The Relation between Augmented Reality and its Spatial Context

Conceptualising the defining features of AR

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Abstract

Key decision-makers in Big Tech have raised the notion that Augmented Reality (AR), a technology that enables the overlay of virtual elements onto the physical world, will emerge as an integral part for the way we interact with digital information in the nearby future. A growing body of AR research has examined in what way AR's technological particularities have implications for several areas of application, such as industrial, marketing, entertainment and cultural use-cases. What did not get as much attention was AR's second defining feature that AR, by widely adopted definitions, is spatially embedded in three-dimensional space. Therefore, the purpose of the present research is to address the complex relation between AR and the space in which it is deployed. To approach the research topic an exploratory qualitative research design was applied, which gathered qualitative data through semi-structured, in-depth expert interviews with a heterogenous group of AR practitioners and conducted a thematic content analysis to examine the data and derive relevant results. In the course of the study AR's media characteristics and the role of space for AR are conceptualised in order to examine the spatial relation. It was found that a purposeful application of AR profits from the interdependency with its immediate spatial environment and improves the user experience. Further, found implications of the relations between AR and space are that certain AR media characteristics, such as visuality and interaction, drive AR's ability to mediate a sense of place and even allow for place-making, which describes the social construction of place. The study concludes with the proposal to adapt the definition of AR in a way that stronger accounts for the importance of a purposeful spatial interdependency between AR and the physical location of its deployment.

KEYWORDS: *Augmented Reality, Media Characteristics, Space, Place, Place-making*

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1. Introduction

In the last decades, digital technology has infiltrated most parts of our daily lives and has become indispensable for humankind. While computers, smartphones and the internet changed the way we think, communicate and work, these inventions were merely starting points for a technological evolution that fundamentally changed the functioning of society and continues to do so (Allen, 2019).

Various key decision-makers of major tech companies predict that augmented reality (AR), a technology that overlays digital content onto physical space, will play a crucial role in the way we interact with digital information and the real world in the nearby future. Facebook's CEO Mark Zuckerberg recently said: "at some point in the 2020s, we will get breakthrough augmented reality glasses that will redefine our relationship with technology" (CNBC, 2020). Tim Cook, CEO of Apple, stated that "AR will pervade our entire lives" (Siliconrepublic, 2020). Apart from praising the vast potential of the technology, major corporations are actively pushing the development of the AR ecosystem. As an integral step, Apple and Google released their AR developer kits in 2017, making AR technology easily assessable on mobile devices (Van der Wel, 2017). This not only drives the development of new types of applications but also introduces the novel technology to a larger audience, which is driving broader adoption (Daniel, 2018). Further, the use of simple AR features in the form of the face and environment filters are vastly popular on social media platforms, such as Instagram and Snapchat, which demonstrates the interest in the principles of augmenting the physical world. Another example is the success of Pokémon-Go, a location-based AR game, which generated over $3.1 billion lifetime revenue so far (The Verge, 2020). These developments imply the strengthening position of AR as a mainstream technology (Dirin & Laine, 2018). The worldwide market for AR is forecasted to increase drastically in the next few years, from around $6 billion in 2018 to almost $200 billion in 2025 (Statista, 2019). Almost all Big Tech companies are said to be working on their version of a mainstream AR device (TechChrunch, 2020).

An equally growing momentum is observable in academia, where the increasing interest in AR research from a wide range of disciplines is observable (Liao, 2019). Scholars define AR as a technology with a set of criteria rather than as a single device (Milgram & Kishino, 1994). According to Azuma (1997), AR is a visualisation technology that is three-dimensional, real-time and interactive. As opposed to virtual reality, which completely immerses the user, AR

overlays computer graphics onto the real physical space surrounding the user (Zhou, Duh & Billinghurst, 2008). Carmigniani et al. (2010) go further and suggest that AR combines virtual and real objects. Reitmayr and Drummond (2006) define AR as an interface for mobile, wearable and location-based-systems (LBS).

The first research efforts in the field of AR focused on engineering and realisation of the technology (Zhou, Duh & Billinghurst, 2008). With the evolvement of the technological understanding of AR and the emergence of first usable applications, scholars from various disciplines, such as art, media and social sciences found interest in the research of AR, due to its potential for cultural expression (Engberg & Bolter, 2014). An important driver for this evolvement was the accomplishment to run AR applications on mobile smartphones, which made the technology widely accessible and thereby aligned AR research with the trajectories of mobile media research (Fortunati, 2005; Humphreys, 2005; Katz, 2007; Ling, 2004). Due to the novel audio-visual capabilities of AR, various studies were conducted to explore how AR might transform media industries, such as gaming (Chess, 2014), journalism (Pavlik & Bridges, 2013) and advertising (Liao, 2015).

1.1 Research Question

Liao (2019) reviewed interdisciplinary research paths of AR and calls for scholars to "put them in conversation with one another" (p. 133). Previous research assessed the properties of AR media by distinguishing it from other forms of media (Katz, 2013; Manovich, 2006) and studying the user experience and interaction (Olsson & Salo, 2011). A different area of research emphasises on AR's spatial embeddedness and the implications of AR consumption for the perception of space and place (Graham, Zook, & Boulton, 2013; Liao & Humphreys, 2015; Sheller, 2013). While studies have addressed the ability of AR to change the perception of space (Oleksy & Wnuk, 2017), it was not expanded upon which specific features of AR are responsible for place mediation to take place.

This study follows Liao's (2019) research agenda to put relating research paths into context with one other. It aims to advance the overall academic field of AR by exploring AR's relation with the immediate spatial context and substantiating it with AR's media features. Scholars agree that the main feature of AR is its ability to place digital elements in the physical world by making them visually co-exist in the same space (Azuma, 1997; FitzGerald et al.,

2013). This justifies bringing together the two research areas, as both address the defining features of AR, which are its media characteristics and its embeddedness in the real world. Combining them will lead to more in-depth and more nuanced knowledge about AR media and augmented space, which Allen and Robison (2018) established as a further area of research.

The purpose of this study is to advance the understanding of AR and align research paths by conceptualising AR's defining features and examining in what way they drive AR's spatial embeddedness and its ability to mediate place. To achieve this, the study takes on the expert perspective of AR practitioners, which are involved in creating AR experiences within different areas of application. It addresses the following aspects: First, it comprehensively maps out the media characteristics of AR, second, defines the role of the physical space for AR and, third, examines in what way these features impact AR's relation with space and the mediation of place. The following overarching research question has been formulated: How do AR practitioners conceptualise the relation between AR and the spatial context in which it is deployed?

In order to structure the study, the research question is supported by three sub-questions: SQ1: How do AR creators conceptualise the defining features of AR? To approach this question previously defined media characteristics of interactive media will act as a starting point to derive and conceptualise the main media characteristics of AR based on AR definitions from the interviewed AR practitioners. The findings establish a conceptual basis for AR research and will be subsequently applied to answer further sub-questions.

SQ2: How do they define the role of space for AR? A widely adopted definition of AR implies a relation between AR content and the physical space in which it is deployed (Azuma, 1997). This sub-question examines in what way space, which according to Harrison and Dourish (1996) is the geographic, three-dimensional environment that hosts all existence, actively contributes to the functioning and purpose of AR applications. According to the role of physical space for AR experience, different types of "Space-AR" relationships will be presented.

SQ3: In what way can AR mediate the sense of place? This question focuses on the implications of experiencing AR for the perception of place, which is value-laden space (Lefebre, 1991). The exploration of AR's impact on the sense of place will give an outlook on how AR can be used as a tool for place-making, which refers to constructing social meaning around a space. This sub-question links back to specific AR media characteristics and examines what effect they have on the user.

This study emphasises on presenting the defining features of AR and the relation to its spatial context in a way, which allows concluding on academic, societal and practical implications of the technology. It further, presents an updated outline of AR as it is a dynamically changing field in which older works might lose part of their relevance. The present research, firstly, includes the detailed conceptualisation of AR's media characteristics and secondly the examination of the relationship between AR and the spatial context in which it is deployed. For answering the research question, a qualitative research design has been applied utilising in-depth interviews with AR expert-practitioners as a research method. The selected experts are AR content creators, who design and realise AR applications for different areas of application, such as industrial, marketing and cultural use-cases.

1.2 Academic and Societal Relevance

The research derives its academic relevance from several aspects. First, it links different areas of AR research, as proposed by Liao (2019), which advances the academic discourse about AR. Second, the proposed study conceptualises AR's media characteristics, which contributes to the general knowledge about AR technology and its use-cases, as well as its potential role in the media landscape. Third, the study helps to understand the role of the spatial context for AR consumption as suggested by Scholz and Duffy (2018), who ask for the examination of the "immediate contexts of AR applications, as it would more thoroughly explore how the visual integration of virtual content with consumers' physical environments can facilitate their consumption" (p. 21). Forth, it adds to the understanding of AR's ability to mediate space and place and fills the research gap about which specific AR features are critical drivers for that. Studying AR's capabilities for place-making contributes to the knowledge about computer-mediated communication and helps to explore in what way AR can produce socially constructed spaces. These findings find application in various AR research disciplines, such as AR in marketing, AR in arts and culture, as well as AR in urban space and smart city contexts. Fifth, it advances immersive technology research in regard to conceptualising immersive system features and their implications as proposed by Suh and Prophet's (2018). Their research agenda, further, addresses the need for an elaboration of the concept of immersion as well as an investigation of the aspects that contribute to an immersive experience. Javornik (2016) established a similar research path for AR in marketing research by suggesting that "future studies need to investigate

to which extent the immersion defines AR consumer experience, given that AR possesses some traits of virtual technologies, but also differs from it in the sense that it does not create a disruption between the physical and virtual world." (p.259) These aspects are addressed in the course of the research. Lastly, the study examines the topic of AR from the viewpoint of expert AR practitioners, which constitutes an insightful perspective.

Practitioner oriented literature often depicts AR as a slightly improved "information delivery paradigm", which helps its user to "rapidly and accurately absorb information" (Porter & Heppelmann, 2017, p. 53) by overlaying digital content onto the spatial context. Scholz and Duffy (2018), however, stress that "restricting one's perspective on AR to how virtual information is visualised does not fully capture the complexity of meanings consumers associate with a given AR app" (p. 21). The societal relevance of this study lies in its contribution to the general understanding of AR, which helps practitioners, as well as users to grasp the full potential of AR technology and adapt it for their means. The study provides new insights into the consumer experience of AR and addresses suitable areas of societal application, such as education, communication and public space design. Further, this study helps to inform about the particularities of AR's place mediating abilities, which users should be aware of in order not to be misguided.

1.3 Chapter Outline

Hereafter, the theoretical framework will be presented, which, first, introduces the concept of AR by describing previous research efforts and areas of application. Then, interactive media characteristics, which will be used to derive AR's media characteristics, will be presented. Thirdly, the concepts of space, place and place-making are introduced, as they will be applied to assess AR's spatial embeddedness and its implications. At last, the current state of research on place-making through AR and other technologies will be presented, which gives context for the third sub-questions about AR's abilities for place mediation.

In the third chapter, the methods of the research will be described, which implies presenting the research design, justifying its suitability for the present study and describing the processes of sampling and data gathering. Next, the operationalisation of the study will explain how the reviewed theory has informed the research. Then, data collection and analysis will be presented, followed by an assessment of the studies reliability, validity and ethical implications.

In chapter four, the results of the analysis will be presented and discussed in the context of academic literature. First, each media characteristics of AR will be conceptualised. Here, the theoretical discussion about each feature is integrated into the reporting of the results. Second, the findings on the role of space for AR will be presented and, third, its ability for place-mediation will be explored. Here, the results will be confronted with the theory in a dedicated discussion section.

The concluding chapter of this work sums up the main findings and applies them to answer the proposed research question. After that, theoretical and societal implications will be addressed. At last, the limitations of the study will be discussed, and future areas of research proposed.

2. Theoretical Framework

Next up, the theoretic framework will be presented, which constitutes the foundation for the following research. For a start, the concept of AR is introduced by describing its primary attributes, the academic history and areas of applications. After that, media characteristics of interactive media will be presented, as they will serve as the groundwork for the conceptualisation of AR media characteristics. Then the concept of space and place will be introduced, which are required to explore the second sub-question. The chapter ends with addressing the concept of place-making and a literate review on place-making through AR and other technologies.

2.1 Augmented Reality

AR is defined as a technology that overlays computer-generated elements onto the real, physical world through the use of an AR device (Carmigniani & Furht, 2011). According to Azuma (1997), it can be differentiated from virtual reality (VR) by its level of immersion. While VR offers its users the possibility of full immersion into a virtual world, AR takes place in the real world and adds layers of virtual elements onto the physical environment. He further points out three main attributes of AR: 1) blending virtual and real, 2) real-time interactivity and 3) registration in a three-dimensional space. Cheng and Tsai (2013) highlight that Azuma's definition has a better fit for marker-based AR which "require(s) specific labels to register the position of 3D objects on the real-world image" (p. 451). In simple terms, marker-based AR cannot be directly anchored in three-dimensional space due to lack of environment tracking but requires some sort of dedicated markers, such as a QR code or a picture, which is recognised by the AR device. The virtual elements appear on top of the marker and are bound to it.

In the last decades, the availability of ubiquitous computing in the form of smartphones and tablets opened new venues for AR, which introduced location-based AR applications (Martin et al., 2011). GPS tracking enabled the display of digital media, while spatially moving through physical space (Cheng & Tsai, 2013; Dunleavy & Dede, 2013). This advancement increases the possibilities for AR application (Shankar & Balasubramanian, 2009). As a consequence Fitzgerald et al. (2013) suggest a broader definition for AR and describe it as "the fusion of any digital information within real-world settings, i.e. being able to augment one's immediate surroundings with electronic data or information, in a variety of media formats that include not only visual/graphic media but also text, audio, video and haptic overlays" (p. 1). This implies that AR is a technology, which enables mediated immersion by layering digital elements onto the real world and thereby augmenting users' experiences (Rochlen, Levine & Tait, 2017).

The groundwork for AR technology was developed in the context of aviation and military, where heads-up displays were used to present in-flight information (Zhou, Duh & Billinghurst, 2008). Since then the technology has gone a long way and is developing at a fast pace. Researchers differentiate between three types of AR devices, which work on similar principles but bring fundamentally different user experiences. Head-mounted-displays (HMD) in the form of AR headsets or AR glasses are worn on the head of the user and span most of their field of view. Moving the head will move the field of view, including the digital overlay in a natural way. During this kind of AR experience users are hands-free and can use them as input devices or for other activities. Today AR headsets are still expensive and therefore mostly used in industrial settings, where improved efficiency through AR can offset the costs.

