or a combination of these. Further research describes the interface itself to be either stationary or mobile. However, over the last two decades, its potential has been mainly studied as mobile interfaces in head-wearable and handheld systems (Azuma, 2001; Krevelen & Poelman, 2007; Zhou & Billinghurst, 2008; Carmigniani et al., 2010). Researchers have also laid out the key technological prerequisites for the technology to be able to overlay virtual information onto the physical world. These prerequisites include multiple sensors and trackers that act as input devices as well as display and user interaction systems that act as interface devices. Moreover, the technology also requires a strong computational system to process the information and present it in understandable formats (Azuma, 2001; Höllerer & Feiner, 2004; Zhou & Billinghurst, 2008; Carmigniani et al., 2010).

This technical complexity of AR systems has been identified by many researchers as a key limitation to its successful application in various practical fields (Azuma, 1997; Krevelen & Poelman, 2007). Thus, the diffusion of AR into society has been greatly restricted owing to its hyper-complexity and non-availability of compatible interface devices. This barrier was lifted to a great extent with the advent of smartphone technologies in the mid-2000s. Equipped with sophisticated cameras, geolocation tracking, accelerometers and gyroscopes, wireless communication and supremely advanced computer graphics and interaction systems, smartphone technology quickly presented itself as an ideal platform to implement AR systems (Pence, 2010; Olsson et al., 2012; Ko, Chang & Ji, 2013). Since the first demonstration of a smartphone based AR system as a tour guide in 2008 (Carmigniani et al., 2010), the technology’s accessibility has ballooned over the last 10 years, adding more than 3000 diverse AR applications available for use by the billions of smartphone users (Mike Boland, 2019). Novel research in AR systems on smartphones has been continuously exploring and identifying its applications in fields like education, healthcare, entertainment, military, tourism, navigation, industrial design and social interaction (Goldiez et al., 2004; Krevelen & Poelman, 2007, Javornik 2017). It is forecasted that AR consumer market will grow by more than 5000% in the next 6 years from 3.5 billion US dollars as of now to 198 billion US dollars in 2025 (Statista, 2019). However, the availability and accessibility of AR systems may only partially aim to explain its adoption by the masses; they do not represent a comprehensive explanation of its adoption.

Technology adoption or acceptance is defined as the process of user behaviour change to incorporate the technology in their day-to-day lives (Venkatesh, Morris, Davis & Davis, 2003). Research into technology adoption has rigorously studied it to explain the decision-making process of the users in adopting a particular technology and thus, ultimately predicting the success of the said technology. Various technology adoption and diffusion models like Unified Theory of Acceptance and Use of Technology (UTAUT), Diffusion of Innovation, Technology Acceptance Model (TAM) etc. have defined the key constructs that influence a technology's adoption (Davis, 1998; Venkatesh et al., 2003; Rogers, 2010; Venkatesh, Thong & Xu, 2012). There is also a recent paradigm shift in understanding technology adoption as a dynamic and continuous process rather than a linear and unidirectional one. Unlike the deterministic models, this perspective has also initiated discussions to view it from a social constructivist school-of-thought owing to the increasing complexity of the technologies and the user-technology interaction itself (Carroll, Howard, Vetere, Peck & Murphy, 2001).

Although the research into the adoption of augmented reality systems is quite scant, their findings are in alignment with the predictions of various adoption models. Research in specific contexts of AR use spells out *perceived usefulness*, *perceived ease of use*, *perceived enjoyment* and *social influences* as the primary factors that influence its adoption by the users (Theng, Mei-Ling, Liu & Cheok, 2007; Yusoff, Zaman & Ahmad, 2011; Olsson et al., 2012). However, studying the adoption of a multi-purpose and multi-modal technology like augmented reality requires a broadened perspective that takes into account the possible motivations rather than just reasons behind user's initial and continued intention to use technology. The understanding of user motivation in technology adoption from a constructivist point of view may reduce the gaps between expected and delivered performances of augmented reality technology (Bagozzi, 2007). The scope of this research, thus, is twofold - 1) *to identify the motivations that drive the adoption of augmented reality applications on the smartphones*, and 2) *to understand the role of user motivations amongst other factors that influence the adoption of augmented reality applications on the smartphones*.

This exploratory investigation into the motivations of AR users and non-users aims to understand the phenomenon of technology adoption. The study aims to add to the existing literature on AR adoption explaining *why* a user interacts and eventually adopts smartphone based AR applications. The further sections of the paper deal with exploring relevant literature in this field, setting the theoretical approach for this research, explaining the research methodology and the outcome of the investigation. The study identifies the key motivations that drive user intention to adopt the AR technology. It further proposes a holistic approach in studying technology adoption by highlighting the roles of understanding user motivations and the nature of user-technology interaction. Lastly, the paper discusses the implications and limitations of the findings of this study.

2. Literature Review

2.1 Understanding Technology Adoption

2.1.1 Technology Adoption Theories

The concept of technology adoption or acceptance is usually understood as the phenomena of user behaviour change in the context of technology usage. It aims to explain the process of technology adoption by users as individuals and as a collective, and defines key constructs that influence this adoption process (Davis, 1989). It is a heavily researched field in the studies of Science, Technology and Society that predicts growth and growth drivers of innovations in social and organisational contexts. Many theories and models have been proposed to study this phenomenon up until now but the most popular and practical concepts are *Technology Acceptance Model (TAM)*, *Diffusion of Innovation Model (DIM)* and *Unified Theory of Acceptance and Use of Technology (UTAUT2)* (Davis, 1989; Venkatesh et al., 2003; Rogers, 2010; Venkatesh, Thong & Xu, 2012). The Diffusion of Innovation Model is relevant in this field due to its thorough explanation of the process of diffusion of innovation into the society as well as the process of individual decision making for technology acceptance. The UTAUT2, on the other hand, identifies key constructs that play a role in this process and presents a model that predicts the likelihood of success of new technology.

In the context of technology adoption, Rogers (2010) describes a new technology in a much broader sense of *innovation*, which represents any technology, idea, object or practice that is 'perceived' as novel. Meanwhile, he describes adoption as the process of individual decision making of accepting technology and integrating it in their daily lives; this description being a universally accepted understanding of the term. His model has proved to be one of the earliest studies into the adoption phenomenon that is rooted in sociology (Rogers, 2010). The Diffusion of Innovation Model by Everett Rogers proposes a five-stage model of individual decision making to adopt a technology, represented as the flow of communication and interaction between the user and technology. The DIM proposes five stages, namely *Knowledge, Persuasion, Decision, Implementation* and *Confirmation,* in the individual technology adoption decision process. This model also proposes that the rate of adoption for any technology is uneven in the society and therefore a collective adoption takes places as a 'diffusion' through various adopter categories (Rogers, 2010). The model's macro-understanding of the technology adoption process as a society complements UTAUT2's micro-perspective of adoption of technologies in various cross-sectional settings (Straub, 2009).

UTAUT2 and other theories of adoption, contrarily, are typically based on the behavioural change theories like Theory of Reasoned Action (TRA) and Theory of Planned Behaviour (TPB) that propose that perceived behavioural control, subjective norms, and attitudes towards a new behaviour together shape the behaviour intention which ultimately results in a behaviour change (Davis, 1989; Venkatesh et al., 2003). The application of these theories in technology adoption studies was first proposed in the Technology Acceptance Model (TAM) which identified two factors that influence acceptance decision of an individual - *Perceived Usefulness* and *Perceived Ease-of-Use* (Davis, 1989). Proposed by Fred Davis, this simple model proposes that these two factors shape the user's attitude towards technology, influencing their intention to use the technology and ultimately accepting it. Having found applications in numerous contexts and fields despite due criticisms (Bagozzi, 2007), this theory was eventually absorbed into a comprehensive theory proposed as UTAUT.

Venkatesh et al. (2003) collated literature from eight different models to present a unified theory of technology acceptance with empirically tested constructs that influence intention and behaviour change. Along with absorbing TRA, TPB and TAM, UTAUT also incorporated the Motivational Model, combined TAM-TPB model, Social Cognitive Theory, Innovation Diffusion Theory and Model of PC Utilization theories. UTAUT defines four constructs that influence behaviour intention of a user towards a technology; the process is moderated by age, gender, voluntariness of use and experience. These constructs are 1) *Perceived Usefulness* of the technology (performance expectancy), 2) *Perceived Ease-of-Use* (effort expectancy), 3) *Social Norms* (subjective and social norms) and 4) *Facilitating Conditions* (Venkatesh et al., 2003). UTAUT was later expanded into UTAUT2 by Venkatesh et al. (2012) to incorporate additional relevant constructs like 5) *Hedonic Motivation* (attraction to innovation), 6) *Price Value* and 7) *Habit*, meanwhile dropping voluntariness of use as a moderator. UTAUT2 thus far has been frequently updated and adapted to include constructs of ever-evolving Information System (IS) technologies (Venkatesh et al., 2012).