In contrast to that, mobile AR is widely available among consumers, as most recent smartphones can act as an AR device. Mobile AR describes small computing devices that display AR content on the handheld display and makes use of the onboard camera and location tracking systems. In comparison to HMD's, this type of AR experience is somewhat limited as the field of view is confined to the size of the display. The third type of AR device comes in the form of permanently installed media screens equipped with cameras and sensors to track the surrounding. They find application in public places and are frequently used to display interactive marketing campaigns or infotainment. Different AR display devices create experiences with differing degrees of physical immersion. Experiencing AR through HMD's appears to be much more immersive than the perception of an augmented environment through a small smartphone display with cumbersome handling (Van Krevelen & Poelman, 2010).

Carmigniani et al. (2010) present three main fields of AR applications, which have been most often addressed in AR research: 1) Advertising and commercial applications of AR enable the visualisation of products or marketing messages in three-dimensional space. This visualisation capability can also be used for cost-efficient prototyping in manufacturing, design and architecture; 2) Entertainment and education is another main area of application for AR. Mobile AR games have risen in popularity due to their inclusion of the physical surrounding into the game design. In the same way, AR finds applicability in tourism and the cultural sectors. AR has been proven to enhance learning experiences due to its visual, interactive and location-based characteristics and is therefore used in educational settings (Huang, Chen & Chour, 2016); 3) Medical applications of AR are continuously developed and make use of AR's visualisation and (remote) cooperation abilities.

2.2 Interactive Media Characteristics

Some studies have shown how AR media is different from other forms of media (Katz, 2013; Manovich, 2006). However, there hasn't been much emphasis on conceptualising the defining

characteristics of AR in detail. To deduce AR's media characteristics, this research is informed by previously conceptualised media characteristics from interactive media, which are digital technologies that enable mediated communication, such as e-mail, web browsers, search engines, social networking, instant messaging, mobile phones and others (Varadarajan et al., 2010). Mediated communication describes the opportunity to communicate through interactive media as opposed to face-to-face. This can refer to direct communication between two people, but also multi-path communication between many people. In previous academic works, media characteristics have been defined through communication variables that describe different aspects of mediated communication (Stewart & Pavlou, 2009; Littlejohn & Foss, 2008). Thereby, media characteristics enable the comparison of various media or stages of media. A literature review gathered relevant media characteristics of interactive media, which is related to AR media, and built a framework for further research in AR from a media studies perspective (Javornik, 2016). Previous research on interactive media conceptualised several media characteristics, which will be used as a starting point for conceptualising the main characteristics of AR media: 1) digital, 2) modular, 3) interactive, 4) hyper-textual, 5) multi-linear and 6) virtual/immersive. Before introducing them, it has to be mentioned that they do not equally apply to all types of media. The differing degree of application is suitable to differentiate between various types of media. Further, the characteristics are not only technological but also comprise social and conceptual dimensions.

One characteristic that fundamentally sets interactive media apart from old media is the underlying digital technology. Digital media encodes all types of data, which previously were stored in analogue forms of texts, photos and moving images, into numerical data. This form of data is easy to modify with the help of editing software, can be distributed through telecommunication networks, such as the internet, and is decoded through receiving devices, such as computers, smartphones or AR devices. This allows for modularity of interactive media, which implies that the media content can be organised in a modular way by arranging textual, aural or visual representation of information (Sundar, Xu & Dou, 2012).

Another main characteristic of interactive media is interactivity, which contrasts the mere consumption of media and describes the degree of interaction a media allows and is referred to as "(…) the degree to which two or more communication parties can act on each other, on the communication medium, and on the messages and the degree to which such influences are synchronised" (Liu & Shrum, 2002, p.54). This definition suggests that interaction can happen between the user and the content, as well as in-between users. According to Billinghurst and Kato (2002), the same applies to AR technology, which, therefore, can be considered as interactive. Interacting with media leads to higher user involvement in a computer-generated media space (Hoffman & Novak, 1996).

Interaction between the user and the content can take on different forms, such as navigating through media or editing it with suitable software applications. Moving through a virtual environment for a visual, three-dimensional experience is considered as interactive navigation and mostly applies to video games. Another form of media navigation is moving through a mediated environment by following hyperlinked data, such as browsing the web by following hyperlinks on websites. This media characteristic is called hyper-textuality of interactive media, which refers to the link within a media to other data (Sundar, 2009).

The interaction between users is enabled by the networked character of interactive media, which refers to the lifting of the limitations of one-on-one communication toward the possibility to communicate with many different people at the same time (Hoffman & Novak, 1996). This type of connectivity has created a new relationship between users, as well as producers and consumers, as the roles are increasingly blurred, and user-generated-content makes up a considerable part of media content (Jenkins, 2002). The networked character facilitates the interactivity of new media and progresses the democratisation of media production.

While old media, such as books and movies, are generally presented sequentially and is passively consumed from start to finish, interactive media is consumed in a multi-linear way, which requires the active participation of the user. Through an interface, the user is in control of the experience and interacts with the media content according to his preferences. On a website, the audience can co-create their individual experience by following hyperlinked data to extract the content they are looking for, which suggest a multi-linear media use. Bush (1994) indicates that this multi-linear data processing is more "natural" than through alphabetical order.

The last essential media characteristics of interactive media, which is necessary to conceptualise AR media is virtuality, which emerges from the visualisation of virtual elements that have been combined into computer-generated environments and interacting with them can lead to differing degrees of immersion (Lister, Dovey, Giddings, Grant, & Kelly, 2009); Blascovich & Bailenson, 2011). While the term virtuality is used for interactive media, which is mostly consumed on two-dimensional screens, the concept of immersion is more applicable in the context of immersive technologies, such as AR and VR. Slater (2009) defines immersive technology as a technology that offers a high quality or quantity of sensory information to the user. This is termed media richness and implies that sensory stimulation through media content can make a simulated or augmented experience more convincing (Huang & Liu, 2014). Azuma (1997) suggests that the immersion of AR is not only caused by its visuality but can also relate to other sensations. This aspect will be investigated throughout the study, which aims to conceptualise in what way other sensory stimuli can add to immersion in AR.

The concept of immersion has been approached by scholars in various ways. In a more technical sense immersion refers to the "objective" of immersive technologies (Bystrom, Barfield & Hendrix, 1999) and implies "the extent to which the computer displays are capable of delivering an inclusive, extensive surrounding and vivid illusion of reality to the senses of a human participant" (Slater & Wilbur, 1997, p. 604). Immersive technologies, such as VR, AR and Mixed Reality (MR), combine and link elements from physical and virtual worlds and are designed to provide immerse experiences for its users (Lee, Chung & Lee, 2013). Different immersive technologies can be placed among the reality-virtuality continuum introduced by Milgram and Kishino (1994), according to their degree of immersion in a synthetic digital environment. While AR, which is blending virtual and real realms, depicts one end of the continuum with a lower degree of immersion, VR constitutes the other end as it fully immerses its users into virtual environments. Studies about immersive technologies have suggested that they help to engage users (Huang, Rauch & Liaw, 2010), encourage interaction and collaboration (Martínez, Skournetou, Hyppölä, Laukkanen & Heikkilä, 2014) and complement the learning experience (Huang, Chen & Chour, 2016).

In contrast to this technical definition mostly used by VR researchers, Witmer and Singer (1998), argue that immersion refers to a "psychological state characterised by perceiving oneself to be enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli and experiences" (p. 227). Sherman and Craig (2003) adopt this notion and suggest that immersion describes a cognitive state in which users are fully engaged in a virtual experience. Other researchers argue that immersion does not necessarily relate to immersive technologies, but is a natural human state, which can be reached when being entirely engaged with any sort of activity (Weibel, Wissmath & Mast, 2010). This implies that non-technologically mediated activities or virtual experiences with low image and audio realism, such as desktop-based activities, can lead to an immersive experience (Brooks, 2003; McMahan, 2003). In the same regard, one can be immersed into imagined space generated by online communication, such as chat forums, messenger applications or social media platform (Lister, Dovey, Giddings, Grant, & Kelly, 2009). Immersion can be physical, mental and emotional (Brooks, 2003).

Weibel and Wissmath (2011) claim that immersion can be conceptualised through the concepts of flow and presence. The experience of flow is characterised by a high level of concentration, a changed perception of time and a generally positive sensation during an experience (Bian et al., 2016; Niu & Chang, 2014). Flow is "the state in which individuals are so involved in an activity that nothing else seems to matter" (Csikszentmihalyi, 1991, p.4). An example of the experience of flow is reading a book. This activity fully emerges the reader into the content of the book and limits his perception for the immediate surrounding. According to Weibel and Wissmath (2011), the state of immersion is very similar to flow, as both imply a strong focus on a particular experience and reduce awareness for the proximate happenings.

The related concept of presence refers to the sense of being physically located in a particular place at a specific moment (Lombard & Ditton, 1997). The idea of presence is similar to flow in terms of engagement but more physically and sensually rather than a cognitive. An example would be walking through a forest and being aware of the present nature through different sensual stimuli. The feeling of presence arises from the sensual capabilities of the human body and leads to a state of in-depth involvement and connectedness with the environment. (Lombard & Ditton, 1997).) According to Huang and Liao (2015) the feeling of presence is an integral part of immersion in virtual and augmented experiences.

Integrating the concepts of immersion, flow and presence into the context of immersive technologies, Jennett et al. (2008) argue that immersion is a gradual cognitive state of engagement building up towards the stages of flow and presence, which they consider as optimal "states of mind". Georgiou and Kyza (2017) agree with this notion and describe "immersion as a continuum towards flow and presence" in the context of AR applications (p. 26). This hints at the particularities of AR in comparison to other immersive technologies. While the addressed theory concepts were mostly deduced from research on immersive technologies as a whole, which includes VR, AR and MR, this particular study is focused on AR and comprehensively examines in what way the notion of immersion applies to AR.

The introduced theoretical discourse about the concept of immersion will serve the present study as groundwork to conceptualising immersion in the specific context of AR. Further, it will help to examine in what way AR experience can lead to the state of flow and feeling of presence. MORE

2.3 Concept of Space

To explore the relationship between AR and the space within which it is deployed, the concept of space has to be defined. Harrison and Dourish (1996) provide a definition of space that is widely adopted in AR research. They suggest that space is the essential geographic, three-dimensional environment that serves as a basis for all existence, comprising both, living beings and lifeless objects. Next to being the stage for mere existence, space hosts actions and interactions of those living and inanimate objects (Gaver, 1992). Hence, space is the three-dimensional world in which we live and act. Harrison and Dourish (1996) go further in their exploration of space and specify the properties of space: 1) relational orientation and reciprocity, 2) proximity and action, 3) partitioning and 4) presence and awareness.

The relational orientation of space is based upon the fact that space is the same for everybody and everything. The positioning of an element in space at a certain point in time is always the same, which leads to a common perception of space for everybody. The common percipience of space allows us to

orientate ourselves within space. In the same way, as the positioning of an element is always the same, the repositioning of that element in a specific direction also is the same for everybody. If it moves up, it moves towards the sky, and if it moves down, it moves towards the ground. This applies to all possible directions and holds for living beings and their actions. If a person walks in a particular direction, the spatial positioning of that person is equally perceived by everybody else. This mutual spatial orientation allows for our actions to be observable by others and vice-versa. In this way, interactions are made possible. Two people can agree to meet at the same point in space at the same time in order to interact (Harrison & Dourish, 1996). This implies that space and time are related, as it takes time to move between points in space. In the last centuries there has been an ongoing increase in time-space compression, which implies that technological achievements have enabled us to disconnect from the relation of space and time by substantially decreasing the time needed to cover space through new means of transportation (Kirsch, 1995) and mobile communication technologies, which enable the instant link to every point in space - at least virtually (Warf, 2011).

Another feature that defines space is the proximity of actions, which suggests that it is human nature to interact with people and objects, which are located in our spatial proximity. This relates to the required effort of covering distances and the limited reach of our voice and sensual capabilities, such as vision and hearing. While information technology these days allows us to interact with spatially distant persons and objects, we are still interacting with interfaces and devices located in our proximity and reach of our senses (Harrison & Dourish, 1996).

The next property of space, partitioning, results from the proximate nature of spatial interaction. Increased distance between people or objects leads to a spatial division of groups that interacts within their proximity (Harrison & Dourish, 1996).

The last property of space is presence and awareness, which Harrison and Dourish (1996) describe in the following way: "As we move around the everyday world, it is filled not only with the artefacts, tools and representations of our work but also with other people and with signs of their activity. The sense of other people's presence and the ongoing awareness of activity allows us to structure our activity, seamlessly integrating communication and collaboration ongoingly and unproblematically." (p. 2) It can be concluded that space is the three-dimensional environment of the world, which hosts all objects and their actions.

AR technology makes use of that three-dimensional environment by overlaying virtual elements onto the real space (Azuma, 1997; Carmigniani & Furht, 2011) and thereby creates augmented space (Manovich, 2006). Before taking a closer look at augmented space and the various ways it is constructed, the concept of media space will be briefly introduced. Media space integrates audio-visual and communication technologies to create a virtual environment which can be assessed by different parties

and is often used to collaborate remotely (Dourish, 1993). Media space mimics properties of space, especially relational orientation and presence awareness, as those properties enable interaction. Simple examples of media spaces are messenger applications, such as WhatsApp, or social media platforms. While a media space itself takes place in a virtual environment, there remains some "realness" to the use of the virtual space. This realness relates to the real-life actions that are required to use the media space, such as sitting in an office and using a computer or smartphone. Also, the conceptual work, as in the thinking, takes place in a real brain. The media space can, therefore, be seen as a hybrid space of virtual and real elements (Harrison & Dourish, 1996). While both media and augmented space, are hybrid spaces, they contain disparities. Media spaces take place virtually, and augmented spaces are real spaces.

Manovich (2006) introduced the concept of augmented space, which he establishes as physical space that is enriched by locally personalised and dynamically changing multimedia content. This enrichment leads to a novel diversity in space, which results in more active environments (Thrift, 2004). Augmented space does not only refer to augmented reality but is instead an umbrella term for all physical spaces that are loaded with information. The augmentation can arise from different technologies, such as multimedia screens, animated building fronts, signs, smartphones, computers, augmented reality and others. Prime examples of such augmented spaces are urban hotspots, such as Timesquare in New York, Shibuya Crossing in Tokyo or shopping and entertainment centres, which are characterised by a high density of information.

The augmented spaces can also be seen as data spaces, that augment space and, at the same time, extract data from that same space through monitoring technologies. Manovich (2006) argues that "the connection of surveillance/monitoring and assistance/augmentation is one key characteristic of the high-tech society" (p.222). The data flow required for the augmentation of space always also creates upstream data that can be extracted and monitored. Physical space is three-dimensional. Augmentation adds more information to space and makes it multi-dimensional.

While the term augmented space is mostly associated with specific fixed locations, such as major urban hotspots, the development of ubiquitous computing and augmented reality brought a new approach to augmented space, as augmentation can be applied everywhere. Allen (2008) claims that "the majority of city centres in the UK now fall into the category of augmented urban spaces rather than this being confined to major international and global cities" (p.28). Ubiquitous computing describes the spatial distribution of computing devices, such as smartphones and tablets, as opposed to stationary desktop computers (Weiser, 1994). Augmented reality goes along with ubiquitous computing and describes a visualisation technology that overlays virtual content onto the real world in the visual field of the user. Mobile AR is a subcategory of the location-based services (LBS), which use GPS locations of users or artefacts, to enhance the user experience of location-specific applications (Wang & Canny, 2006). This is

also considered as to as geo-tagging (Humphreys & Liao, 2011). Early research from Spohrer (1999) suggested that AR complicates the relationship between space and users, since the AR content, which is overlaid onto the physical space, can be changed at any time, thereby changing the representation of the space. Erickson (2007) found that AR encourages virtual and physical interaction with space.

The addressed theoretic findings on the properties of physical and augmented space will be applied to answer the second sub-question, which aims at exploring the role of space for AR experiences.

2.4 Place and Place-making

Previous studies looked into AR's abilities to change the perception of space and thereby changing place (Graham et al., 2013; Liao & Humphreys, 2015; Sheller, 2013). This research aims to advance the understanding of AR's ability to mediate the perception of space and place by examining which specific AR features drive its space and place mediating abilities. Harrison and Dourish (1996) differentiate between space and place: Space being a more abstract form of the physical environment and place being the social construction around that physical environment. According to them, place is a "space which is invested with understandings of behavioural appropriateness and cultural expectations" (p. 3). Cresswell (2004) defines place as "space invested with meaning in the context of power" (p.12), which implies that societal expectations about appropriate behaviour are inflicted upon place by someone, who has authority over it.

While every place is located in physical space, place incorporates the meaning which is given to space. The differentiation between "house" and "home" illustrates that quite well. Further, place goes along with a specific type of behaviour and thereby frames the behaviour. People can be naked in their bedroom but are not allowed to be exposed on the streets. Place, however, is not permanently tied to specific space and space can be different places at different times. Harrison and Dourish (1996) conclude that "space is the opportunity; place is the (understood) reality" (p. 69). Places are used to navigate space. People make use of maps (Vertesi, 2008), guidebooks (Spring, 2006) or heritage walks (Crang, 1996) to navigate through space. These analogue artefacts present narratives of space, and studying them reveals how people experience space (Liao & Humphreys, 2015).

Place can also be understood as so socially produced space. Lefebre (1991) suggests the notion that the social production of place is based on spatial practices, space representations and representational space. Spatial practices describe the observations of oneself and others in space. Observing people's practises in space reveals how they engage in place-making by changing and adapting the space for their means. Humphreys and Liao (2011) share this notion and suggest that such social production of space takes place through communication about place and communication through place. The former implies

that people talk about particular space and thereby create a value-laden version of that space - a place. The latter is more indirect and describes a place-making process, which gives meaning to space through the people who stay there. A celebrity going to a bar might change your idea of that bar even if you never stepped inside it. Contrary, representations of space are not self-realised but inflicted by others.

A framework for this suggests that urban space is constructed by strategic and tactic spatial practices. According to DeCerteau (1984), strategic practices are undertaken by dominant parties, which have authority for place-making, such as governments or municipalities, to inflict their values and ideals onto space. An example of that is Hausmann's design of Paris. Representational space is the result of the most definite form of strategic, authoritarian place-making, which emphasises on the power-laden and symbolic nature of space and converts it into place with determined meaning by authoritarian actions (Lefebre, 1991). Tactic spatial practices, in turn, refer to the creation of meaning for spaces by people, individually and collectively, in a subversive way.

Concluding, it can be said that the social conversion of space into place occurs through self-realisation and observation as well as through the power-laden infliction of understanding (Pickles, 2004). While there are structural and pervasive power asymmetries in the strategic creation of physical spaces, we see examples in this study where people are utilising mobile AR technology to exert their power on these places tactically. The provided theoretic explorations of place and place-making will serve as a foundation for the analysis of AR's place-making abilities, which are explored through the third sub-question of this research.

2.5 Place-making through AR and Technology

Previous research efforts have examined the place-making capabilities of AR and other technologies. Mobile technologies and ubiquitous computing, such as LBS and AR, can change the awareness of a place by interfering with its social construction (Dourish, 2006). Studies have shown that people perceive LBS as useful for exploring unknown environments (Chang, Hsieh, Lee, Liao & Wang, 2007; Junglas & Watson, 2008). People, further, use these applications to organise and give meaning to urban spaces (Brown & Chalmers, 2003; Foth, Choi & Satchell, 2011; Sutko & de Souza e Silva, 2011). This shows that people use mobile technologies to create their narratives about space.

An example of this is the exploration of unknown places through the use of smartphone applications. A navigation app is used to plan the city-tour, a restaurant rating app to find places to eat and social media apps to share, rate and discuss the experience. This shows that people not only use media to co-create their perception of space but also to influence other people by sharing it online. Sheller (2012) introduces the term "mobile mediality", which describes the notion that mobile technologies offer

various possibilities to create new and flexible mediated environments through the mediation of experiences and practices.

Graham et al. (2012) suggest that AR provides opportunities to change the social construction of space, which implies changing the place. Liao and Humphreys (2015) apply DeCerteau's (1984) theory of spatial practices and confirm that AR can be a tool for place-making, as it can enable its users to engage in the bottom-up social construction of space, which was previously conceptualised as tactical spatial practice. They found that users of Layar, an AR platform, virtually modify spatiality through AR. Users of the app could change the virtual appearance of their neighbourhood by overlaying digital elements with individual messages to change the perception of the space. An example would be that someone augments the logo of his favourite soccer club onto the streets, which would suggest to other users of the app that the entire neighbourhood is supporting this particular club. In the same way, it could be used to share political ideals. AR's temporal, spatial and personal characteristics make it a very suitable tool for public and private spatial communication, as messages can be permanently tied to a particular geo-location (Liu & Fuhrmann, 2016).

Augmented space is non-exclusive, which implies that one augmentation does not prevent a different virtual overlay by someone else. Tactical place-making practices of AR have been used to memorialise public and contested places (Liao & Humphreys, 2015). One example is the augmentation of the Tiananmen Square in China, where activists virtually overlaid democratic messages and augmented tanks onto the real square to protest against the totalitarian regime. Another one is a project called "The Border Memorial: Frontera de Los Muertos", which depicts augmented skeletons on places where human remains of people, who tried to immigrate from Mexico to the United States, have been found. These cases confirm that AR has the potential to shift the power relations of social space creation and enable "powerless" parties to re-engage, reproduce, and re-appropriate place (Crang & Graham, 2007). Westlund, Gómez-Barroso, Compañó & Feijóo (2011) shares this recognition and points out that AR offers infinitely more means of place-making compared to what was previously available. Crampton (2001) describes a "discourse of power, which both enables and abridges possibilities for people to act" (p.236). Graham et al. (2012) share this notion and conceptualise four different powers that affect place-making through AR: 1) distributed power, 2) communication power, 3) coder power and 4) timeless power.

Distributed power describes the possibility for decentralised AR content creation, which implies that in theory, everyone can use AR to change the spatial representation of place. While distributed power mostly relates to the formation of spatial augmentation, communication power applies to the interaction with AR content. Through engaging with, interpreting and sharing of AR content, users can actively shape the perception of space, which fits into the previously addressed notion that place-making takes

place through communication about place. Both of these powers are exerted by social actors rather than being inflicted upon by some sort of authority.

In contrast to that code power and timeless power are exerted through software or rather the author of the software, which underlies all augmentation. Code power suggests that software acts as a mediator for content and can, therefore, influence it. Kitchin (2011) argues that code resembles a set of laws that govern the formation of augmented space. Code by itself is neutral, but the power of code lies in the hands of whoever writes it, especially as code remains in the background and is not assessed by the vast majority of users. The result of code being used for the enactment of place makes this enactment non-permanent, as code can always be changed to display different content. Timeless power relates to the relationship of time and space and suggests that augmented space mostly dissolves its meaning over time unless it is updated continuously (Graham et al., 2012). A simple example is the existence of a restaurant on Google Maps, even though it has been closed for years. While it still exists in augmented space, it is not around anymore.

As the third sub-question of this research aims to explore AR's ability to mediate a sense of space and place the provided theoretic frameworks about the different powers that drive place-making will serve as the groundwork for further examination. Distributed and communication power are concepts that support the research about democratic place-making through AR. Code and timeless power help to understand the underlying functioning of place-making through AR. In particular timeless power is an important concept, which will be applied to investigate the capabilities of AR for long-term mediation of space and place.

3. Methodology

This chapter addresses the methodology applied in the present research. First, the research design is presented, including an argumentation for the appropriateness of the chosen qualitative research method. Second, sampling and data gathering methods are described. Next, the operationalisation of the study explains how the reviewed theory has informed the research design and method. After that, the process of coding and analysing the data is addressed. The chapter concludes an assessment of the study's validity, reliability and ethical implications.

3.1 Research Design

The purpose of this study is to explore AR's interrelation with the spatial context in which it is deployed by conceptualising its defining features. To approach this topic from an informative and credible perspective, and ultimately answer the research question a qualitative research design was applied, which uses in-depth expert interviews to gather qualitative data and thematic content analysis to interpret that data.

Qualitative methods are most suitable for this type of exploratory research because they not only give an overview of the research topic but enable the extraction of deep and contextual meaning (Geertz, 1973). This exploratory nature of this study is appropriate for relatively new and unexplored research areas, such as AR (Stebbins, 2010). A qualitative approach helps to understand concepts based on lived experiences and practices (Brennen, 2017; Tracy, 2010), which in the case of the present research implies the generation of expert insights from AR practitioners about the properties of AR and its relation to the spatial context.

3.1.1 In-depth Interviews

To gather suitable data for this study in-depth expert interviews were conducted with AR practitioners that are involved in the conception and realisation of AR experiences for various areas of application, such as industry, media, marketing, entertainment, arts & culture and education. The purpose of in-depth interviews is to "achieve both breadth of coverage across key issues, and depth of coverage within each" (Legard, Keegan & Ward, 2003, p.148). The main advantage of in-depth interviews is that they can gather much more detailed and nuanced information about a particular topic than other data gathering methods (Boyce & Neale, 2006; Hermanowicz, 2002). Rorty (1980) suggests that knowledge is socially constructed through

human interaction and that interviews are imitating this process, thereby creating and manifesting knowledge. Therefore, in-depth interviews are suitable to assess this socially constructed knowledge

In-depth interviews are helpful to explore the insights and opinions that people have about specific topics (Kvale, 2007). Interviews convey the participant's point of view (Burgess, 1982), which makes it very suitable for the present research as it enables the gathering of expert knowledge from the perspective of AR practitioners. Expert interviews constitute a research method through which comprehensive results can be obtained quickly and effectively (Bogner, Littig & Menz, 2009). Particularly in the field of AR, which remains a novel and niche area of research, this type of data gathering method is valuable by contributing otherwise difficult to capture insights. At this point, the AR practitioners can still be categorised as early adopters, which allows for relevant contributions and provides an understanding of the people who drive the adaption of the technology and their social context (Hermanovics, 2002).

The interviews were conducted in a semi-structured way, which combines structure with flexibility (Legard, Keegan & Ward, 2003). This implies on one side that specific pre-defined topics can be elaborately explored through open questions (Harvey, 2011) and on the other side maintaining the flexibility to ask follow-up questions and adjust the interview flow (Brennen, 2017). This implies that topics that emerge in the course of the interviews can be covered next to pre-defined topics. Based on the presented theoretical framework, a topic guide was set up, which aligns the direction of the interviews towards answering the research question. Another benefit of the topic guide is that it allows for the interview to be conducted in a non-sequential order. This implies that the researcher can jump between topics according to the development of the interview (Brennen, 2017). Further, the interactive nature of in-depth interviews enables the researcher to ask follow-up questions, which help to expand upon specific relevant topics and insights (Ritchie & Lewis, 2003). According to Holstein and Gubrium (1997), the knowledge does not flow unidirectionally from interviewee to researcher but rather is co-created through the conversation between the two. This implies that the researcher has an active role in the construction of knowledge and meaning through in-depth interviews (Kvale, 1996).

After gathering the data, qualitative content analysis in the form of thematic analysis was conducted. Several rounds of open, axial and selective coding were used to extract the main themes from the data, which are then presented and discussed in the results chapter of this study.

3.2 Sampling

In order to gather relevant data, eleven interviews of about one hour each were conducted with AR creators in the period from March 2020 to May 2020. Purpose sampling has been applied to select a suitable sample group (Suri, 2011). According to Creswell, Hanson, Clark Plano & Morales (2007), purpose sampling is most suitable for this research, which is not aimed at finding generalisable results but at the extraction of in-depth knowledge about the research topic. This implies that the interviewees have been selected based on the researcher's knowledge of the population for the fit of the study (Babbie, 2013). In this case, the researcher has done online and phone research on each of the participants and their profession in order to assure their fit for the study.

Further, at the start of each interview, the participants were asked to present their relation to AR, which constituted another check for the research eligibility of the participant. The profession of a person is said to allow the presumption about his knowledge and can be used to determine the sampling fit (Flick, 2007). The interviewed AR creators were all professionals who design and realise AR experiences for different types of application. They had to be either part of the AR division in a digital agency or a freelancer, with a proven track record or references from other experts with confirmed suitability.

Several reasons justify the use of AR practitioners for this study. First, they are heavy, long-term users of the technology, who work with it daily, and can, therefore, be considered as experts about the technological aspect, as well as the social implications. Next, to their own experience, they continuously get feedback on their projects from users and customers, which develops their knowledge of AR. It can further be assumed that they keep up to date with the technological developments of AR and the ecosystem in general. The interviewees were carefully selected to represent the most relevant areas of AR application as introduced by Carmigniani et al. (2010) which are industrial, medical, marketing, communication, entertainment and education. This variety in areas of application makes the sample more diverse, which allows for multifarious insights (Flick, 2007) that can be compared or point out common features amongst them (Maxwell, 2005).

The interviewees were partially sourced from the network of the researcher and through the process of "cold calling" of digital media agencies via email and social media. Of particular

help was the website of a co-working space focused on immersive technologies in Amsterdam, which offered access to its far-reaching network of AR professionals. In the course of the interviews, snowball sampling was used to find additional suitable interview partners (Babbie, 2013). While Littig (2018) points out that it is not an easy endeavour to gain access to expert interviewees, this did not materialise in the case of the sampling process.

While initially mostly participants from Rotterdam and Amsterdam were reached out to due to their proximity to the researcher, the shift towards virtual interviews loosened this criterion. What remained though was that all participants had to speak English, as this was the language of the interviews. The interviewees were based in different parts of the world, such as Amsterdam, Rotterdam, Berlin, Hamburg, London and Los Angeles. The sample consisted of ten male and one female participant. The age of the participants was not disclosed. For more information about the sample group, see Appendix A: Interview List.