A divergent approach to technology adoption is presented as the Technology Appropriation Model (Carroll et al., 2001). Adopting a social constructivist approach to technology adoption, the Appropriation Model rejects the deterministic, linear models of technology adoption and identifies it as a dynamic, multi-directional interaction between users, technology and the social world. It defines ‘appropriation’ as a process of exploration, evaluation and adoption or adaptation of technology in user’s lives. Identifying the processes of *Appropriation, Non-appropriation* and *Dis-appropriation* as possible outcomes of the adoption process., the model proposes that the adoption process is usually undertaken by users to address the issues of *Identity, Cohesion* and *Power* in their lives (Carroll et al., 2001). Unlike UTAUT2 and its predecessors, this theory only identifies critical concepts that are influencing technology adoption in general backdrops. However, the model also opens research in this field to a more fluid perspective by grounding its research in the social constructivist school of thought.

2.1.2 Drawbacks of Technology Adoption Theories

The technology adoption models like TAM, UTAUT, DIM have been applied in many scenarios in different fields of applications. The constructs identified by these models, especially TAM and UTAUT, have a strong heuristic value that has been validated thoroughly. However, as suggested in the previous section, the adoption process is neither a one-off process nor is as simplified as proposed by these models. Therefore, the next step is to understand and discuss the major drawbacks of these models to identify the missing gaps better.

The drawbacks of the available technology adoption theories are better visualised when its very theoretical foundation is critically reviewed. The fundamental basis of these models is resting on the direct influence of user attitude on their intention to use a technology and the influence of this intention on their behaviour change (Bagozzi, Baumgartner & Yi, 1989); both these relationships are explained better with a long list of independent variables that have an impact, like perceived usefulness, ease of use, social influence etc. While these linkages have been empirically tested multiple times over, the insufficiency of the described constructs is obvious to observe as numerous additions have been made to both TAM and UTAUT over time. While TAM only proposes two constructs that shape the user intentions, UTAUT has more than 41 independent variables that make up the constructs influencing it and another 8 independent variables that influence the behaviour change (Bagozza, 2007). Along with Roger's Innovation Diffusion Model, these theories have been criticised for their inadequacy to explain the complex relationships between the user and technology as such theory applications tend to ignore many important predictors that influence this relationship (Mohr, 1976; Plsek & Greenhalgh, 2001). Moreover, the simple understanding of attitudes shaping intention which then shapes the behaviour has been criticised as well. Research has highlighted that these linkages may not be as strong as established by many adoption studies but rather may completely be missing in certain situations, e.g. when behaviour change does not need much cognitive effort (Bagozzi et al., 1989). Research also identifies a missing link in the understanding of the formation of attitude towards technology itself. Bogazzi (2007) investigates this further and proposes goal-setting as the initiation step of technology use and ultimately adoption. He also identifies that the linearity of the models has little value as the time gap between forming attitudes, developing an intention and adopting a behaviour change is variable and, therefore, open to many external and internal influences (Bogazzi, 2007). Lastly, the role of the technology itself has been largely understood in the context of influencing user attitude towards it, manifesting as technology's perceived ease-of-use and technology's usefulness. As technology has evolved over the few decades, the role of technology has evolved as well to move beyond accomplishing goals and addressing the hedonistic needs of the user. A technology that stands tested on the identified predictors and constructs of technology adoption model may still be refused by the user. These theories fail to explain the cause of such varied interactions and, unsurprisingly, also fail to acknowledge social, group and cultural predictors.

The drawbacks of the various technology adoption models, hence, can be broadly put in two categories - 1) *diminishing value of the theoretical framework of the models,* and 2) *change in the role of users, technology and the complex relationship they share*; thus demanding a shift in perspective. Such a shift has been proposed as the Technology Appropriation Model that aims to take a social-constructivist approach to technology acceptance (Carroll et al., 2001). Even though this model is a step in the right direction, it still studies appropriation of technology in isolation, ignoring other competing technologies and misses the cue to describe constructs that shape appropriation in-depth, as its biggest contribution is of proposing an alternative model of technology adoption. This model misses identifying the role of the scenarios in which technology is appropriated over other existing technologies as well as proposes the influencing constructs only from the point-of-view of the youth engaging with the technology. Acknowledging these drawbacks, Bagozzi (2007) identifies the role of user motivations in this process and highlights it as a compatible perspective to the study of technology adoption, which so far has been missing in technology adoption models.

2.1.3 Role of Motivation in Technology Adoption

Motivation can be explained as the reason behind the actions, goals and willingness of a person (in context of the technology adoption, technology users) (Ryan & Deci, 2000). Broadly described, these motives could either be intrinsic or extrinsic in nature, depending on whether the motivation is inspired from within or influenced by external events or people. Given the vastness of this concept, many theories have been proposed to elaborate on the concept as well as make it applicable in practical fields (Ryan & Deci, 2000). Both Davis et al. (1989) and Venkatesh et al. (2003) have incorporated the concept of motivation to their proposed models respectively to hypothesise their constructs. They argue that extrinsic motivations like the usefulness of technology are one of the key determinants of technology adoption. Although Venkatesh et al. (2012) adapted their model of UTAUT to include hedonistic motivations, as a form of intrinsic motivation, as well as social influences. However, their definition of hedonistic motivation is only related to the novelty of the technology. This makes it a one-dimensional perspective in understanding the role of motivations in technology adoption. On the other hand, Rogers in his Diffusion of Innovation Model initiates the discussion on individual adoption decision of a user by specifying the *needs* of a user to use technology. He recognises that every decision made towards a technology use is directed by a need. However, he also argues that the need is inherently linked with the awareness of the technology. Ending the discussion on this topic while referring to it as a chicken-egg situation, he explains that awareness of technology may come before a user acknowledging his needs from a technology and vice-versa is true as well. (Rogers, 2010). The problematic part is that the topic of needs and motivations has been left largely unaddressed by Rogers along with others.

The role of motivations in technology adoption has been partially acknowledged by studies investigating the adoption of media technologies. Uses and Gratification theory has been applied to better comprehend the media needs, adoption and preference of users. This, user-entered, approach posits the need for a deeper understanding of *why* a media audience uses or prefers one media vis-a-vis other available media. It acknowledges the existence of a latent reason behind user's media intention, consumption and adoption (West, Turner & Zhao, 2010). This theory has been actively pursued to explain the rise and impact of new-age communication technologies like smartphones, the internet, social media, games, and other entertainment technologies including AR. This approach, too, suffers from many drawbacks for being too open-ended and individualistic (Ruggiero, 2000) and, thus, cannot be treated as a functional alternative to contemporary all-encompassing technology adoption models. This research recognises these limitations and therefore only borrows the generic definition of 'motivation' to explore its role in AR technology adoption.

2.2 Augmented Reality Systems

2.2.1 Understanding Augmented Reality Technology

In their bid to formulate the taxonomy of such technologies, Milgram and Kishino (1994) defined a *virtuality continuum* to represent all display technologies that aid in the visualisation of real, virtual and mixed environments. At the centre of this spectrum are the Augmented Reality (AR) technologies that have been fundamentally categorised as interface technologies. Augmented reality is a constructed reality based on the physical environment supplemented by relevant virtual information (Azuma, 1997). This definition given by Ronald Azuma in 1997 is the most agreed upon definition of AR technologies in the research community. In his two thorough surveys of AR, the first ones in the field, he also lays out four properties of AR-based systems - "1) *combines real and virtual*, 2) *interacts in real-time*, 3) *registers in three dimensions* and 4) *interactivity*" (Azuma, 1997; Azuma et al., 2001). These defining traits of AR have been instrumental in differentiating it from other Mixed Reality (MR) technologies like Virtual Reality (VR). Citing augmented reality as an example of *Intelligence Amplification*, Azuma (1997) states that the key differentiator of AR from VR is its ability to supplement reality rather than replace it. In VR systems the user is completely immersed in a synthetic virtual environment and can interact with it. Even though immersion and interaction are fundamental to AR systems as well, they differ from VR systems by offering a semi-virtual environment to the user to interact with.

This loss in quality of immersion in the AR environments is compensated by an increase in the interactivity of the system (Milgram & Kishino,1994). In AR environments, a user is, therefore, able to interact with the virtual information using real objects. This quality makes AR categorically dependent on sensing, computing and display system technologies (Zhou et al., 2008). Implicitly, restricting its growth for the lack of sophisticated practical technologies as explained below.

As a reality based interface technology, an AR system deploys sensors and trackers as input devices, a computing system to make sense of the input data and display & interface technologies as output devices (Azuma, 1997; Carmigniani et al., 2011). For a user to interact with virtual information projected onto the real world, display technologies, therefore, act as the *enabling* technology for AR (Azuma 2001). Even though the initial innovations and investigations in AR systems explored it as a head-wearable device, today AR display systems are classified into three types, namely - Head Mounted Display Systems (HMD), Handheld Display Systems, and Spatial Systems (Azuma et al., 2001; Krevelen & Poelman, 2007). These display systems rely on various display techniques like retinal, optical, projective, video displays etc (Krevelen & Poelman, 2007). In AR systems, this output display system is complemented by a demanding array of sensors and trackers based input system. While a camera only digitises optical information, various sensors are needed to comprehend the real environment. This is achieved through application of various user movement tracking sensors like gyroscopes, accelerometers, GPS, ultrasonic, magnetic and optical sensors along with marker-based tracking (i.e. depends on visual cues to display virtual information) and marker-less tracking (i.e. does not use visual cues or markers) technologies (Höllerer & Feiner, 2004; Reitmayr & Drummond, 2006; Zhou et al., 2008). Since AR is an interactive technology, another prerequisite technology for AR is the user-interface and interaction system. Given that interactivity has been classified as a defining characteristic of AR systems, it has received the most attention by the research community in the AR field from both technical and user evaluation points of view (Olsson & Sato, 2011; Ko et al., 2013; Kim, Hwang, Zo & Lee, 2016 and Javornik, 2016). Finally, an AR system has a prerequisite of a computational system to receive, process and relay virtual and digitised information (Carmigniani et al., 2011). The complexity of AR system and its dependence on various unrelated technologies inhibited its growth as a majority of the research effort was poured solely into creating a functioning and standalone wearable AR device that acts, principally, as a portable mini-computer deploying augmented reality systems. Developing a head-mounted or handheld device with these capabilities from scratch proved to be a strong deterrent in its practical application as the costs of a standalone AR device outweighed its functional benefits (Azuma et al., 2001).

2.2.2 Augmented Reality on Smartphones

The advent of smartphone technologies, the complexity of AR systems discussed above was addressed by the far more complex smartphone technology. The smartphone presented itself as a ubiquitous device capable of performing multiple tasks like communication, information search, gaming and entertainment, and utilitarian functions. Moreover, smartphones already came equipped with component technologies of AR, thus solving the issue of finding a compatible technology for AR systems. This resulted in a boom of AR-related research (Pence, 2010; Ko et al., 2013). Fields like education & training (Dede, 2005; Dunleavy, Dede & Mitchell, 2009; Bacca, Baldiris, Fabregat, Graf & Kinshuk, 2014), tourism (Bruns, Brombach & Bimber, 2008; Nassar & Meawad, 2010; Yovcheva, Buhalis & Gatzidis, 2012) gaming (Raushcnabel, Rossman & Dieck, 2017), marketing (Billinhurst, Belcher, Gupta &

Kiyokawa, 2003; Javornik, 2017) and entertainment (Javornik, 2017) have led the way in incorporating AR systems as Mobile Augmented Reality Systems (MARS) on handheld devices like smartphones and tablets (Ko, Chang & Ji, 2013). Independent investigations into applications of AR in marketing, consumer behaviour, tourism, gaming and education find a common ground in identifying AR's interactivity, immersion and novelty as impactful characteristics of the technology, influencing the quality of interaction with the users (Kim et al., 2014; Raushnabel et al., 2017; Javornik, 2017). As mentioned earlier, there is also research studying the usability, user experience and the impact of these characteristics on the AR-User interaction. Research from various fields find AR to be persuasive, engaging and immersive (Dede, 2005; Dunleavy et al., 2009; Ko et al., 2013; Huang & Hsu Liu, 2014;). A comprehensive list of AR media characteristics, owing to its interactivity and immersive features, was first published in 2016 by Javornik. He listed *interactivity, virtuality, mobility, multi-modality, hyper-textuality* and *location-specificity, augmentation* as the defining media characteristics of AR systems. His research points out that while AR enjoys a genuine attraction and positive perception by the users, its unique property of altering the reality is not widely exploited in practical realms that encourages a mass usage of AR systems. (Javornik, 2017).

The definitions of AR technology, its characteristics and the technical requirements have been polished and improved over the last two decades, especially since the realisation of MARS as a commercially attainable AR system. These improvements have come after a long period of non-availability of compatible and accessible devices for AR systems. However, the research into user evaluation of the technology has rarely ventured beyond experimental trials and laboratory tests (Yusoff & Ahmad, 2011). The foundations of augmented reality as a potentially revolutionary technology is strongly anchored in various research aiming to improve the functionality of technology, usability, user experience, applications and impact but these studies are quite fragmented. There seems to be a general dearth of in-depth, cross-functional and generalised investigations in the field of AR. The prior research also uses demonstrative AR systems and very few research involves functioning active AR applications on the smartphones (Theng et al., 2007; Rauschnabel et al., 2017). More research is needed which looks at augmented reality technology as a whole and is not restricted to particular application sectors like education, gaming etc. Moreover, a technology's success is merited by both the quality of technology as well as the user's positive or negative reaction to their interaction with the technology. Therefore, there is a compelling case to dive deeper to study its adoption by users and society.

2.2.3 Adoption of Augmented Reality

Relevant literature in the studies of AR adoption is scant. The available research in this field is fairly recent, going back to little beyond half a decade (Yusoff & Ahmad, 2011; Rauschnabel et al., 2015; Kim et al., 2016). This is due to the non-availability of an AR device in the mass-market. Consequently, most research in AR adoption is based on smartphones. Nevertheless, the onset of the first AR headset devices like Google Glass and Microsoft HoloLens had sparked initial research into the adoption of these technologies (Rauschnabel et al., 2015). Most studies undertaken to understand AR adoption are cross-sectional and deploy quantitative methodologies to validate the constructs of the Technology Acceptance Model. *Perceived usefulness* (or *uselessness*) and *perceived ease of use* have been found to be valid constructs that influence AR's adoption (Theng et al., 2007; Olsson & Salo, 2011; Yusoff & Ahmad, 2011; Haugstvedt & Krogstie, 2012; Olsson et al., 2012). There is also literature studying the impact of AR's media characteristics on its adoption, identifying its novelty, perceived enjoyment and interactivity as key drivers of the adoption (Huang et al., 2014; Javornik, 2017; Rauschnabel et al., 2017). Studies that have identified these hedonistic constructs have their theoretical background set in Uses and Gratification (UGT), Usability and User Experience (UX) principles rather than the technology adoption theories. It is worthwhile to note the interactivity of AR media and its impact on adoption has been identified to be linked to the Flow Theory (FT) as well (Rauschnabel et al., 2017). It is evident that relevant literature in AR adoption does not provide a mature standpoint on the process. Moreover, these studies either aim to validate outdated constructs from TAM to study adoption or aim to identify constructs relying on data from users who have little exposure to AR applications. Lastly, most MARS based research is contextual to particular application fields such as gaming (Rauschnabel et al., 2017). A generic broad view study of AR applications on the smartphone is lacking as well.