3.3 Operationalisation

The purpose of this study is, first, to conceptualise AR's media characteristics in detail, second, to explore the role of the physical space for AR and, third, to describe AR's ability for place-making. Therefore, the research question is supported by three sub-questions, each of which was operationalised in a particular way.

In order to derive AR's media characteristics, the media characteristics of interactive media were used as groundwork. AR belongs to interactive media but is distinguishable due to its unique combination of features (Javornik, 2016). Therefore, literature about media characteristics of interactive media informed the research design, particularly the first sub-question, and established the first interview topic about the defining features of AR. During the coding of the data, interactive media characteristics were used in a deductive way to establish axial codes. This will be addressed in more detail in the data collection and analysis section of this chapter.

The literature review about the concept of space and augmented space informed the sub-question about the role of space for AR. It was essential to understand in what way the properties of the three-dimensional world frame human life and existence (Harrison & Dourish, 1996; Kirsch, 1995; Warf, 2011). This informed the potential roles of space in the context of AR. In the

same way, the exploration of augmented space (Manovich, 2006; Thrift, 2004; Allen, 2008) served as groundwork and was used to frame the interview topic about the role of space.

The last sub-question about the mediating abilities of AR was informed by the theory about the general concept of place-making (Humphreys & Liao, 2011; Lefebre, 1991) and studies about mediating a sense of place through technology (Dourish, 2006; Sheller, 2012; Graham et al., 2012). In the course of the analysis of the third sub-topic, selective codes from the first sub-question about media characteristics were used as axials codes for the theme of AR's ability for place-making.

3.3.1 Operationalisation Topic Guide

To maintain a common thread during the expert interviews and make sure all relevant points are covered in a way that helps to answer the research question, a semi-structured interview guide was set up (see Appendix B: Topic Guide). The questions were stated in an open-ended way to encourage the interviewees to give extensive answers and provide in-depth insight and opinions (Harvey, 2011). The sequence of the topics was adapted according to the direction of the interview. The interview topic guide was set up based on the theoretical framework and tested in pilot interviews. The learnings from these pilot interviews were applied to improve the guide in an iterative manner, which helped to streamline the guide towards answering the research question. While all questions aim at answering the overall research question, the interview topics are structures according to the three sub-questions.

After the introductory conversation, the first interview topic has the purpose of investigating the media characteristics of AR. For a start, the interviewees are asked about their definition of AR. This question aims to extract various slightly different definitions of AR, which each add some nuances to a collective understanding of AR. After that, the media characteristics framework derived from interactive media research is applied to channel the individual depictions of AR towards a more structured result, which expands upon the interviewees' definition of AR and examines conformities and differences between interactive media and AR media. Next to drawing from theoretical argumentation, the interviewees are asked to present practical examples, which support their opinion.

Secondly, the spatial context of AR is assessed. This interview topic focuses on the role of space for AR and in what way it adds to the purpose and outcome of the experience. It,

further, addresses the creation process of AR applications and examines how space influences the production of AR content. Here it is interesting to hear the perspective of AR creators and what issues they have in mind while creating an AR experience.

Thirdly, the ability of AR for place-making is examined by asking about corresponding, personal experiences and practical examples. What is crucial here, is that the driving forces for place-making through AR are examined, as well as the actors who have the power for place-making through AR.

Lastly, the AR practitioners are asked for their reasoned outlook on the near-term future of AR. This adds a variation to the previously addressed sub-questions, as AR creators can describe their vision for AR technology and what social implication that might bring.

3.4 Data Collection and Analysis

The initial plan was to conduct face-to-face interviews with AR practitioners, which allow for better interaction with the interviewees and the observation of subliminal expressions (Legard, Keegan & Ward, 2003). This, however, was ruled out by the coming into force of social distancing measure related to the Coronavirus outbreak. Therefore, eleven virtual interviews were conducted via Skype video calls, each of which was approximately one hour long.

The first step in each interview was to establish a good relationship with the respondent to facilitate the knowledge exchange (Hermanowicz, 2013). This was done by starting with an informal chat about the topic. What helped was starting with some open questions about topics that do not directly address the research topics, such as asking about the respondent's career path or motivation to work in the AR field. From there, it was led over to the topic of the interview, by briefly introducing the research topic without being too leading in a way which could influence the answers of the interviewee. From there, the interview was guided by, but not tied to, the topic guide in order to touch upon all relevant areas (Hermanowicz, 2013). While using the interview guide, a level of flexibility was maintained, which allowed diversion from the topic guide and expansion of topics, which were introduced by the respondent. This unanticipated data could prove helpful to answer the research questions and gain new perspectives. Further, a high level of interaction between interviewer and interviewee was anticipated, which helped to co-construct interesting insights and shed light into the researched topic (Legard, Keegan & Ward, 2003).

All interviews were recorded and transcribed with the help of software solutions. The transcripts were used for the thematic analysis.

3.4.1 Thematic Content Analysis

Qualitative content analysis is suitable for examining large quantities of qualitative data, such as media texts and interview transcripts, and helps to extract explicit and implicit meaning from the text (Hsiu-Fang & Shannon, 2005). In this particular case, a thematic analysis was most suitable as it allows to extract all relevant information from the gathered qualitative data gradually. In order to examine the research topic in its entirety and account for the theoretical concepts, a combination of inductive (data-driven) and deductive (concept-driven) analysis was conducted. The thematic analysis allows categorisation of data, which facilitates the detection of patterns (Braun & Clarke, 2006). This type of analysis, moreover, enables the efficient screening of large amounts of data and the juxtaposition of findings (Williams & Moser, 2019). What further improves the quality of the analysis is the iterative approach of thematic content analysis (Braun & Clarke, 2006).

In the course of thematic content analysis, open, axial and selective coding rounds were conducted to refine the extensive data set and capture all critical themes (Williams & Moser, 2019). As a first step, the researcher familiarised himself with the data by reading the transcripts, taking notes and broadly subdividing the data into groups according to the primary research trajectories (Boeije, 2010). Next, open coding was conducted to categories the data into open codes and make them more assessable for further coding by attaching short descriptions (Strauss & Corbin, 1990). The use of open coding as a first step allowed to explore the entire data and establish first codes (Boeije, 2010). After that, axial and selective coding was conducted for each of the three sub-topics separately (see Appendix C: Codes).

Axial coding consists of "intense analysis done around one category (i.e., variable) at a time, in terms of paradigm items (conditions, consequences, and so forth)" (Strauss, 1987, p.32). Through axial coding, the connections between and among open codes can be established (Williams & Moser, 2019). Glaser (1978) suggests that "the six C's", which are "causes, contexts, contingencies, consequences, covariances, and conditions" are suitable categories to describe focal variables (p. 74). In the present research, the categories *context*, *conditions*, *consequences* and *contingencies* were used as axial categories, as

they help to structure the axial codes in a way which reveals their contribution to each specific characteristic. Through categorising the variables, each AR media characteristic was conceptualised in detail. *Context* describes the media characteristics and the quality it adds to AR. *Conditions* describe what enables the media characteristic. *Consequences* imply the implications of media characteristics for AR. *Contingencies* address limitations and downsides of a media characteristic.

In order to explore the role of space for AR and its ability to mediate place, axial coding was conducted to merge similar codes into more comprehensive, final themes (Braun & Clarke, 2006). For the selective coding of the data about how AR mediates the sense of place, the codes were matched with the conceptualised AR media characteristics from the first sub-question in order to explain which particular features of drive its ability for place-making.

After conducting the coding, the main findings from the data were related to one another and discussed in the context of academic literature. It was of high importance to make sure that all data has been included in the coding process to not miss out on essential themes. The main themes that were revealed in this thematic analysis will be presented and discussed in the subsequent results chapter of this study.

3.5 Validity, Reliability and Ethical Conduct

A driving principle throughout each stage of the research process was to be as rigorous as possible to ensure the validity and reliability of the research. While validity describes the appropriateness of method, processes and data for the research, reliability address the replicability of the research and the findings (Leung, 2015). Rigour is said to be integral for the conduction of qualitative research methods in order to achieve comprehensible results (Nowell, Norris, White & Moule, 2017)

As a first measure to achieve rigour, the sampling method and criteria had to be suitable for the research trajectory. Therefore, purpose sampling was applied, as random sampling would not have ensured the quality of the sample and jeopardised the validity of the research (Morse, Barrett, Mayan, Olson, & Spiers, 2002). Particular attention was paid to the quality of interview participants, which could valuably contribute to the topic of the research, by researching their eligibility. Further, it was ensured to have some degree of variety within the sample group of AR experts by including practitioners from different areas of application. Second, before starting the

data gathering process, several pilot interviews were conducted to test the topic guide and the interview questions. The testing, further, developed the researcher's proficiency in the research topic and helped to practise interviewing, both of which is essential for data gathering through in-depth interviews (Hermanowicz, 2002). Third, every stage of the research was meticulously documented, such as through descriptions of the participants, recording and transcribing of the interviews, taking notes of observations and general impressions and writing down the progress of the process of analysis. Forth, it was focused on the iterative nature of qualitative research by applying verification strategies with the purpose of adopting the process by moving between research design and implementation (Morse et al., 2002). In order to enhance the reliability of the present research, five propositions by Silverman (2011) were applied: Refutational analysis, constant data comparison, comprehensive data use, inclusive of the deviant case and use of tables.

Moreover, it is crucial to address the aspects which ensured the ethical conduct of the study (Tracy, 2010). The research topic did not examine any delicate topics, which might have been discomforting or harmful for the participants in any way. The interview practitioners were free to deny answering any question or ask for more context before responding. All participants agreed to be recorded during the interview. In general, the research was vigilant to and applied the maxims of ethics (Ramos, 1989).

4. Findings and Discussion

This chapter presents the main findings from the interviews and conceptualises the defining features of AR from a practitioner's perspective. The first section presents the findings related to the AR characteristics. In this part of the chapter, the theoretical discussion is integrated with the respective findings. The second part of the chapter offers the findings about the relation of AR with the spatial context and includes a dedicated discussion section to ensure the clarity of reading.

4.1 Defining Features of AR

4.1.1 The Visual and Sensual Appeal

For a start, the findings suggest that AR can be characterised by its strong ability to *visualise information in a novel and appealing way* by overlaying digital content onto physical space and objects. Ketel (Interview 6) states that "being able to add these digital elements, kind of creates a layer of magic on top of the physical world ….". The displayed information can take on all forms of visual data representation used in other interactive media formats (Sundar, Xu & Dou, 2012). As opposed to the requirement of screens for conventional interactive media, the virtual content in AR appears as a holographic projection in the user's field of view and seamlessly integrates into their subjective perception of reality. This leads to a highly visual experience for AR users, which creates an impression of virtual and real worlds merging into one. Veenhof (Interview 10) argues that location-based technologies already blend virtual and real. He states:

> Even in a normal, ordinary day, that's what people do on their phone all the time … but with AR you make it visual. It manifests itself in that way. It's a sort of immediate connection between this whole digital online realm and the physical situation that you're in. (Veenhof, Interview 10)

This implies that AR can be defined as a suitable tool for all kinds of visualisation tasks requiring the display of various media in physical space. This feature aligns with Sundar et al.'s (2012) description of modularity, which suggests that the digital content is organisable and exchangeable in a modular way. At the current stage of the technological adaptation of AR, this

novel kind of visualisation carries an innovative appeal. It is frequently used in the context of trade fairs due to its ability to attract visitors as Bannenberg (Interview 1) describes: "One of the reasons Phillips is using all these new technologies as eye-catchers, they want to have something to stand out from the rest of the exhibition to attract the public to the stand".

Next to its *novel appeal*, the findings suggest that AR is *very suitable for the visualisation of data* that is not easily visualised on screens or paper. Through AR information can be linked to the corresponding physical environment or object, which makes it easier to understand and extract. Strunden, F (Interview 7) argues: I think it's the access to information that otherwise we cannot print because it's not feasible. … through AR you sort of unlock a story for every object, everything that can be accessed. So, it's this digital trail that otherwise is invisible and not available upon interest - with AR glasses you are unlocking that." This indicates that the way AR can visualise data is more natural as stated by Veerman (Interview 2): "I think learning wise and how we perceive data and how we can better understand data, make it less abstract, I think that's a really big power and also the way we communicate."

This visualisation capabilities also enable AR to be a very *cost-efficient solution* for a variety of use-cases, such as for product visualisation and prototyping:

> We have presented those [prototypes] to the medical professionals so they could experience these solutions without Phillips actually having to build them, and so depending on the responses from those people, we would either continue the project and work on built physical prototypes of them, or say abandon or re-examine them if they said the responses were not very favourable. (Bannenberg, Interview 1)

Also, in industrial processing and maintenances use-cases, AR can lead to improved efficiency as described:

> So, with augmented reality, the very interesting potential here is the again, the user interface. You can, in a very natural way, see visually what's the status of everything. Then access very easily, do documentation and even take the next actions. So, it saves a lot of time. (Karam, Interview 5)

The aspect of being hands-free further improves the efficiency as the user can still use their hands for the task at hand. In the same way, AR can be used to efficiently organise events

without physical preparation as Veenhof (Interview 10) explains: "You could also go outside, and it was an evening with a lot of fun and not a lot of preparation required. No, physical preparation, just an empty space was enough."

While most descriptions of AR emphasise the visual aspect of displaying information in textual and graphical form onto the physical world, some creators suggest a more extensive definition of augmented reality, which follows a phenomenological understanding. This implies that the perception of reality can also be enriched by augmenting the *sensual experiences of sound, tactility, scent and taste*. What is striking is that Azuma's (1997) fundamental definition of AR addresses the importance of all human sensual stimuli, but this is often overlooked in most conceptualisations of AR. Strunden, P. (Interview 3) points out that "that's one aspect that is not so much spoken about. But I think it's this whole idea of this big field of phenomenology, the way we interact through our senses with space and how we perceive space." Several of the interviewed AR practitioners highlight the importance of audio elements for AR. Karam (Interview 5) implies: "What we learned is that adding a sound component definitely plays a huge role for making it an immersive experience". The findings suggest that the integration of suitable sound elements can make virtual elements appear more realistic. The encounter with a wild animal in your living room through AR is way more exciting if the virtual animal not only behaves like a real animal but also makes the same sounds. This drastically increases the belief in the realness of the animal and the user experience in general.

Next to adding additional content in the form of sound to increase the media richness of experience (Huang & Liu, 2014), the use of audio can create a simple*, stand-alone AR experience* without the need for visual overlays. This notion was introduced by Eker (Interview 11), who describes an interactive experience at the ARTIS Zoo in Amsterdam, which uses sound elements to guide the tour:

> Depending on where you are standing, it triggers a different [audio1] part of the story…. So that kind of takes you around there and it tells you about this particular corner with the green flowers or something like that. And then there actually is this corner, you can see it with your eyes, but you're also hearing the story on top of that. So, I think this is already augmenting the reality, you see a reality and the audio adds on top of that. (Eker, Interview 11)

Eker (Interview 11) mentions another example of an exhibition at The Metropolitan Museum of AR, where the binaural (3D stereo) sound was used to create an AR experience by overlaying audio elements onto the exhibition experience:

> They had an exhibition about a certain period in Versailles [see Appendix D] …. But what they did on top of that, they found a building that was similar to Versailles and used this building to binaurally record some sound of people talking, gossiping, bulking, shouting, the things that you could have experienced in Versailles during that period of time, like during a party or something. At the entrance of the exhibition, they handed out headphones and putting them on you would hear the binaural recordings, hear the voice as if you were there (during the party) from different angles. … thereby adding this extra layer of feeling that you are actually in Versailles in that period of time. (Eker, Interview 11)

This again shows the power of audio, especially binaural audio, for augmenting reality. Eker (Interview 11) concludes: "These two basically show that, yes, the most common way is with visual, but if very nicely done audio is also a big element." He goes on and suggests that adding audio to an AR experience can be an easy way to make it more immersive: "I think it becomes easier to add audio and I think that we will start seeing it in more projects."

The *tactile sensation* was proposed as another significant sensory stimulus for AR, as touching a physical object, which is overlaid with digital elements, can enhance the feeling of immersion. Deussen (Interview 8) describes one of his projects, in which the content of a print catalogue was digitally augmented when looked at through an AR device. This enabled the user to navigate the content by physically by touching and turning the pages. This tactile experience made the augmented content more believable, and the user interaction more natural. The previous studies revealed that AR can enhance the learning experience (Huang, Chen & Chour, 2016). Deussen (Interview 8) suggest that the integration of physical artefacts in educational AR application further improves the learning experience: "There's the concept of haptic learning through physical objects. You can experience and manipulate the objects with all your senses, which increases the possibility to learn and experience." While the role of physical artefacts in AR will be examined more closely in the course of the study, these findings confirm the importance of tactile sensation for AR.

Paula (AR creator) implies that if AR is experienced through several senses "it feels seamless to reality, it's even more immersive than just having a lot of visuals." She further illustrates that by comparing AR experiences to the human perception of physical space: "We don't only perceive space through our eyes, but perceive it very strongly by the sound that a space emits, by the smell it has, by the tactility's of materials, textures and by very much all our own locomotion." Concluding, the findings suggest that next to visual stimuli, aural and tactile sensory stimuli can be considered as essential for creating immersive experiences in AR.

Further, the findings suggest that AR opens new means of personalised storytelling as some respondents pointed out. Bannenberg (Interview 1) states: "You could possibly tinker or adapt experiences to personal preferences and experiences of the user, thereby making it a much more personal experience." This especially could have implications for marketing, as Ketel (Interview 6) suggests: "Perhaps an advertising billboard is just going to be like a QR code because everyone can get like their personal live advertisements. So, I think the physical space will change once we start adding more digital elements." The same notion is being shared by Strunden, F. (Interview 7), who describes this as being contextual: "AR really makes the world adjust around you. And that's a contextual aspect where a label that's printed obviously tries to target you, but it also has to satisfy everyone else, because everyone sees the same thing." Another promising application of AR in this regard is personalised education, which could adapt to individual learning preferences. The personalisation is enhanced by the data capturing abilities of AR. While this attribute will be introduced in more detail later on, it can be pre-empted that the combination of health monitoring wearables and AR can offer new means of personalisation. Bannenberg (Interview 1) suggests: "If you, for instance, would tie in wearables and include their feedback, I guess in the widest sense, you could include blood pressure, heart rate and all of that stuff, depending on what application you're doing."

4.1.2 A Different Kind of Immersion

Next to the visual and sensual particularities, immersion emerged as a related characteristic of AR. Bannenberg (Interview 1) describes: "For me, the appeal is that it [AR] offers you a chance to create an experience that's much more inclusive, much deeper than watching a movie or reading a book." What is striking, though, is that the underlying definition of immersion differed among the respondents.

Some made use of the term more conventionally and compared the immersion of AR to the fully enclosed, immersive experience of virtual reality, which aligns with Lister et al.'s (2009) notion that immersion refers to entering a surreal, virtual space generated by computer graphics, which leads to seclusion from the real world. Karam (Interview 5) describes this enclosed nature: "Basically, you forget about the surrounding; you are in at the moment." Ketel (Interview 6) describes a lack of spatial perception during virtual immersion: "… you have no idea where your physical presence is at the time [of immersion]." This type of self-contained immersion draws parallels to the technical definition of immersion, which is often used by VR researchers and defines immersion as the "goal" of immersive technologies (Bystrom et al., 1999). Slater and Wilbur (1997) define this kind of immersion as an "inclusive surrounding and vivid illusion" created by computer-generated graphics. This type of immersion particularly applies to headset-based AR, as it was implied:

> It's immersive in the sense that with a book you have a small area of focus and once you've moved your eyes away you are out of that experience. … some TV screen or cinema screen … [might be] much bigger, but there still are ways of looking away or stepping outside the experience or losing the link to an experience, whereas in AR, you tend to have to actually remove the headset in order to stop or get out of the experience. However, you move the experience tends to move with you. (Bannenberg, Interview 1)

This matches with Krevelen and Peolman's (2010) findings that headset AR is more immersing than mobile AR.

In contrast to this virtual immersion generated by visual and sensual stimuli, stands another concept of immersion, which is not so much bound to digital realism, but instead describes a human state of mind, that arises from being emerged into a particular activity. According to Weibel and Wissmath (2011), immersion conceptualises through the concepts of flow and presence. Jennett et al. (2008) suggest a different relation between the three concepts and imply that immersion is a gradual cognitive state of engagement building up towards the stages of flow and presence. This implies that immersion is not similar to but ultimately leads to the experience of flow and presence. Some findings suggest that immersion as a state-of-mind is more applicable in the context of AR. They suggest that an AR application that supports efficient problem-solving by driving the focus of the user toward reaching a specific goal can be

considered as immersive, without the necessity of digital realism. This type of immersion was described as follows:

> I could imagine if I were somebody who would let's say, fix a car, and it would just augment me the perfect pieces I needed, the right bits of information. When it really fits into what you do, you kind of accept that quite intuitively because it actually helps you to do your physical activities. (…) And the more you can profit from it, the higher the immersion or the acceptance of that as part of your reality would be. (Stunden, P., Interview 3)

This description of immersion in AR aligns with Jennet et al.'s (2008) notion that immersion is a prerequisite for flow. This implies that if an AR application is helpful to fulfil a particular task, a user might fully immersive himself in the experience to complete the task as efficiently as possible with the support of AR, which refers to the concept of challenge-based immersion (Gamez, 2009). For AR to be supportive, the user has to "trust" the augmented information. Strunden, P. (Interview 3) argues: "Immersion is a lot about believing in the content that you're being exposed to and trusting it and acting upon the laws of that content and accepting as part of reality." Adopting the challenged-based notion of immersion, mobile AR experiences, whose immersive capabilities were previously denoted as limited, can, therefore, be considered as immersive, too, if they drive the focus of the user toward reaching a specific goal.

Further, it was suggested that well-suited *experience and audio designs* are integral to reach immersion. Karam (Interview 5) implies that "The way you design your experience can make it immersive or not." He also links the immersion back to AR's data visualisation capabilities: "I also consider it immersive for another reason. You have so much data in most fields, and it's just on screens. But by visualising data [in AR1], people can interact with it and get a feeling about it. … it allows a better understanding, although it's the same information and data. The discussions are much more interesting and creative." These findings argue against the notion that immersion is primarily challenge-based and that non-technologically mediated activities can lead to immersive experiences (Brooks, 2003).

Another line of argumentation suggests that AR is immersive if it *blends virtual and real* realms. Ketel (Interview 6) suggests that "augmented reality can perhaps be even more immersive in a sense that, (…) at some point, you don't know what's real, what's digital

anymore." Strunden, P. (Interview 3) implies that AR is most immersive when the digital layer is subtle: "I think with immersion of augmented reality it's different [than in the case of VR experiences], because it's not about forgetting the reality, it's more about forgetting that this is a projection." Some of the experts argue that the virtue of AR lies in its ability to enrich the user's perception of the real environment, while not limiting his attention to a particular exclusive experience. Strunden, P. (Interview 3) suggests: "It's maybe more like a merge, not an immersion." This opposes the virtual, enclosed notion of immersion and implies that the user is merged with the real world in his experience and is constantly aware of the proximal happenings while experiencing AR. Strunden, F. (Interview 7) even suggests that "when AR becomes immersive, it's the bad part of it." In this statement, he refers to immersion as being enclosing and limiting the perception of the real world. He argues that purposeful AR should always maintain the percipience of the physical environment and enrich it with digital information. He implies: "If AR manages to remain as this additional information layer on top without sucking you in, that's very powerful." Veerman (Interview 2) supports this notion: "While we interact with and look at the data (through AR1), we still have the ability to interact with the 'normal' world as well."

Depending on the combination of virtual and real elements, different degrees of immersion can be achieved:

> [The degree of immersion] has to do with to what extent you are in the physical world or in the virtual world. I think everything in between is immersive if it's done well, but there's a different mix of how much it's physical and how much is digital. (Ketel, Interview 6)

Here the link to Milgram and Kishino's (1994) reality-virtuality continuum can be drawn, which arranges different immersive technologies according to their degree of immersion in a synthetic virtual environment. AR is located at the end of the spectrum, as it is featuring no or low immersion with a fully synthetic, digital environment, as the user is immersed in the real, physical world.

Examining the immersive character of AR, the *limitations of the current state of AR technology* has to be addressed. It was suggested that current AR devices do not allow for an enclosed and virtual immersive experience yet. Eker (Interview 11) describes:

> I wouldn't use the term with the current state of AR. With VR by definition, you are enclosed. I mean, that's as immersive as it gets. And with AR especially with the current hardware that you have, either a phone or a tablet or a headset with a limited field of view, you are still looking at it from a window, right? Either it's on your face or your hands, and that is not yet as immersive as it could be if we had headsets with a 180-degree view, vertical and horizontal, then we would be able to say that maybe this is also immersive. Yeah, but I think at that point VR is still more immersive because with AR, by definition, you see the real world and you don't get that disconnected, which I enjoy more. (Eker, Interview 11)

This implies that for AR to be immersive in the "technical" sense of virtual immersion (Witmer & Sinder, 1998), it requires some technological enablers to be in place. The AR device must enable a large field of view and precise environment tracking. As previously suggested, a sound component can increase immersion. AR devices of the current state, however, do not sufficiently fulfil these requirements to make an experience visually immersive. The potential of immersion through mobile AR devices was considered as particularly limited according to some AR creators. Veenhof (Interview 10) states:

> But right now it's not [immersive], of course. Holding up a phone and looking at something, even if it's a portal into another dimension. I mean, it's still a phone. It's a small screen. So especially for somebody seeing it for the first time, they just see a small screen. (Veenhof, Interview 10)

Some AR practitioners indicate the lack of a term that accurately describes immersion in the context of AR and distinguishes it from immersion in VR, which also explains the various notions of immersion. Deussen (Interview 8) implies that:

> This term should somehow play with the fact that [immersion in AR] is physical. You're more engaged with the world because you get additional content and additional features … make clear to people that this is kind of like one of the core differences between augmented reality and virtual reality. (Deussen, Interview 8)

Combining the different notions of immersion that were presented, their technological feasibility and the condition, that AR, by definition, upholds the perception of the real environment, the concept of a particular type of immersion for the context of AR can be introduced. *Perceptive immersion* describes a state of immersion that is not enclosed to one experience, but that includes the immediate spatial context, in which the experience is taking place, through digital elements, which links to virtual immersion. The experience is immersive in a sense that a user is engaged in the given experience, which draws from challenge-based immersion, but he is not losing the perception of the real surrounding, which refers to the merger of virtual and real worlds. *Perceptive immersion* intensifies through giving the user a feeling of presence. Huang and Liao (2015) define presence as the mental and bodily feeling of being in a particular place. AR users experience the "real" surrounding, enriched by information in digital form while being able to see and feel themselves, use their hands and look around naturally. In this regard, the concept of embodiment plays an important role. Strunden, P. (Interview 3) outlines the relation of presence and embodiment for AR:

> I think this phenomenological understanding has a lot to do with embodiment and the presence of your body within that space. And to understand your environment through your body. … So, these are things in AR, I think you always have the presence of your physical environment, and you have the presence of your physical body. So, I think it's closer to reality in that sense. (Stunden, P., Interview 3)

What adds to *perceptive immersion* is the display of digital content in real dimensions. Seeing a life-sized dinosaur in AR allows a user to grasp its enormity more accurately by comparing it to the proportions of the physical surroundings and himself. Van der Plas (Interview 4) states: "It's part of the world you are looking at. … You get the dimensions … and you can imagine how tall it [object] is just by standing next to it." Veenhof (Interview 10) even suggests that the appropriate scaling of the content is essential for an AR experience:

> I was just complaining a bit on a project I saw on my Facebook feed, where gigantic virtual things for the outdoor could now be experienced inside your house in a sort of scaled-down version. I think that is not what you want. You don't want to see a tiny animation on your desk, which is about cars floating through the sky. You know, those

> are only impressive when they're actually floating around, for real, in a real sky and when they're big. So scaling is important like positioning location and context is very important. (Veenhof, Interview 10)

4.1.3 An Extension of the Human Body

The third most frequently mentioned characteristic of AR is its intuitiveness in use and experience. This intuitiveness results from several aspects, such as the natural way of looking around the over-layered space and the multi-linear way of interacting with the content. This fits with Bush's (1994) notion that assessing data in a multi-linear way is more natural than in alphabetical order. While traditional interactive media is consumed through screens, which require physical touch gestures or input devices to navigate the displayed content, AR glasses allow a natural way of observing information by looking around space in the same way someone would look around in reality.