The insufficiency of AR adoption literature can be partly compensated by reviewing investigations that study the adoption of smartphone devices and technologies. Many cross-sectional quantitative research has been conducted to study the adoption of smartphones in various contexts and fields of application. It is noted that most of the literature on smartphone adoption has employed TAM to either validate its constructs or add additional ones to it. In an overview, both *perceived ease of use* and *perceived usefulness* have been found to be critical in smartphones' adoption (Park & Chen, 2007; Aldhaban, 2012). Noteworthily, four pivotal additions to these constructs have been identified by various studies in smartphone adoption, namely - *hedonistic*, *social*, *learning*, *context relevance, and mobility constructs* (Ha, Yoon & Choi, 2007; Schierz, Schilke, & Wirtz, 2010; Liang & Yeh, 2011). Smartphone adoption studies identify *cost*s and *perceived risks* associated with technology usage to be the major deterrents for the users (Heijden & Ogertschnig, 2005; Aldhaban, 2012). These studies share the same drawbacks as AR adoption studies of exploring established constructs in cross-sectional and longitudinal studies. A dissimilar perspective on smartphone adoption and usage has been pursued by studies anchored in UGT theories (Park, Kee & Valenzuela, 2009; Chua, Goh & Lee, 2012). These studies acknowledge the complex characteristics and uses of the smartphone technology and identify them with gratification seeking behaviour. *Entertainment*, s*ociability*, m*obility*, i*nformation*, i*nstrumentality* were described to be the key uses and gratifications in these studies (Stafford, Stafford & Schkade, 2004; Park et al., 2009; Chua et al., 2012; Phua, Jin & Kim, 2017). A differing perspective, however, is still not a holistic one. These tangential approaches to understanding AR and smartphone adoption arise because of the inherent nature of these technologies. A single function or usage cannot be attributed to such technologies that meet multiple utilitarian, social and entertainment requirements of a user. Each smartphone serves as a multimodal device that is equipped to be portable mini computers as well as personal media devices, making the contemporary adoption theories insufficient to explain their adoption. Therefore, there is an appropriate need to bridge these fragmented perspectives on smartphone based AR system's adoption in order to address the complex nature of involved technologies and user's interaction with them.

2.3 Setting Research Agenda

In a more than ever-connected world, a highly interactive, immersive technology like augmented reality on a ubiquitous device like the smartphone is bound to find purpose in a rainbow of facets. Its potential as a revolutionary technology can hardly be understated. So far it has found applications in numerous fields like education, healthcare, entertainment, tourism etc. as described in section 2.2.2. Understanding the drivers of its adoption is, therefore, necessary to create meaningful applications while being aware of its possible impacts. The first step of explaining its adoption is innately linked to understanding the motives of adoption. Beyond this, there is also a need to break away from the default deterministic mindset applied in these studies. Observing cross-sections of this process in isolation is a valuable tool to understand it from a micro-perspective, nevertheless, a need for a holistic standpoint is also being realised to connect these pieces. The agenda of this paper is set twofold - 1) *to identify the motivations of users to use AR based applications on the smartphones,* and 2) *to understand the role of motivations and other actors in the adoption of AR applications*.

3. Method

3.1 Research Approach

Identifying the latent motivation of technology use requires an in-depth investigation into the user's attitudes, beliefs, values and perception of the users. Given the dearth of literature to study the smartphone based AR adoption process holistically, an exploratory study was conducted to mine qualitative insights. A social-constructivist mindset was adopted to understand the uses of AR based smartphone apps and the user's motivation behind their usage. As the context of AR use for this study is focused on smartphone applications, the study dug deeper to also understand the user motivation for smartphone usage to get a broader perspective. The collected data were then analysed using the Grounded Theory approach to be translated into workable insights.

3.2 Data Collection

3.2.1 Research Design

Semi-structured in-depth interviews were used as the primary method for data collection for this study. A selection of such AR applications, basis contemporary popularity, were compiled into an in-exhaustive list of AR apps to understand the current AR uses on the smartphone. The AR applications were grouped into two sub-groups, namely - 1)

Table 1
Respondent Information

N = 18		Frequency	Percentage
Demographics			
Gender			
	Male	8	44%
	Female	10	56%
Age group			
	18 - 23	3	17%
	24 - 29	13	72%
	30 - 35	2	11%
Occupation			
	Student	10	56%
	Part-time Professional	3	17%
	Full-time Professional	5	27%

Primary AR apps and 2) *Secondary AR apps*; this classification served to identify the apps that are fundamentally based on AR technology and would lose its purpose without the AR features (Primary AR apps) and also to identify the apps that have adopted AR features as subsidiary feature of the app (Secondary AR apps). The apps were further categorised as per the services they offer. The grouping was based on the categories listed by iOS' App Store and Android's Google Play for the chosen apps. These categories were - 1) *Information & Education*, 2) *Entertainment & Gaming*, 3) *Social Networking & Communication*, and 4) *Utility & Marketing apps* (see Appendix A). Apart from understanding current AR selections on offer, this activity also to gauge AR usage by the smartphone users, hence, the list was incorporated into an online questionnaire that respondents of this study were requested to fill in. The online questionnaire also captured the demographic details of the respondents.

The primary research was conducted through in-depth personal, telephone and video call interviews with smartphone AR users. The topics investigated ranged from user's smartphone usage, the context of use, user's relationship with their smartphones and their perception of it to awareness of AR applications, their context of use and usage, perception of AR apps and technology and user's attitude towards such applications. In order to get mineable data, the perception and attitude towards this technology were explored in detail by including questions regarding the perceived strengths and weaknesses, its perceived role in users' day-to-day lives, perceived threats as well as social influences that impact AR usage and adoption. Furthermore, users' attitude towards novel technologies like AR on smartphone and head-wearable devices as well as VR headsets were also included as topics to be investigated in the semi-structured interview. (see Appendix B)

3.2.2 Procedure

Each respondent was briefly explained the topic of the investigation before the process began. The respondents were then asked for their consent of voluntary participation in the study as well as their consent to record and analyse their responses with personal data for the purpose of this investigation. The respective one-hour long process was conducted in two steps, the *first* required the respondent to fill the short online questionnaire, as mentioned earlier, and the *second* included an interview with the respondents. The average duration of the interviews was around 45 minutes.

3.2.3 Participants

A total of 19 respondents participated in this study. A combination of convenience and purposeful sampling methods were used to identify the respondents for the study; the condition for inclusion required the respondent to be a smartphone AR apps user in the age group of 18-35. The online questionnaire, mentioned in the previous section, was used to filter invalid inclusions. Data from 1 out of 19 responses were deemed insufficient for this study as the respondent was a non-user of AR applications as well as smartphones, thus not belonging to the proposed sample group of this study. Therefore, the total valid sample size (N) was brought down to 18 (N=18). The research participants for this study comprised of full-time students as well as part-time & full-time professionals from various fields and of diverse nationalities. The respondents' demographics and AR app usage information is detailed Table 1.

3.3 Data Analysis

The analysis of the collected data was carried out using the Grounded Theory approach. The information from the interviews was coded using an open-coding scheme. A total of 46 codes were identified and then tested for reliability. Cohen's Kappa test was used to assess the coding scheme's inter-rater reliability and it was found to be substantial (K=0.75) for the identified codes. The second rater of the coding scheme was a peer of the researcher from the Masters Programme in Communications at the University of Twente. The further stages of the analysis included forming concepts and categories from the codes. The 46 codes were collected together in 13 distinct codes, which were further grouped into 5 categories as listed in Table 2.

4. Results

4.1 Augmented Reality Usage

As the prerequisite for participation in this study required the respondents to be AR users, 17 out of 18 respondents were regular users of AR applications on their smartphones, while only 1 respondent was a non-user of AR applications but had previous exposure and history of usage. 50% of the respondents were using AR features on an everyday basis and 44% of the respondents were using AR at least a few times in a month. This data was inferred basis the selections made by respondents on the online questionnaire, however, it was revealed in the personal interviews that the respondents were not necessarily and completely aware of their AR usage. While 100% of the respondents were aware of the AR technology and its key features, respondents own usage of some secondary AR apps were not understood as AR systems. This is found to be true especially for apps belonging to Social Networking & Communication category. All respondents were either regular users or were aware of the 'filter' feature of apps like Snapchat, Instagram and Facebook, only 67% of the respondents identified this feature as an AR feature. Most respondents identified apps belonging to Primary AR apps as smartphone apps where they could access the AR features. The reason behind this is found to be associated with the nomenclature and marketing of these apps that explicitly mentions 'AR', thus making recognition of AR feature more obvious. However, interestingly the Secondary AR apps represent the largest chunk of the most regularly used AR apps by the respondents.

The Social Networking & Communication category of AR apps was the only universally used category by this study's respondent group. The top apps used by the respondents were the social media apps of Facebook, Instagram and Snapchat. While the respondents were more active on Facebook and Instagram apps on their smartphones, their interaction with augmented reality was found to be more regular on Snapchat and Instagram. The second most used category of AR apps was the Utility & Marketing apps, again most belonging to the Secondary AR apps group. A point to be noted here is that this group of apps were the second most used category only because of the app called Google Translate, as 78% of the respondents reported to use this app regularly. The other apps belonging to this category had only a few users (less than 20%). On the other hand, Primary AR Apps that are almost exclusively represented in the Entertainment & Gaming and Information & Education categories of AR apps were used by only 33% of the respondents. The most used apps in the Primary AR apps group were the in-built AR apps and Tape Measure AR. The total unique users of apps belonging to these two categories were also mostly represented by other Secondary AR apps like PokemonGo, Google Lens and Night SkyWalk. More details on AR apps usage can be found in Table 3. Thus, it can be observed that social media apps have played a key role in the accessibility and penetration of augmented reality technology and features among the respondents.

4.1.1 General Perception of AR

Perceived as an innovative novel technology, AR was viewed positively by the respondents universally. The most common trend in respondents' sentiments towards AR is found to be associated with the technology's ability to 'augment' or to add layers of virtual information onto the physical world. Most respondents found this feature to be the most attractive attribute of the technology, contributing to the positive attitude towards it. Most respondents also noted that the technology's current and potential applications also promote a positive perception of the technology. On the other hand, most of the negative or unfavourable attitude towards AR stemmed out of its inconsistent or glitchy performance, which affected user experience for the worse. Similarly, considering its future impact, a few respondents also seemed to be wary of its social implications, related mostly to disruptive social and personal behaviour, privacy issues and health implications.

4.1.2 Smartphone Usage vs AR Usage

A key component of the in-depth interviews was also to evaluate the current usage and relationship respondents shared with their smartphones. While a link between the smartphone usage and AR apps usage was expected and also observed, a conspicuous difference is also noticed in the respondent's preference to use AR on smartphones. Foremost, the respondents who were actively and regularly using their smartphones for social media needs, also reported being actively using the AR features of the social media apps, skewing slightly towards female respondents. Amongst the respondents who reported to be avid social media users, not only tended to use the apps' filter feature more but also shared positive sentiments towards it. A similar trend is also observed for respondents who reported to not be serious social media users. These respondents harboured unfavourable or indifferent attitude towards the AR features of these social media apps. Unsurprisingly, respondents who reported to use their smartphones for self-expression or eCommerce needs were also regular users of AR services on apps like Lenskart or TikTok. Furthermore, the respondents who tended to use their smartphones for basic functionalities like communication, banking, utility etc. reported to be more regular users of Primary AR Apps like IKEA Place, Tape Measure AR and BBC Civilisation AR and infrequent or non-user of Secondary AR Apps like social media apps.

Contrarily, the difference between the parent device usage and AR usage is observed amongst the select group of respondents who reported to be heavy social media users but non-users of its AR services. These respondents reported to have no use or need of the AR services of the social media apps and mostly shared either negative perceptions of the feature. Similarly, respondents who reported to use their smartphones for gaming purposes reported to be 'impressed' by the AR features of games like PokemonGo, Knightfall AR but also noted the limitations of these gaming apps. Moreover, the respondents of this study, independently but unanimously, reported to be wary of their dependence on their smartphones and were actively seeking to take control of their interaction with the device. This control, however, was not exercised on the apps that offer utilitarian AR services like Google Translate, Google Lens, eCommerce apps like IKEA or Lenskart. The respondents noted their continued usage or reliance on these AR apps as preferred or needed, owing to the useful services offered by them.

4.1.3 Smartphone AR vs Head Wearable AR vs VR

While the scope of this study pertains to Smartphone AR applications, around half of the respondents of this study reported having some prior experience with wearable AR and/ or Virtual Reality (VR). Investigating the perceived differences, similarities and preferences between these technologies, all relevant respondents claimed to prefer Smartphone AR apps over wearable AR devices for day-to-day activities. The major reason ascribed to this preference is the ready availability of a handheld device, smartphones, for the respondents. Most respondents reported finding head wearable AR devices inconvenient and impractical for daily

Table 2

Identified categories, concepts and codes

Categories	Concepts	Codes	
Interaction Goals	Communication Goals	Communication	
	Social Goals	Social	
	Information Goals	Information	
	Entertainment Goals	Entertainment	
	Utilitarian Goals	Utilitarian	
Interaction Context	Spatial Context	At home	Outdoor use
		Professional use	
	Temporal Context	Duration	
	Frequency	Habitual usage	
		Regular usage	
User Motivation	To Control	To make life easy	To depend
		To be productive	
	To Belong	To socialise	To communicate
		For self-esteem	Fear of disconnecting
		Fear of missing out	
	To Escape	Boredom	To distract
		To enjoy	
	To Explore	To learn	Curiosity driven
		Attraction to novelty	
Technology Characteristics	Technical factors	Interactivity	Mobility
		Realistic	Immersive
Inhibitors	Inaccessibility	Medical	Monetary
		Availability	
	Resistance	Inertia	Privacy
		Ignorance	
Projected Attributes	Hedonistic factors	Cool	Playful
		Entertaining	Fun
		Innovative	
	Utilitarian factors	Useful	Convenient
		Usable	

activities even as mobility is offered by all the parent devices. However, all relevant respondents recognised the superiority of wearable devices at workplaces in accomplishing specific tasks. Moreover, the respondents reported finding wearable devices as apter for AR services with respect to smartphone devices. This is associated with the screen size of smartphone devices which limits the field-of-vision and hence the capabilities of AR applications on smartphones. Comparatively, the major difference in preference and perception of Virtual Reality systems from either of the AR systems mainly rested on the immersive qualities of these technologies. The VR systems were perceived to be more immersive, and hence more 'dangerous' for everyday generic applications. This perception was least attributed to AR systems on smartphones.

4.2 Projected Attributes

Upon further analysis and inference from the coded data, the initial apparent findings of this study are the perceived values that AR applications users ascribe to their interaction with the technology on smartphones or wearable devices. These *Projected Attributes* can be defined as 'the degree to which an interaction with technology is perceived as valuable by a user'. The value of the interaction is manifested through its perceived benefits which are, broadly categorising, *Utilitarian* or *Hedonistic* in nature. These attributes can be understood as to *how useful and/or convenient* the AR applications are considered to be by the users. The study noted these attributes were used to describe applications categorised primarily as *Utility & Marketing* AR apps and a few as *Information & Education* AR apps. Respondents who regularly use apps like Google Translate stated that its utility in everyday life is central to this application and their reason to continuously use it. Similar attributes were used to describe marketing apps like Lenskart, IKEA Place or utility apps that offer dimension measurements in AR. The respondents also found apps like Google and Night Sky (*Information & Education apps)* to be both useful and convenient in their perceived utility. Other strongly identified attributes are mainly hedonistic in nature. These attributes describe *how entertaining and/or playful* the AR applications are perceived by the users. Apps that belong to *Entertainment & Gaming* and *Social Networking & Communication* categories were described as entertaining, fun and playful. These *Hedonistic Attributes* can be understood from a similar lens as well. The AR services on mainstream social media apps like Snapchat and Instagram were universally identified to be hedonistically appealing with their playful characteristics. Another important component of the *Hedonistic Attributes* is the innovativeness of the AR applications, which had been described by the respondents as the differentiating characteristic of AR based gaming and entertainment apps.