> Even my grandma immediately understood the environment because she just had to reach out and look around. My guess is that all humans are used to interact with AR [in the form of headsets or glasses]. If I give her an iPad, she has no idea what to do, everything goes wrong. I think in that sense indeed, intuitiveness is very important because we can create these interfaces and interactions that are closer to the way we interact with our physical world. (Ketel, Interview 6)

This natural way of looking around augmented space fits into the previously introduced phenomenological understanding of immersion, which suggests that AR can be experienced through all human senses. Interactive media distinguishes itself from old linear media, such as tv and radio, due to its multi-linear organisation (Javornik, 2016). The multi-linearity is achieved through hyper-textuality, which enables moving through the mediated environment by following hyperlinks to access data (Hoffman & Novak, 1996). While the same applies to AR, it further entails a multi-linear way of interaction through the physical movement of the user. Deussen (Interview 8) compares it to visiting a gallery where you are not bound to a specific order to look at the paintings. An AR experience can be similar. He states:

> If you would do it as a film, it would be a linear experience. In AR you can see the last picture first and then go to the next one, so it's not linear anymore, it's interactive. So even on that level, it's the physical space that determines how you experience the augmented reality. (Deussen, Interview 8)

Another important aspect that adds to the intuitiveness of headset-based AR is the fact that users are hands-free. Paula suggests: "I think the idea of intuition is really nice because you have like, let's say, when you're cooking or when you're fixing something when you're making something, you're kind of creating something. It's really nice to be hands-free, no device to hold, nothing to kind of scroll your fingers through. When you wear gloves, when you have tools in your hand when you actually do any kind of manual work, that level of intuition of having additional content that can be controlled through your eye movement is really a very big characteristic of AR."

Some creators, such as Deussen (Interview 8) suggest AR will bring "a revolution in the way we are experiencing digital content" by being the next stage in the evolution of digital media interfaces, as it adapts to the natural way of receiving information and interacting with it. Ketel (Interview 6) suggests that

> We are now used to this rectangular, flat interfaces, but there is probably a big productivity gain we can get from designing it completely different …. So with VR, there is quite a high threshold, I would say, to start using it, but AR should be kind of a natural blend. The natural evolution of interfaces and in general, the way we interact with digital environments. (Ketel, Interview 6)

Deussen (Interview 8) agrees:

> It's on one side a new user interface where suddenly every object can speak, can become interactive, by putting a digital layer on it and on the other side, I think it's just not going to take so long before our world is going to be full of augmented reality content. (Deussen, Interview 8)

For that to happen sophisticated AR technology in the form of headset or glasses has to become more much accessible to mainstream users. Current AR headsets are still very expensive, and

using them is currently only worthwhile when it can offset the costs. Some of the interviewed practitioners believe that Apple, Google and Facebook will be releasing AR glasses for mainstream use in the near future. This would accelerate the production and distribution of AR content. Ketel (Interview 6) describes the move of the major corporations into mobile AR as an approach to develop the AR ecosystem:

> I think what they're trying to do is create an ecosystem where developers start experimenting with AR capabilities. They start developing apps for that to create this marketplace, like a good mix of consumers and developers to then release the glasses and have that be a success. This is kind of the first phase of that. I think mass adoption is going to wait until we have these glasses that are affordable or immersive or perhaps create some productivity advantage. So, I think that's when we will reach the masses, but until then, hopefully, to grow the ecosystem, we're going to have some very good mobile AR experiences as well. (Ketel, Interview 6)

Linking this back to the findings about the immersive capability of AR, it can be said that mobile AR applications can be immersive and purposeful if the experience design helps to solve a certain task efficiently.

4.1.4 Interactive in Various Ways

Interactivity emerged as another fundamental characteristic of AR. According to Billinghurst and Kato (2002) AR, by definition, can be considered as interactive, as it enables both, interaction with the content and with other users. In addition to that, the findings suggest that AR offers another level of interactivity, as a user not only interacts with the digital content and other users but also with the physical world around him, which was conceptualised as *spatial interaction*:

> The main feature [of AR] really is interaction …. That can be social interaction, that can be a visualisation, that can be getting data out of the environment, and it can also be a spatial interaction. … it's kind of like the dream of the art critic. The work only happens in the interaction with the viewer. (Deussen, Interview 8)

What adds to that is the fact that consuming AR can be considered as a highly individual experience, because the user has strong means to co-create the experience in terms of where he looks and in what way he interacts with the content. This high level of interaction increases the user's involvement in the experience (Hoffman & Novak, 1996). Ketel (Interview 6) describes:

> You provide a toolset, not necessarily an experience. And I think even with an experience you never know where someone is going to look. It's not like with traditional film where you can decide exactly what someone's going to see. So, you create a space for people who have their own experience rather than fully designing every aspect of the experience itself, which also makes it more powerful, I think, especially for branding purposes. If people have their own experience, it's usually more powerful than when you decide that experience for them. People have more room to kind of shape their own experiences. (Ketel, Interview 6)

He thereby, addresses how the *co-creative nature of AR* can make it a suitable tool to create individual and meaningful experiences by giving the user the ability to co-create his own experience.

As previously touched upon, AR offers numerous opportunities for *social interaction.* A prime example is Pokémon-Go, a game where people are searching the physical world for digital content, which results in social interaction with other players gathering at the same location. The findings suggest that the ability of AR to enable shared experiences plays an integral part to generate a believable experience and drive immersion. This implies that different users of the same AR experience, witness the same digital content from different perspectives through separate AR devices. The emerging social consistency increases the belief in the realness of the augmented content if all users experience the same content, as Strunden, P. (Interview 3) mentions:

> I think that social component is a bit more intuitive using AR, and that might also potentially help the acceptance of these augmented contents we see in between us." This implies that if several users witness the same augmented content, they are more inclined to forget about the facts that the content is virtual and accept it as their reality. (Stunden, P., Interview 3)

Ketel (Interview 6) mentions the thoughts that go into figuring out how to design an AR experience that encourages social interaction: "If we're doing a social experience, we want to think about: Who are these people? What's the setup going to be? How are they going to sit to promote interaction between them?"

Next to shared experiences, it was suggested that AR could be used as a *direct communication tool*, eventually, replace video calls and improve efficient remote cooperation. Deussen (Interview 8) suggests: "It's definitely a communication tool. (…) You let a 3D model appear on the table, and you can talk with your client about it. (…) You can also do that remotely." Next to allowing for shared experiences at the same physical location, AR can be a tool for *remote shared experiences*, where users are dispersed around different locations as Deussen (Interview 8) describes:

> On the first look, you would say it doesn't make sense, because the physical space is so important and if you're not in the same physical space, why would you share that experience? But what they're doing is just sharing positions of content that is shown around the 3D model so that somebody who is maybe in a virtual space can interact with somebody who is in augmented space. … it's really like a true added value in terms of working remotely and collaborating. (Deussen, Interview 8)

Further, it was pointed out that AR could open a whole new segment of marketing and political communication in the public realm by overlaying messages onto the real environment as Deussen (Interview 8) states: "(…) you could leave messages, or statements anywhere, like a graffiti." He further, points out the potential for tourism, which will be another way AR can drive social and cultural interaction: "I mean, obviously, tourism is going to be a thing, that you are being guided by augmented content through touristic attraction in a public space."

Just like experiencing a new city by following an AR tourist guide, AR can demand increased physical activity, as a user has to physically move around the real space to fully experience AR. Deussen (Interview 8) uses one of his AR games as an example and explains that "if you want to go across the island, you have to actually physically move around." This increases the feeling of embodiment and presence, which was introduced earlier and drives the immersion of the experience. A prominent example of this physical interaction is the game Pokémon-Go, which required its players to walk around the real world to find Pokémon's located

at specific geo-locations. This, however, is not necessarily always a favourable aspect, as users might not always be inclined to take physical actions, as stated by Deussen (Interview 8): "… [physical interaction] is right now also what can stop people from using this app because when you play a game, they're not used to walking around. They just want to sit on a couch." Veenhof (Interview 10) shares this notion and suggests that moment and purpose of interaction should be wisely chosen:

> You also have to think of the moment when you're going to bother your audience with it because people, they're not easy to activate, even at a theatre festival. I was trying to let people use my Meet-Your-Stranger app; it was a theatre thing they could do together. And they say: 'Ok, whom am I playing with?' I said: 'Well, everybody here can be a player in your play. Just invite them. Let them go to the app and then you can play together'. But it was not happening. People wanted to sit back and just drink a beer, watch the performance. People don't always want to be active. (Veenhof, Interview 10)

As a final remark about AR's interactive feature Deussen (Interview 8) points out that some aspects of interaction do not sprout from AR itself, but rather relate to the underlying experience design and game mechanisms. He argues: "The other aspects are, of course, the whole interactive features that you get in, but that is not necessarily specific to augmented reality because there are gaming techniques that are running in the background."

4.1.5 Data Generating and Capturing

The last characteristic that was consistently addressed during the interviews but was mostly left out as a defining characteristic of interactive media is AR's *ability to capture the environment and extract unique data points about the user*. Capturing the environment implies using the camera feature of the AR device to record the surroundings, which can be helpful for industrial applications as Strunden, F. (Interview 7), who develops AR enterprise solutions, states:

> [If] you want to capture something, similar to strapping a GoPro to your head and record something you do. There's a huge value [for AR] as an input means of capturing the operator on their job because you can then create instructions on the back of that. So, this

> knowledge transfer from the expert into the knowledge base, essentially that is incredibly powerful. (Strunden, F., Interview 7)

Next to the productivity gain, which can be realised through capturing the environment, AR can *generate unique data about its users* in a way that exceeds the data collection of conventional interactive media, such a social media platforms or search engines. The eye-tracking feature of most AR glasses, for example, can track the movement of the eyes and can generate accurate data profiles of the user's preferences while consuming AR content. Ilic (Interview 9) suggests that it is about:

> That information you get through the interaction with VR and AR. It's telling more than anything how you interact online. It's what your body language, micro gestures and face are telling technology. If you have an algorithm to extract information from it, such as the AI that looks at a couple of videos of you and determines if you are depressed or not, it's super scary. And just imagine you have all the input information, how you walk, how you talk, your voice. It is like you upload all of the human information that you have. (Ilic, Interview 9)

Veerman (Interview 2) describes the same feature from a more positive perspective:

> All that information and AR can really make big leaps in how to approach living together in cities or approach living together in crowded spaces and convert all the data that's coming in from millions of points, from every person, every information stream in the city to make that into a more comprehensible set of data that we can make really good decisions on (Veerman, Interview 2)

These findings go along with Manovich's (2006) notion that there is a reciprocal relationship in terms of data flow when any form of media is consumed. AR is no exception to this and provides upstream data that can be extracted and monitored.

4.2 Spatial Context of AR

4.2.1 Space as a part of the Narrative

As explored in the previous findings about AR's characteristics, the physical space, in which AR is deployed, constitutes an integral part of an AR experience. It can be said that it even gives the experience the purpose and therefore, deserves particular attention. Strunden, F. (Interview 7) describes: "If the space is relevant in addition to the digital information, the space is fundamental, right? That's really when you use AR when the space is relevant. … if the space is irrelevant, AR is not interesting."

Deploying AR onto space is one way of converting it into augmented space, which entails the enrichment of that space with information in the form of digital multimedia content (Manovich, 2006). The interviewees frequently make use of the Pokémon-Go game to illustrate the essential role that physical space can have for an AR experience. Strunden, F. (Interview 7) explains that

> Pokémon-Go was very much location-based. So, it wasn't necessarily so much the visual aspect that we think about when we think about AR (…) That context around it that adds to the experience itself is super important, ... you can communicate through its environment as well. (Strunden, F., Interview 7)

Tim (2020 states: "Depending on where you are in the physical space, there's different Pokémon's and it's actual space that you are interacting with." This demonstrates the notion conveyed by most interviewed AR creators that the physical space is essential for AR, as it plays an active part for outcome of the experience. In a sophisticated AR experience, the digital content should interact with the real world and create a dialogue between the space and the user, as Ilic (Interview 9) implies: "It should always be a place where stories can happen. … The focus is always on the human or the interaction happening within the environment."

What adds to that is the finding that space can influence the connotation of an AR experience. Karam (Interview 5) describes an example in which exhibition visitors valued virtual AR artwork placed on real pedestals at a higher price than digital artwork that was placed on the floor. Further, it was suggested that a location choice for an AR experience could carry an eigenvalue and combined with AR create new meaning. A project about placing AR sculptures

around a city was brought up by Abdul, where the positioning of AR art carried an implicit meaning: "Because this physical place means a lot for the city ... and if you can see something on top of it, the combination creates new meaning." He also describes in what way that can be used as a stylistic tool: "You can contrast things, for instance. If you have a very traditional space and you bring in avant-garde [AR] art, you can create a contrast, also for the artwork." In the same way, Ilic (Interview 9) highlights:" space makes you think differently about everything. So, the context where you place the AR piece changes the entire story of what you made originally, which is pretty cool and super important."

Moreover, it was brought up that space can be used to organise content in AR according to its purpose. Strunden, P. (Interview 3) discusses the idea of spatially separating different types of applications, such as only showing work-related content in work-related spaces. She implies:

> "I think that will play quite a big role because it helps a lot the way we would treat that space. We are very critical of our phones, people take it to bed, they open it in the morning, and it opens that whole world to you, it sucks you into this environment. It might be really nice at some point if these digital worlds become more and more present. If there's more of these like transitional zones that let you understand why certain things are closer than others. For me, it's important that my work email is not in my bedroom … it might also be nice if you have these more spatial barriers or spatial organisational modes in order to differentiate. (Strunden, P., Interview 3)

This implies that the role of space could be to structure digital content similarly as physical space is organising our everyday lives.

The findings suggest that in order to precisely determine the role of the physical space for an AR experience, one has to differentiate between two main types of experiences. The first type of experience *location-specific* and achieves its full effect only when deployed at the dedicated space for which it was designed. Veenhof (Interview 10) puts it this way: "I think with AR it's not just about creating the virtual thing, but it's also about thinking of the best spot where you can experience it or maybe the only spot."

The second type of AR experience is *omni-spatial* and can be deployed in various spaces, which fulfil the spatial practicalities, without losing its purpose. An example for the latter would be a simple AR visualisation of a 3D model. This would work on any flat surface, such as a table

or floor, which can be tracked by the AR device. Here space only acts as a stage to host the content but does not add to the experience. Some of the interviewed creators suggest that this kind of experience does not offer the full potential of AR, because the physical space does not have a real function, as there is no meaningful interaction between the virtual and the real. Ketel (Interview 6) suggests that in this case, VR might be a more suitable solution to visualise the content, unless the physical context does matter for the visualisation, which then makes it a *location-specific* experience. He suggests that "augmented reality is more about these virtual worlds interacting with the physical world." In practical terms, this indicates that the definition of AR should contain a meaningful interdependency between the virtual content and the physical space. *Location-specific* AR experiences suit this definition in a better way, as the purpose of the experience relies on the liaison of visual and real, which assigns the space with an important role. Veenhof (Interview 10) implies: "The essence is that it's not just a layer on top of something, it starts becoming something meaningful when it actually takes place in and changes things in these physical realities."

Paula (AR creator) suggest that *space acts as a canvas* for AR experiences, which fits into Harrison and Dourish's (1996) denotation of space as an "opportunity". The analogy of *space as a canvas* implies two things. The first one is that there are limitless possibilities to fill the digital canvas with content. Strunden, P. (Interview 3) points out "the question on how to design within a virtual environment, where you don't have any of the constraints you would have in a physical environment … there are no financial constraints; there are no physics; there are no laws."

The second part of the analogy, however, implies that the canvas is *physically and spatially limited*. AR experiences cannot exceed the physical space within which they are deployed. An empty room can be filled with all kinds of digital overlays and content, but the spatial realities limit the scope of the AR experience in terms of usable surface for augmentation and freedom of movement for the user. Veenhof (Interview 10) points out "that space presents the physical criteria for what you need [to deploy AR]." Van der Plas (Interview 4) agrees with that by mentioning that in all of his AR projects, the physical space depicted the starting point for developing the experience. During the conception and creation process, much thought goes into figuring out the spatial situation. Eker (Interview 11) agrees: "I think it should be at the very beginning …. it kind of dictates what you are trying to do, with why you are using AR."

Veerman (Interview 2) describes the importance of the spatial conditions for the sensual experience and the experience design by means of the questions her asked himself for an AR experience in a gym: "How large is each of the gyms? What do you want to augment? How do you account for other people who are walking there? How do you keep it scaled and … the illusion?".

At last, space is defined in literature as the physical, three-dimensional environment that hosts all existence (Harrison and Dourish, 1996) and actions (Gaver, 1992). In the context of AR, however, physical objects can also act as space if they are subject to augmentation. Doruk (AR creator) describes one of his AR projects, which enriches cultural artefacts with digital elements: "For the Rembrandt [see Appendix D] project it was decided that the documents are going to trigger the experiences because we are trying to show this extra information about the stories that are hidden behind these documents. That's why the documents should be the starting point of that story." In this case, AR is applied to an object and not bound to a specific location. Strunden, F. (Interview 7) implies: "(…), it's not just about space. It can be contextual to an object as well. "

4.2.2 Unlocking the environment through spatial AR

Karam (Interview 5) points out that the physical space has to fulfil several technological requirements, such as (preferably) flat surfaces and suitable light conditions, to allow for stable tracking and smooth user experience. While current AR technologies are mostly marker-based, such as most mobile AR, which uses the camera of the smartphone to track the environment for dedicated markers, such as pictures or QR codes, the near-term future is said to be spatial AR, which accurately tracks the environment through dedicated sensors and makes use of cloud-based 3D mapping data. Dedicated AR sensors, such as Apple's LiDAR scanner, are the technology that can accurately map three-dimensional environments by analysing how the light reflects from the immediate surroundings and point cloud data makes these spatial mappings available for use on other AR devices via the internet (Gupta & Lohani, 2014). Veerman (Interview 2) implies that this is already technologically possible: "Yes, it is possible because that's the beauty of a volumetric capturing and point-cloud technology. … we've got the possibility to scan an entire street … or an entire room photo-realistically. So that's very possible at this point." The challenge for the near-term future, however, is to bring down the costs of these technologies to enable their mainstream adoption for AR.

While it is not widely available yet, recent developments are promising. In March 2020, Apple introduced a LiDAR scanner to its latest iPads, which brings accurate spatial tracking that will substantially improve the experience of mobile AR (Apple, 2020). This new dedicated AR sensor will also be coming to the iPhone's next-generation as implied by Deussen (Interview 8): "… the new iPhones have a sense of spatial recognition, depth sensing, and those are really important technological developments to bring augmented reality forward." This might drastically accelerate the adoption of AR for three reasons. First, the iPhone is a mainstream device that is used by "ordinary" users every day. Second, the improvement of spatial recognition will allow for more use-cases, which will attract users to the technology. Third, this new interest will develop the AR ecosystem, as more demand will lead to more AR app development. He further suggests that "as soon as you understand the physical space, you can hide things behind columns and there's a whole new level of interaction. … I think there will be a complete digital layer basically layered on top of our world."

4.2.3 Place-making through AR

The concept of place has been defined as value-laden space, which carries memories, feelings and meanings for people (Harrison & Dourish, 1996). Strunden, P. (Interview 3) acknowledges this: "[talking about places] I think [they are] spaces that have the capacity to kind of stick with you or stay with you." She further explains: "So to me, a place is a space that exists within [the users] memories …. People know that space. I think that has a lot to do with memory, the capacity to make an impression on a person." This illustrates that there are reasons why certain spaces carry meanings for people and are established as places. The findings confirm that AR has the ability to change the perception of space and thereby to create place. The following anecdote about place-making through AR illustrates this quite nicely:

> What I thought was really interesting at that time, I was living in the west of Amsterdam, and there was this square near my house, and it was just one big open square like no one ever went there because it was too open and too cold. And there was wind, and it wasn't designed very well. But suddenly there were two Pokémon Stops out there. So, every Friday afternoon, there were people all over the place, bringing beers; they were bringing music. And that really shows how a digital layer on top of the physical world can really

> disrupt it and can really create something there. So, there was this digital layer impacting the physical world and where those two interact, that I think is where Augmented reality is really interesting. (Ketel, Interview 6)

The place-making potential of AR can be traced back to specific AR characteristics, which have been conceptualised in the preceding sections. It has been suggested that the strong visual and sensual capabilities of AR can drive its place-making ability. Deussen (Interview 8) points out that "the view of augmented reality can change the way you perceive the space. At the moment you give people additional information or context, it changes the way they think about the space. … it's a reinterpretation of the space." Ketel (Interview 6) implies:" You cannot change the physical space, but you can change the way people perceive this physical space by adding digital elements to it." Strunden, F. (Interview 7) shares this notion: "I think it has definitely potential, the idea of environments changing because they have this virtual redecoration coming."

What is part of the visual experience, that can change how space is perceived is AR's ability to enrich the physical space with additional information in an appealing way. For example, adding an informational layer about local crimes rates onto certain streets or neighbourhoods can make users less inclined to stay there. Another example is a recent AR experience developed by the New York Times, which made the pollution of major cities visible through visualisation in AR. Deussen (Interview 8) describes a similar one:

> You're walking through the death zone around Chernobyl, and you're seeing the glowing all-around your prairie, radiation in the forest, which is there, but you can't see. You're going to get a really uncanny feeling, and if you go away, that feeling is going to persist. You're suddenly going to know it's not a forest. It's not the normal forest. It's not even an enchanted forest. It's a forest being polluted by atomic waste. … So that is an example of how I think augmented reality can change the way you perceive the space. At the moment when you give people additional information or context, it changes the way they think about the space. (Deussen, Interview 8)

Ketel (Interview 6) argues against that and suggests interaction through AR is required to enable place-making through AR, rather than just a brief visual experience: "I don't think having

one AR experience for five minutes is going to change your complete idea or concept or the emotional experience of a space." Other interviews revealed that the interactive character of AR plays an integral part in its place-making potential. This relates to the phenomenological way of how humans make memories and develop a connection to space. Ilic (Interview 9) explains:

> We need to interact with something to make it stick to our heads. So, if you, for example, buy some random item in the store and leave it in the package in the corner, you have zero connection to that item. Only through using that item, it becomes yours. That's how we humans work. So only this way you can build up the proper connection. It's called object consistency. We have to interact with the environment to have it last within our psyche. (Ilic, Interview 9)

According to Veerman (Interview 2), the same implies for virtual experiences through AR:

> That's basically how our brains work, if we experience something, in a certain spot, then that memory stays behind. And I don't think it matters if it's an experience that you have in a bar where you're sitting together and having the best night of your life with your friends, which will become our memory. I think it's no different from maybe you saw a really brilliant piece of artwork or a performance by a band which was projected [through AR] on a certain spot at a certain point in time, which is no longer available. But with that experience yourself, it really blew your mind at that point in time; I think it's no different. In your mind, it will become: 'Hey man, you know, last year we were here on the square, we had that whole virtual small festival, yeah that was so great '. (Veerman, Interview 2)

Karam (Interview 5) implies that the intensity of an AR experience increases its capacity for place-making: "…if you have a very intense experience; definitely you would remember it. When I say intense experience, it's not necessarily on the content alone, it's also the people around you or how much of a shared experience you have." He thereby also addresses the aspect of social interaction and the value of shared experiences for place-making through AR. Strunden, P. (Interview 3) cautiously compares it to religion and the role of relicts. She suggests that the act of speaking about AR experiences make them stick to the users:

> It's a bit like religion … certain things exist by [the belief of] a certain amount of people. Speaking about it, acting it out, creating it, but then I think it's still these physical pieces that remind us of it within our everyday life that it exists. (Strunden, P., Interview 3)

She suggests that physical artefacts, which have a connection to an AR experience, but persist when the experience has ended have a substantial impact on place-making because they link the content to the reality of the user. Deussen (Interview 8) also points out the role of physical objects in one of his projects, which augments physical catalogues with AR content: "physically switching a page changes digital content that's being displayed. It's actually an interaction between the physical space." This physical interaction appeals to the tactile sensation of the user, thereby enriching the user experience and increasing immersion by linking virtual and real worlds.

4.2.4 Discussion: Space and Place-making

As mentioned before, Gaver (1992) defined space as the three-dimensional environment, which hosts all existence and actions. This definition can be linked to the findings of this research, which suggest that *omni-spatial* AR makes a use of physical space as its stage. However, in the case of *location-specific* AR experiences, space does not only act as a stage but actively contributes to the outcome of the experience and gives it purpose. In that context, it is proposed to widen the definition of AR in a way that accounts for the active interdependency between AR and the immediate spatial context.

It is also worth revisiting other definitions of space and revise them in the context of their relation with AR experience. Harrison and Dourish (1996) conceptualise four main attributes of space as (1) *relational orientation,* (2) *proximity and action*, (3) *partitioning* and (4) *presence*. While (1) *relational orientation* suggests that space is commonly perceived by everyone and thereby makes interaction possible, this is only partly true for augmented space. For augmented space to be perceived by everyone in the same way, users have to have access to the same AR experience. If that is the case, relational orientation can apply for shared AR experience, as every user experience the same digital layer. In contrast to that, however, AR experiences can be highly individual and personalised in terms of their content, experience design and the fact that

they can be co-created by the users to a certain extend. This can lead to very different, individualised, perceptions of the same physical space.

The attributes of (2*) proximity and action* apply for augmented space as the user can only experience AR in its proximate surrounding. However, most AR devices are mobile and can be used in different places, which then expands the area of application. Therefore, this attribute is neglectable for the portrayal of space in the context of AR.

(3) *Partitioning* describes the forming of groups around spatial proximity. On the one hand, this applies to shared AR experiences. On the other, however, AR can also enable remote shared experiences, where participants are dispersed around different locations.

The last attribute is (4) *presence*, which implies that space is characterised by the presence of others and their activities. This attribute is essential for AR, as it was found that, by experiencing a sense of presence along with the presence of other people, while interacting with AR, the experience offers an increased sense of immersion for a user. In particular, the introduced concept of *perceptive immersion* is built around the concept of presence, as the AR user maintains full percipience of the immediate surrounding. While Avery, Piekarski, Warren and Thomas (2006) suggest that immersion can lead to the higher experience satisfaction, it was found that immersion is not a requirement for an AR experience to be purposeful or of high-quality.

Harrison and Dourish (1996) further describe space as an opportunity. The findings support this notion by suggesting that space in the context of AR can be seen as a blank canvas, which can be filled with unlimited forms of digital elements. While augmented space bears unlimited virtual possibilities, it is bound to the physical limitations of space. Another fundamental difference between Harrison and Dourish's (1996) conceptualisation of space to the practicalities of augmented space is that the latter is non-exclusive. This means that there can be infinite variations of that space, depending on what digital elements have been used to augment it. Van der Plas (Interview 4) suggests that:

> You could turn off the layer you're not interested in. For example, if I want to see Jim's Layer in this street, something that Jim's added. I turn it on. I don't like it. It's too noisy, too flashy. Let's switch to another one. Let's see what Carol made out of it. (van der Place, Interview 4)

This relates to the findings that AR offers its users means to co-create their induvial experiences.

Graham et al. (2012) suggest that AR can interfere with and change the social construction of space, which implies changing the place. The findings of the present study support this notion and explain which specific media characteristics drive AR place-making abilities. While some AR practitioners suggest that the visual particularities of AR can drive place-making, others argue against that by stating that these characteristics alone are not able to change the user's perception of space. They argue that for AR to achieve a lasting impact on a user's spatial perception, there has to be some kind of interaction, which connects the user to the particular space. Further, the intensity of the experience was suggested to have an impact on place-making, for example, through a personalised or shared experience.

The literature further implies that the social construction of space can be changed through certain spatial practices (Lefebre, 1991). Observing those spatial practices helps to understand the creation of place, such as by examining how people adopt space for their means. The ability of AR to place UGC into space can be considered as a spatial practise, as users make use of the technology to co-create their spatial environment, charging it with personal value and thereby converting it into place.

Humphreys and Liao (2011) suggest that communication through and about space is another type of spatial practise that people use to socially construct place. In this regard, AR was found to be a very suitable tool to enrich space with additional information, which can serve as the basis for conversations, such as in tourism or cultural applications, which might deepen the connection to a particular space.

DeCerteau's (1984) conceptualisation of spatial practices implies that there are two kinds of practices for place-making, which distinguish themselves by a different balance of power. Strategic spatial practises apply authority to create places and inflict meaning upon them in a top-down manner, which implies that a sense of place is not commonly constructed but unidirectionally imposed by authority. Tactic spatial practices, on the other hand, are democratic, bottom-up means of place-making. The findings suggest that AR can be considered as a tool for spatial tactic practices because users can co-create the digital appearance of space. This notion, however, is still theoretical at this point, as AR has not yet reached the mainstream, only which could make it a truly democratic way of place-making. The findings, however, indicate that this might be about to change in the near-term future, as the adoption of mobile AR is on the rise and

will have an essential role for developing the AR ecosystem. Strunden, F. (Interview 7) points out:

> So, I think that's an interesting opportunity to have a conversation that everyone can be a part of as well. And I think that's also maybe that aspect where AR in some regard is meant to bring people together because it brings it back to the physicality of the world as well. There's an opportunity for it to be more accessible. Information can be more physically distributed, so maybe more accessible to more people as well. (Strunden, F., Interview 7)

5. Conclusion

The study explored the relation between AR and the immediate spatial context by conceptualising AR's media characteristics and the role of space. After summarising the most important findings regarding the three sub-questions, the overall research question will be answered, followed by a reflection on the method, presentation of theoretical and societal implications and the proposition of further research areas.