The findings of this study suggest that the presence or absence of these Projected Attributes are key concepts that influence user's attitudes towards AR applications. The study notes that while there are utility targeted apps available for smartphone users to use, their practical applications were found to be limited by the respondents, barring a few apps. The absence of utilitarian attributes (*perceived uselessness or inconvenience*) of these apps were influencing user's interaction with the technology unfavourably. This finding was made more obvious by understanding the usage of apps that were ascribed hedonistic attributes by the users. The universally used AR apps belonged to the category of Social Networking & Communication. The AR services offered by these Secondary AR apps like Facebook, Instagram and Snapchat, while perceived to have hedonistic attributes, had still not been actively incorporated in many of the respondent's daily social media usage. Similarly, while the gaming and entertainment apps too were considered to be enjoyable and innovative by most user respondents, the apps

Table 3

AR Usage Data

N = 18		Frequency	Percentage
AR Usage	AR User	17	94
	AR Non-user	1	6
Frequency of use	Everyday	9	50
	Few times in a week	6	33
	Few times in a month	2	11
	Rarely	1	6
		Unique Users	Penetration (%)
Top Apps	Facebook	17	94
	Instagram	16	89
	Google Translate	14	78
	Snapchat	12	67
	Other AR Apps	8	44
Top Categories	Social Networking & Communication	18	100
	Utility & Marketing	16	89
	Information & Education	9	50
	Entertainment & Gaming	8	44

had yet not found a place in the respondent's gaming preferences. A consensus on the perceived attributes possessed by AR apps and a in user's usage preference and attitude towards the technology highlights the subjectivity of technology usage. A step further into the investigation hinted at the possible relevance of the *context of use* in this study. It is with this understanding that this study defines *Projected Attributes* in relation to a user's *interaction* with the technology rather than as constructs that shape user intention of technology adoption.

4.3 Role of Interaction Context and Interaction Goals

The concept of *Interaction Context* can be defined as the 'use scenario of the interaction' and includes variables like spatial context, temporal context, device and use frequency. The study finds that the attributes projected onto the user's interaction with the AR applications were not static but were rather shifting from one use scenario to another. This is explained by the multi-modality of the parent device (smartphones) as well as of the AR technology itself. The first key observation made here is the undeniable influence of the parent device on the user interaction with AR applications. The respondent's AR usage was categorically influenced by their smartphone usage and the primary activities performed on the device. The study finds that the respondents who stated their smartphone usage to be directed predominantly towards social networking or information & communication activities were also frequent users of AR services offered by the various Secondary AR apps like Snapchat and Google. Similarly, the use scenario of smartphones, e.g. outdoors, at home, habitual usage, while commuting etc., also influenced the user preference for relevant AR applications in the specific context of interaction. The shift in the projected attributes becomes clearer for apps from the

Entertainment & Gaming category. The few respondents who spent time playing non-AR games on their smartphones were reported to attribute strong hedonistic values to AR games only in specific contexts like indoor gaming. Similarly, specific interactions contexts with *Social Networking & Communication* apps commanded favourable projected attributes while interactions with the same technology in other contexts were attributed to unfavourable values. An example of this would be respondent's preference to use the face filter feature of various social networking apps in social contexts as more respondents reported to find them 'useless' or 'not entertaining' otherwise. Contrarily, respondents with prior exposure to wearable AR headsets identified different preferred contexts of interaction on different parent devices. While the respondents found AR's applications to be limited on the smartphone due to its screen size or field of vision vis-a-vis a head wearable device, they were nevertheless identified to be more practically useful and convenient than the HWDs. This concept of *Interaction Context*, therefore, allows a technology or a respective application of the technology to offer multiple, unique interactions to the users, who then project favourable or unfavourable attributes on them.

However, while the context of interaction explains the shift in projected attributes, it does not explain the preference of users to an interaction. The multimodality of smartphones and AR applications also bring specific goals for each user interaction with the technologies. The concept of *Interaction Goals* can be defined as 'the unique goal of users' interaction with a technology'. This study finds that the respondents' interaction with their smartphones as well as AR applications were goal-oriented and these goals can be classified as 1) *Communication Goals*, 2) *Entertainment Goals*, 3) *Social Goals*, 4) *Utilitarian Goals*, and 5) *Information Goals*. The findings suggest that the respondents' interaction with their smartphones were driven by all of the above five mentioned goals in various contexts. While for AR applications on smartphones, the study finds that the interactions were particularly driven by Entertainment and Utilitarian goals. The dissonance mentioned in the previous section is addressed if the role of *Interaction Goals* is taken into account when studying the adoption of technology. The respondents who habitually use social media apps like Facebook and Instagram for their social, information and communication -s were interacting with the AR services offered on these apps for only entertainment goals in social or private contexts. Thus, both context and goal play important roles as the respondents ascribe attributes to their interaction with the technology. The findings suggest that user interaction with every application of a smartphone, AR or non-AR, has single or multiple goals in differing unique contexts. The projected attributes on these interactions, thus, depend on the goals of a respective interaction in unique contexts. Although the roles of these two concepts explain the dynamic nature of user interaction with a technology, the motive for the adoption of AR applications is yet not explained by either the projected attributes or interaction goals in a given context. A deeper analysis of the respondent's AR usage revealed the concepts of Motivators and Inhibitors to be relevant in this study.

4.4 Motivators & Inhibitors: Role of User Motivation, Technology Characteristics & Adoption Inhibitors

A striking revelation in this study was the affirmation of the role of *User Motivation* in users' interactions with the AR applications. The study finds that while some of the respondents projected favourable attributes onto their interaction with the AR applications in a respective context, the goal of the interaction is the realisation of one or more of the 4 identified User Motivation classifications - 1) *To Control,* 2) *To Escape*, 3) *To Belong* and 4) *To Explore*. The User Motivation can be defined as ‘needs, wants or desires of a user from their interaction with a technology’. The classification of the User Motivation into said categories have been similarly described by many Motivation Theories in sociology and psychology. The respondents of this study reported to have a generally positive perception of the AR technology as well as its applications on smartphones. However, this positive perception as well as the favourable attributes like AR applications’ perceived ease-of-use or usefulness as Venkatesh et al. (2003) propose do not necessarily translate into use intention or behaviour change for a user. While Rogers (2010) does highlight the role of user needs in his model, he does not elaborate on its description or types. This study explains this inconsistency in existing models by proposing the integral role of user’s motivation in their decision to adopt AR applications into their daily lives. These motivations, as mentioned above, can be viewed from the lens of user’s hedonistic, utilitarian and social needs. The respondents of this study are understood to use smartphones as well as AR applications to fulfil their needs from the respective interaction. The User Motivation, therefore, can be explained as *why* does an AR user prefer a particular application over other in a given context of interaction. A user of these technological applications seems to be continuously evaluating the fulfilment of their motivation against the interaction goals in a context. To elaborate on this more, as mentioned in the previous section, the use of Secondary AR apps like Snapchat and Instagram, which are mostly used for social and communication goals, is mainly driven more by the entertainment goals of the users. The explanation of this misalignment of the interaction goals is understood better by identifying the user motivation to interact with technology in a specific context. The respondents in this study reported finding these services more apt for their individual and social entertainment needs. Similarly, the respondents reported their need ‘to distract’ or ‘to enjoy’ as their primary reasons to use Entertainment & Gaming apps on their smartphones, which, however, were not met by the AR applications owing to the limitations of the technology in gaming context. Most Entertainment and Gaming AR apps require either mobility or open spaces to play the game successfully, while the respondents preferred to use gaming applications when they commute or have to ‘pass time’. Despite the respondents’ ascribed positive attributes to the AR gaming apps, the disparity between the user motivation to play games on smartphones and their interaction goals for AR games restricted the successful fulfilment of the user needs from the said interaction. This concept also explains the initial pull that the respondents experienced to interact with AR services of certain gaming apps like PokemonGo and social networking apps like Snapchat and Instagram. The respondents’ motivation to be ‘not left out’ or *To Belong* were identified to influence their first interaction with AR services. Moreover, the study finds that the user’s continuous interaction with the *Utilitarian & Marketing* AR apps were driven by their *Utilitarian* goals that fulfilled the needs of the users ‘to be more productive’ or *To Control* their lives in better and more effective ways.

Another aspect that motivates users to interact with AR applications was found to be brought from the technology itself. The study finds that *Technology Characteristics* of AR applications and AR in general were found to be strong motivators for the respondents to interact with the AR services. The *interactivity, immersiveness* and *mobility* offered by AR apps were found to contribute not only to the novelty of these services but also actively shaped the interaction goals of an application for the users. The respondents found AR applications’ technical properties to also positively influence their projected attributes in virtually all use scenarios, implying that the role of these technical characteristics go beyond just shaping the perceived usefulness or ease-of-use of a technology. This implies that the interaction goal, therefore, is independently defined by both the users and the AR technology. The *Technology Characteristics*, thus, act as a complementary concept to *User Motivation*, both exemplifying the collective roles of technology and users in technology adoption. This study defines these two concepts as the *Motivators* that push or pull a user to interact with a technology, where the User Motivation pushes and the Technology Characteristics pulls a user towards the technology.

Contrastingly, the study also finds certain *Inhibitors* in the AR adoption process that deter the users from initial or further interactions with the AR services on smartphones. These Inhibitors can be categorised as 1) *Inaccessibility Issues* and 2) *Resistance Issues*. The respondents of the study reported various *Inaccessibility* related deterrents to interaction with AR applications like medical, monetary or availability of these apps on their devices. A user with a smartphone that doesn't support AR services or a user for whom physical movement is medically restricted, may not be able to access the AR services, thus inhibiting its adoption. On the other hand, while these inhibitors were found to be either technical in nature or out of user's control, the intrinsic concerns of the respondents regarding this technology were manifested as *Resistance* to the AR technology. Privacy concerns as well as unawareness or ignorance towards technology were cited fairly strongly by the respondents as inhibitors to regular AR adoption. A peculiar finding of this study also hints at possible *inertia* in users towards *any* technological or lifestyle changes. While the respondents reported to actively explore new technology interactions owing to their need *To Explore* the novelty of these services, the findings suggest that most respondents showed reluctance as well as inertia to behavioural changes, including adoption of new technologies. A few respondents reported themselves to be comfortable with the present available features on their smartphones and were not willing to proactively develop a use for AR features . They reported that it would not bring in a habit change unless it either becomes unavoidable due to technology advancements or the AR features are thoroughly penetrated socially, depicting inertia in behaviour change. Similarly, a few respondents were cautious in adopting new technologies like AR and were actively avoiding a greater reliance on this technology. Both cases can be understood as examples of Resistance by the users. Collectively, these two issues identified in this study are termed as adoption *Inhibitors* for AR services on smartphones as well as head wearable devices.

5. Discussion

5.1 Adoption of AR Applications on Smartphones: A Holistic Perspective

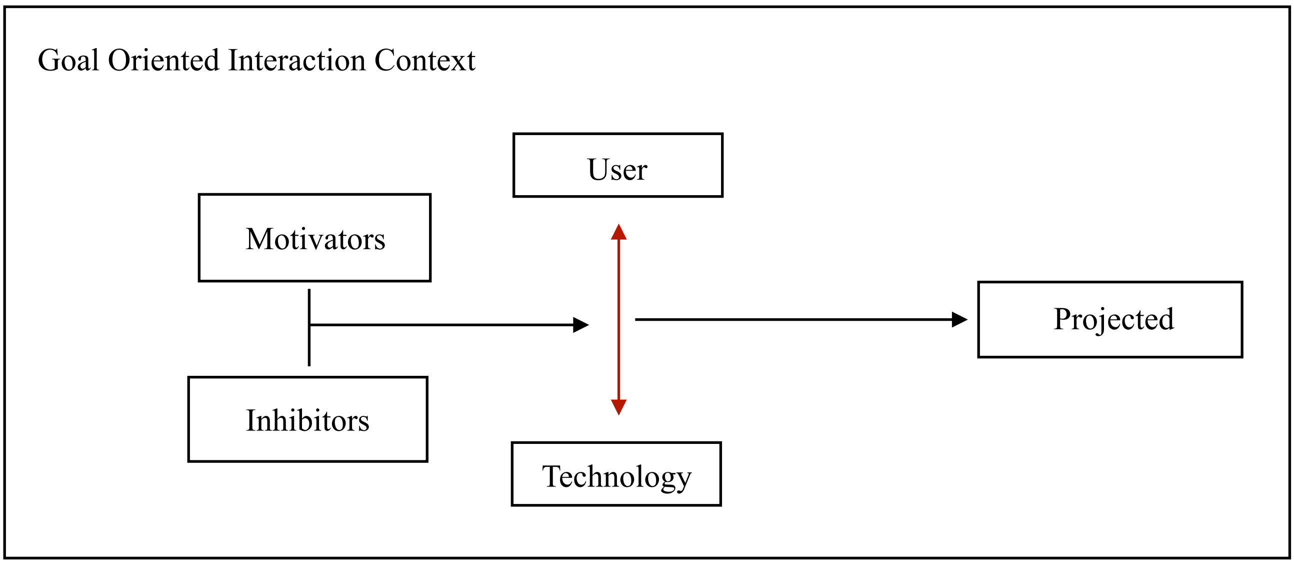
Complex technologies like augmented reality offer multimodal, multipurpose services on even more complex technologies like smartphones. The adoption of which, then, is not a binary phenomenon and is dependent on variables that number far more than the proposed constructs proposed by Venkatesh et al. (2012). As seen in section 4.2, the findings mentioned there are in line with the constructs proposed first by Davis (1989) and then by Venkatesh et al. (2003). Most contemporary and renowned technology adoption models predict *Perceived Usefulness* and *Perceived Ease of Use* as primary variables in the process. The *Utilitarian Attributes* defined in this study explain similar variables as proposed by other models. Meanwhile, *Perceived Enjoyment* as a variable in technology adoption process has been identified for media technologies like Smartphones and AR in previous studies (Huang et al., 2014; Javornik, 2017; Rauschnabel et al., 2017). The findings in section 4.2 are also in line with the findings of some studies investigating adoption of AR technologies from a media perspective. However, the key takeaway of this study is that the existing literature is not sufficient in explaining the user-technology interaction and adoption that comes thereafter. This is exemplified by the findings described in the sections 4.3 and 4.4. Owing to its multipurpose applications, the technology is judged by the users basis their interaction with it in a specific context of use. Therefore, while contemporary adoption models perform well in predicting the success factors of a technology in cross-sectional investigations, they miss out on explaining both partial and failed adoptions of innovation. A holistic perspective that acknowledges other factors acting in the technology-user ecosystem is crucial to understand technology's adoption, impact and evolution in an increasingly convoluting world. Moreover, a better understanding of the technology-user ecosystem also accommodates user's expectations and needs from a technology.

As described in the previous sections, the user chooses to engage and interact with a technology regardless of their reliance on it. Therefore, the active participation of the respondents in defining their relationship with the technology cannot be understated as it highlights serious flaws in the technological determinism school of thought which takes users and their actions to be solely influenced by the technology and not vice-versa. Taking the social constructionist school of thought forward, this research paper is proposing to base further investigations into the technology adoption process on the following two assumptions -

1) The interaction of a user with a technology is goal oriented and contextual. The goals of this interaction are independently and actively defined by both the users and the technology.
2) The motivators and inhibitors of technology adoption collectively influence the fulfilment of goals for a user interacting with a technology.

The Figure 1 explains the roles of the identified constructs in a visual perspective. Identifying variables that comprehensively predict technology adoption thus requires to investigate the role of variables from various concepts that play a role when a user interacts with any technology. Therefore, this study suggests a holistic perspective to understand this process, acknowledging the role of context, user motivation, technology characteristics as well as social influences in influencing the continuous process of technology adoption. The identified constructs of projected attributes, interaction context & goals, motivators and inhibitors present a more sustainable explanation of AR adoption that is relevant to the complex and multi-dimensional roles of contemporary technologies. As the findings of this study suggest, the AR adoption is primarily driven by user's motivation that are utilitarian, social and hedonistic in nature.

Figure 1. User Technology Interaction in a goal oriented context



The many applications of augmented reality offer multiple unique interactions to the user catering to their specific needs through its technology characteristics; explaining the missing *why* from technology adoption models, by incorporating elements from Uses and Gratifications theories as well as Motivation theories. To summarise, the decision of adoption or non-adoption of the AR technology, thus, is taking place for each context in an interaction in a non-deterministic and a non-linear fashion where both the user and technology play active roles in the adoption process.

5.2 Implications

5.2.1 Theoretical Relevance

As highlighted in the second chapter of this study, the existing literature in augmented reality from a non-technical point of view is rather limited and research into its adoption is barely sufficient to understand user's adoption of the technology. Moreover, the explosion in this technology's growth is fairly recent given the compatibility advancements in an available parents device is recent as well. Therefore, this study serves to add to the existing literature on this topic. The second important addition of this study is the propagation of the social constructivist school of thought into the studies that aim to understand technology adoption as a process better. This study proposes five key concepts that influence the technology adoption process for AR applications on smartphones. The investigations based on the Grounded Theory approach require the findings to be validated by its *fit, relevance, workability,* and *modifiability*, the concepts proposed in this study are proposed keeping these criteria in perspective. The proposed findings are generic in nature and therefore can be adapted to study the adoption of other technologies as well. The study aims to provide a more relevant approach to understanding this process in a technologically complex world. Moreover, the study aims to provide a thorough insight into users' interaction with AR applications by adopting a qualitative approach to investigation. Exploratory and qualitative studies like these provide a nuanced comprehension of multi-layered phenomena like technology adoption from a variety of primary and secondary data sources. The relevance of this study is also backed by the findings of the existing literature which were found to be in line with some of the proposed concepts in this study.

5.2.2 Practical Implications

The concepts of *Interaction Context* and *User Motivation* serve as the starting point for AR technology designers to understand its usage and non-usage by potential users. As the user becomes more empowered and play an active role in adopting and then appropriating a technology into their lives, it is vital to understand the driving motivations behind their acceptance. A technology's ease-of-use and usefulness as important predictors of this process have become default expectations for users from any technology they interact with. As the technology's role itself expands to accommodate user's hedonistic and social needs, the differences between media & entertainment technologies and utilitarian technologies is progressively diminishing. Technologies like augmented reality that offer immense interactivity and mobility find applications that are potentially universal in nature. Especially, this study highlights the role of interactivity and immersive-ness of AR technology in driving user acceptance of its services. Therefore, the primary practical implication of this study is to propose a shift in focus while designing innovative technologies from a unidirectional and unilateral technological standpoint to a more inclusive and dynamic standpoint. Such a standpoint accommodates the users' current and potential needs from a technology in a given context. As discussed in the previous chapter, both technology and users play active roles in influencing its adoption. Therefore, understanding one aspect overlooking the other may not produce fruitful and long-term AR applications that find practical applications in daily lives of the users. Moreover, this research underscores the inherent competitiveness in the technology adoption process as one technology seeks to replace other (existing technology or process) to fulfil the goals of a user in a said context. Understanding this competition and user's motivation to prefer/accept one method over others in order to fulfil their goals can direct technology designers to co-create technologies with human-centred design approach at the core of the process. An inclusive approach like this may potentially aid in innovating technologies that are both meaningful and purposeful, saving mis-directed efforts that either do not survive for long or are completely rejected by the users.

5.3 Limitations and Scope for Future Research

The limitations of this study can be explained in two parts - 1) limitations in the scope of this investigation and 2) limitations in the methodology adopted for this investigation. First, the objective of this study was to identify user motivation for AR applications on smartphones. As the presence of AR applications is more obvious on smartphones, its applications on other applications were excluded from the scope of this study. Even though this study took an effort to understand usage of the parent device as well to explore the whole of interaction holistically, excluding one or more applications of AR technology present only a partially complete perspective. Another limitation in this regard is the in-exhaustive list of AR apps on smartphones analysed in this study. While care was taken to include the most relevant and popular smartphone AR applications in this study, a majority of the available AR apps were not included in the study, thus missing on more insights into AR adoption. These limitations arose due to the complexity in the analyses involved in sifting through thousands of AR apps, unawareness of most other first generation AR apps, non adoption of many AR apps in the mainstream use and time constraints in carrying out a detailed study with a wider scope. Second, this study adopted an exploratory research methodology to investigate a topic whose theoretical foundations were fragmented and incomplete. While an exploratory methodology may present unique advantages over other methods, the drawbacks of this method are gravely restricting as well. First and foremost, the outcome of this study does not spell out practical and objective findings that aid in decision making. As the scope of this study was to present the overarching themes acting in the user-technology ecosystem for AR applications, the findings proposed here lack the support of quantitative validation. Moreover, the biggest drawback of this study is its inability to explain the relationships between the identified themes in the context of technology adoption. Therefore, the study lays out a three fold scope for future research in this domain - 1) further qualitative and quantitative investigations into the role of each of the identified themes in this study, 2) expansion of the scope of the further studies from smartphones to other available augmented reality devices and applications and 3) establishing empirical relationships between the identified themes. The scope for future research from hereon would also be to take the social constructionist school of thought further to explain the complex interactions between users and technology.

6. Conclusion

The potential of Augmented Reality technology on ubiquitous devices like Smartphones have been explored by numerous innovators, researchers and technology corporations. Although the scientific research in this domain is limited, the literature available do point out the predictors of its success. While these studies prove to be stepping stones for investigations like these, crucial concepts that influence technology adoption have not yet been incorporated in the existing literature on augmented reality as well as technology adoption. On the other hand, as a few previously undertaken studies defined augmented reality applications as media technologies (Javornik, 2017; Rauschnabel et al., 2017), the effort to understand its adoption from user's perspective brought the user's role to centerstage. The objective of this study to connect the fragmented understanding of augmented reality's usage and acceptance was realised by investigating into the user motivation to interact with these applications. As presumed, the findings of this study acknowledge the driving role of user motivation in their acceptance of augmented reality applications. This study goes a step beyond to also identify other themes that play crucial role in this process. The study proposes that the user interaction with a technology is contextual in nature and is driven by the goals & needs of the users. The user's role is complemented by the role of technology characteristics in its adoption, acting as motivators to the users to interact with the technology. To explain this process better, the study identifies five key concepts that are acting in the sphere of user-technology ecosystem, namely - 1) Projected Attributes, 2) Interaction Context, 3) Interaction Goals, 4) Motivators and 5) Inhibitors. The findings of this study present a holistic perspective to augmented reality adoption as it acknowledges the role of social, hedonistic and utilitarian motivations of the users. Moreover, this perspective allows both the user and technology to play active roles in the adoption process. Further research in this domain, therefore, can build on the proposed themes to investigate the adoption of AR and other technologies, given the parsimonious and generic nature of this research. However, this approach still presents an incomplete standpoint on the process owing to the limitations of the methodology adopted by this study as well as the restricted scope of the investigation. Further longitudinal and cross-sectional research studies are needed to validate the findings of this study statistically and present a comprehensive model that explains the relationships between the identified themes in this study.

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Appendices

Appendix A

Table 4

Categorisation of AR Apps

Sub-Groups	AR Application	Category
Primary AR apps	ARise	Entertainment & Gaming
	Knightfall AR	Entertainment & Gaming
	Just a Line	Entertainment & Gaming
	Quiver	Entertainment & Gaming
	AntiMosquito AR Game	Entertainment & Gaming
	ZombiesGo	Entertainment & Gaming
	SketchAR	Information & Education
	Civilisation AR	Information & Education
	WallaMe	Social Networking & Communication
	Tape Measure AR	Utility & Marketing
	Holo	Utility & Marketing
	IKEA Place	Utility & Marketing
	InkHunter	Utility & Marketing
	Roomie	Utility & Marketing
Secondar AR apps	Google	Information & Education
	Mondly	Information & Education
	Yelp	Information & Education
	Night Sky/Star Walk 2	Information & Education
	TikTok	Social Networking & Communication
	Facebook	Social Networking & Communication
	Snapchat	Social Networking & Communication
	Instagram	Social Networking & Communication
	Google Translate	Utility & Marketing
	Lenskart	Utility & Marketing
	YouCam Makeup	Utility & Marketing
	iPhone Animoji/Other in-built apps	Entertainment & Gaming
	PokemonGo	Entertainment & Gaming

Appendix B

Table 5

Questionnaire Details

Questions	Respnose Options
Do you use any of the following apps?	
	Instagram
	Knightfall AR
	Google Translate
	ZombiesGo
	Snapchat
	PokemonGo
	Google
	Facebook
	InkHunter
	IKEA Place
	Star Walk/Night Sky
	Civilisation AR
	YouCam Makeup
	TikTok
	AR Measurement Apps
	iPhone Animoji/Other unbuilt Apps
How often do you use these apps?	
	Everyday
	Few times in a week
	Few times in a month
	Rarely
Please mention your age	
Please mention your gender	

Appendix B

Interview Questionnaire

Part 1

Smartphones

Topics to investigate:

- Context of use
- Usage history
- Relationship of respondent with their smartphones
- Perception of its importance

Part 2

Augmented Reality based apps on Smartphones and User Motivations

Topics to investigate:

- Context of use and the usage history
- Awareness around the technology and its features
- Preferred characteristics/ features and reason for the preference
- Perception of the technology -
    - Perceived strengths and weaknesses of the technology
    - Perceived role/importance of the technology in their everyday lives
    - Perceived threats from the technologies
    - Perceived social influence
- Sentiments towards such novel technologies
- AR on smartphone vs AR on wearable
    - Context of use
    - Perceived differences
    - Preferences