5.1 AR Media Characteristics

Firstly, the study affirms the theoretic stance that visuality, which is a media characteristic of interactive media, is undoubtedly one of AR's defining features. The findings, however, point out differences between interactive media and AR in terms of their visual capabilities. The unique visual appeal of AR arises from the way AR merges virtual and real worlds through the overlay of digital elements onto physical space. This highly novel user experience has a high visual appeal on users and is therefore used for innovative media concepts and eye-catchers at trade fairs. The visual means of AR go further, as it was pointed out, AR enables the visualisation of data in a natural and approachable way by linking it to the corresponding environment, which is usually hard to achieve on two-dimensional screens. Due to AR's unique visualisation capabilities, it can be deployed as a highly efficient solution for various areas of application, as it, for example, renders costly physical production and preparation unnecessary and offers intuitive user interaction, which in the case of headset AR is hands-free. While the AR definitions from the interviewed practitioners, as well as from academic literature most prominently address the visual features, the findings highlight the importance of other sensory stimuli to reach the full potential of AR. Notably, the use of audio elements can improve the experience of AR or even create simple, stand-alone versions of AR. Next to that, the use of tactile sensation, such as by integrating physical artefacts, amplifies the AR experience in terms of immersion and learning potential. It can be concluded that the inclusion of all human senses enhances the experience of AR. Due to its visual and sensual capabilities, AR offers new means of storytelling. What adds to that is AR's ability to distribute modal and personalised content, which opens up new opportunities for marketing and political communication, as well as direct communication and personalised learning.

Secondly, the findings suggest that AR's ability to create immersive experiences is another of its main features. The term immersion, however, has to be treated with caution, as it is defined in different ways. The findings go along with the theory, which distinguishes between "technical" immersion and immersion as a state of mind. For AR to create a fully enclosed "technical" immersion technological enablers, such as a wide field of view and precise spatial tracking, have to be in place. It was argued that

these enablers are currently not at the required technological level to enables this type immersion. However, it was found that AR does enable immersion as a state-of-mind, which relates to the concept of flow and presence, due to its ability to support the focus on a particular task or experience by enriching it with helpful information. Therefore, it can be said that AR is immersive in the way that it helps a user to solve a task. This requires a suitable experience and audio design, which is a subject of further research.

A different line of argumentation implies that the aim of AR should not to be immersive in an enclosed way, but to maintain percipience of the real environment and enrich it with digital elements. In order to account for the various notions of immersion and conceptualise immersion in the context of AR, the concept of *perceptive immersion* was introduced, which describes AR immersion as non-enclosed and with a sense of presence in the real surroundings. It was suggested that *perceptive immersion* is highest when the digital layer is very subtle while still enriching the spatial context in a way that supports the task or experience at hand. An essentials aspect of this type of immersion is the display of AR content in real dimensions.

Intuitiveness in use and experience was found to be the third main characteristic if AR, which mainly counts for headset AR. It was suggested that (headset) AR embraces the natural way of looking around by turning the head and walking around, thereby catering to the phenomenological understanding of humans. What adds to that is the multi-linear user experience which implies that a user can physically approach content in a non-linear way. Further, users are hands-free while experiencing (headset) AR. Some practitioners imply that AR will be the next interface for interaction with digital information, but at the same time they curb precipitous expectations by stating that the technology is not yet at a stage to make AR a widely adopted user interface. They are, however, positive about current developments in the AR ecosystem, which might accelerate the adoption of AR in the nearby future.

Forth, interactivity was established as another defining feature of AR. While AR per definition can be considered interactive, as it allows its user to interact with content as well as with other users, it was found that AR's interactivity, further, spans *spatial interaction* with the physical environment. One example of this is the requirement of physical activity to experience AR fully. While this is considered to drive immersion through providing a feeling of presence and embodiment, it also impedes the use of AR, as some user might not be inclined to engage in physical activities at all times. It was pointed out, that the moment and purpose for physical interaction in AR has to be well-thought-out to improve the experience of AR fundamentally.

Social interaction, such as through shared AR experiences, are integral for AR as common percipience of AR content increases the immersive experience and the belief in the reality of the virtual content. Moreover, it was suggested that AR could be used for direct communication and remote cooperation, as well as for marketing and political communication in the public realm.

The last main feature of AR is its ability to capture the environment as well as generate unique data about its users through monitoring the experience and the behaviour of the user, such as tracking his eye-movements. Surprisingly, academic literate does not address this reciprocal data flow as one of AR's defining features. AR practitioners stress this feature, as it enables the creation of accurate data profiles about AR users, which can be used for the personalisation of the user experience.

5.2 Spatial Context Interdependency

The findings emphasise the importance of physical space for AR. For *omni-spatial* AR experience space acts as a passive stage and for *location-specific* AR experience space takes on an integral part and even gives it purpose. The results suggested that the spatial context can carry meaning in itself and thereby add connotations to the AR experience. Further, it was proposed that space can be used to spatially organise AR content according to respective areas of application, such as specific spaces for work and others for private use-cases.

Space, defined as the three-dimensional environment that hosts all existence, is considered as a blank canvas for AR with no virtual constraints. At the same time, however, space is considered to be physically limiting AR by restricting the area of augmentation and the physical actions of the user. Therefore, considering the properties of space is the starting point for the conception and creation process of AR. It can be concluded that for AR to reach its full potential, space should not only host the experience but also add to it. An AR experience becomes very valuable when there is an interdependency between AR and the immediate spatial context. While the required technology for precise spatial AR is not widely available yet, it was pronounced that the ecosystem is developing in a promising way, which could lead to a better embedding of AR in physical space through better environment tracking and point-cloud technologies.

At last, the ability of AR to substantially change the perception of space was examined, which is considered as place-making. The findings indicate that AR can be a tool to intervene in the social construction of space due to a number of its characteristics. Some argue that AR's visual and sensual appeal in combination with the embeddedness in the spatial context can be so imposing that the experience lastingly stays with the user and his feeling about a place. In the same way, the display of location-related data can change how people think about a place. Others argue that the mere "consumption" of AR is not sufficient to convert space into places for the users. They suggest that for place-making to occur, users have to actively interact with space through AR, as this links back to the human way of making memories. Another factor is the intensity of the experience, which not only refers to the audio-visual production quality but also to the degree of how much of a shared experience it is. A

common perception of AR content in a socially consistent way is said to increase the belief in the reality of the content and thereby adds to AR's ability to create places. Further, the integration of physical artefacts into AR, that remain after the experience has ended, establish a constant awareness for the experience and thereby drive AR's ability for place-making.

Coming back to the research question is can be said that throughout the conceptualisation of AR's media characteristics (*visual & sensual stimulation*, *perceptive immersion*, *intuitiveness*, *spatial interactivity* and *data generation)* and the role of space for AR (*active, mediating, passive)*, a complex and elemental relation between AR and the spatial environment in which it is deployed was observable. It can be concluded that the relation between AR and its immediate spatial context is highly interdependent and has profound implications for the purpose of AR, the user experience and its ability to mediate the sense of place. Therefore, this research stresses the importance of a purposeful "Space-AR" relation and proposes the addition of spatial interdependency to the list of AR's defining features. Further, AR's ability for place-making can be explained by its unique combination of media characteristics, in particular its visual, sensual, and interactive features.

5.3 Theoretical and Societal Implications

The findings of this research align with and progress most of the theoretical discourse addressed in the theory chapter but not without raising some controversies. While AR's media characteristics generally show a high concordance with interactive media characteristics, as implied by Javornik (2016), the conceptualisation of each main feature revealed particular distinctions, which distinguish AR from other media as suggested by Katz (2013). The findings that AR can be characterised by its high visuality affiliates with the digital (Varadarajan et al., 2010) and modular (Sundar, Xu & Dou, 2012) characteristics of interactive media. Next, the findings about the importance of sensual stimuli for AR confirm Manovich's (2016) notion that AR is multidimensional. The findings about immersion in the context of AR, which has been conceptualised as *perceptive immersion*, show similarities with Witmer and Singer's (1998) notion of immersion as a human state-of-mind and oppose the "technical" definition of immersion, which describes a technologically mediated and enclosed experience (Bystrom et al., 1999). Further, the study confirms that immersive technologies feature high user engagement (Huan, Rauch & Liaw, 2010) and encourage interaction (Martinez et al., 2014).

The findings about space in the context of AR being a *canvas* with unlimited possibilities align with Harrison and Dourish's (1996) notion of space as an "opportunity". Further, the organising role of space for AR content correlates with Brown and Chalmers (2003) findings that mobile applications mediate the organisation of urban space. While literature that aims at defining AR technology (Azuma,

1997; Carmigniani & Furht, 2011; Milgram & Kishino, 1994) generally is neglecting AR's data collection abilities, this study points out their importance and implications. This aligns with Manovichs (2006) assumption that augmented space, which is an umbrella term for all data-loaded space, features a reciprocal flow of data from media to user and the other way around. While Spohrer (1999) suggests that AR complicates the relation between space and users, the findings imply that AR drives interaction between the user and spatial context, which confirms Erickson's (2008) work. Previous work examined AR's ability to mediate the sense of place (Graham et al., 2013). This study adds to this line of research by examining the main AR features that drive place-making, namely visuality and interaction and explaining the functioning behind it.

Next to the contributions to the theoretical discourse about AR, the study has several societal implications. It is crucial to fully understand AR technology and its consumer implications as it is likely to have an impact on how digital content is displayed in the near future. Mainstream adoption of AR as a new digital interface would bring profound changes in various fields, such as entertainment, marketing, education and cultural experiences. The novel type of user exp erience, which was found to emerge due to visual, aural and tactile stimuli, enables the production of new gaming and exhibition formats, as well as new means of storytelling for marketing and political communication. Besides, the findings suggest that some of AR's main features, such as its sensual stimuli and remote cooperation capabilities, make it a suitable tool for educational purposes. The findings further imply that until headset-based AR reaches the mainstream, mobile AR, which is already widely available, can enable immersive experiences by helping to solve specific tasks efficiently. Mobile AR is, further, said to be crucial for the development of the ecosystem and the broader adoption of the technology.

Apart from adding to the general understanding of AR, the study reveals practical implications for AR creators. First, the value of an AR experience can be increased by establishing a persistent connection between the AR content and the immediate physical space. Secondly, AR creators should consider adding sensual, particularly aural, elements to the experience design next to visual content to increase media richness of AR. Thirdly, the experience should be designed to solve a particular task or provide a specific experience. If the application helps to solve a problem at hand, it will immerse the user, while he maintains full percipience of his presence and the immediate spatial context.

5.4 Limitations and Future Research

The applied qualitative research method proved suitable for answering the exploratory research question by gathering insightful data from the expert perspective of AR practitioners and extracting comprehensive results. There are, however, certain limitations that have to be addressed. For one thing, the subjectivity of the researcher can be a point of discussion concerning the validity of the study.

Including additional researchers in the coding process would have improved the validity. About qualitative research, in general, it can be said that it contributes to in-depth and extensive knowledge generation, but on the other hand, the generalisability of the findings is challengeable. To arrive at more generalisable results and validate the findings of this study, applying quantitative methods for further research is suggested. Alternatively, a mixed-methods approach, consisting for instance of focus groups and interviews, could contribute to the knowledge about AR and its defining features. Concerning the sample of the study, it can be said that the interviewed AR practitioners might be biased towards talking about the positive aspects of AR to promote the technology.

Future research should take on the user perspective to validate the findings on AR's main features from a different point of view than the expert one which was applied in this research. While the scope of the present research was limited in terms of resources, a research approach with more means could set up several experiments to explore the differences in AR's spatial relation across different types of locations and AR applications. AR's ability for place-making could be further explored through a large-scale quantitative survey study with vast sample size. Further, each of the conceptualised AR media characteristics opens up a respective research path that can be explored regarding the possibilities and implications of each feature. Some suggestions are the further assessment of AR's sensual stimuli or the opportunities of content personalisation based on AR data-generation capability. Lastly, the development of next-generation AR applications and experience design, which takes advantage of all of AR's unique features, should be on the agenda for practitioners, as well as for academia.

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7. Appendix A: Interview List

#	Date	Name	Profession	Field	Agency	Location	Website
1	19.03.20	Bannenberg	AR creator	Industry	Oddz	Amsterdam	http://www.oddz.nl/
2	20.03.20	Veerman	AR creator	Marketing	Freelance	Amsterdam	https://www.linkedin.com/in/kees-veerman/
3	26.03.20	Strunden, P.	AR creator	Art, Research	Freelance	Amsterdam	https://micro-utopia.org/About
4	27.03.20	van der Plas	AR creator	Industry	MCW	Rotterdam	mcw.nl
5	27.03.20	Karam	AR creator	Art/Culture	XibitXR	Berlin	www.xibitxr.com
6	30.03.20	Ketel	AR creator	Marketing	Freelance	Amsterdam	https://www.linkedin.com/in/casketel/
7	02.04.20	Strunden, F.	AR creator	Industry	Mira Labs	Los Angeles	https://mirareality.com/
8	23.04.20	Deussen	AR creator	Entertainment	Studio Deussen	Berlin	https://tim-deussen.de
9	25.04.20	Ilic	AR creator	Art, Entertainment	Freelance	Hamburg	http://www.vrhuman.com/augmented-reality-art/
10	01.05.20	Veenhof	AR creator	Art, Research	Freelance	Amsterdam	sndrv.nl
11	06.05.20	Eker	AR creator	Art, Marketing	Freelance	Amsterdam	https://dorukeker.com/

8. Appendix B: Topic Guide

1) Demographics and Profession

Can you introduce yourself and your profession?

How / When did you get started with creating AR content?

What kind of AR content do you create? (Purpose / Content / Device / Style)

What do you personally find interesting about AR? → characteristics

What was your most exciting AR project/one you are most proud of? (can you show me/ ask them in advance to bring one)

2) AR Media Characteristics

a) Experience

How would you describe a general AR experience to someone without showing it?

What motivates users to engage with AR media?

In what way are users interacting/engaging with AR content?

Would you consider AR an immersive technology? Why?

(What do you think are users expecting from AR?)

b) Characteristics

Which main characteristics would you use to define AR media? Explain why..

Can you expand upon … *(Interactivity, Hypertextuality, Modality, Connectivity, Location-specificity. Mobility, Virtuality)*

What are arguments for using AR media instead of other media?

What is in your option a very suitable use-case for AR?

3) Augmented Space

a) Role of Space

To what extant are AR users aware of the physical space while they are engaging in an AR experience?

How would you describe the role of the physical space for an AR experience?

Can you explain what role the physical space plays in on of your AR experiences?

Is the same AR experience different when deployed in different spaces?

How do AR experience in public spaces differ from experience in private spaces?

So how would you define space in AR experience? How does that differ with place?

(In what context/environment do users consume your AR content?)

In what way do you think about the space while creating AR experiences?

Do you think physical spaces are important in AR experience design? How/why?

How does it influence the process of experience design?

How does it influence the experience itself?

b) Place-making

Can an AR experience give new meaning to a space? How? Example?

Do you think this new perception of space is temporary or permanent?

Who has the power over that new meaning / the place-making?

Is it the author of the experience?

Or the user? What about UGC in AR?

Can AR be a tool to democratise place-making?

4) Future of AR

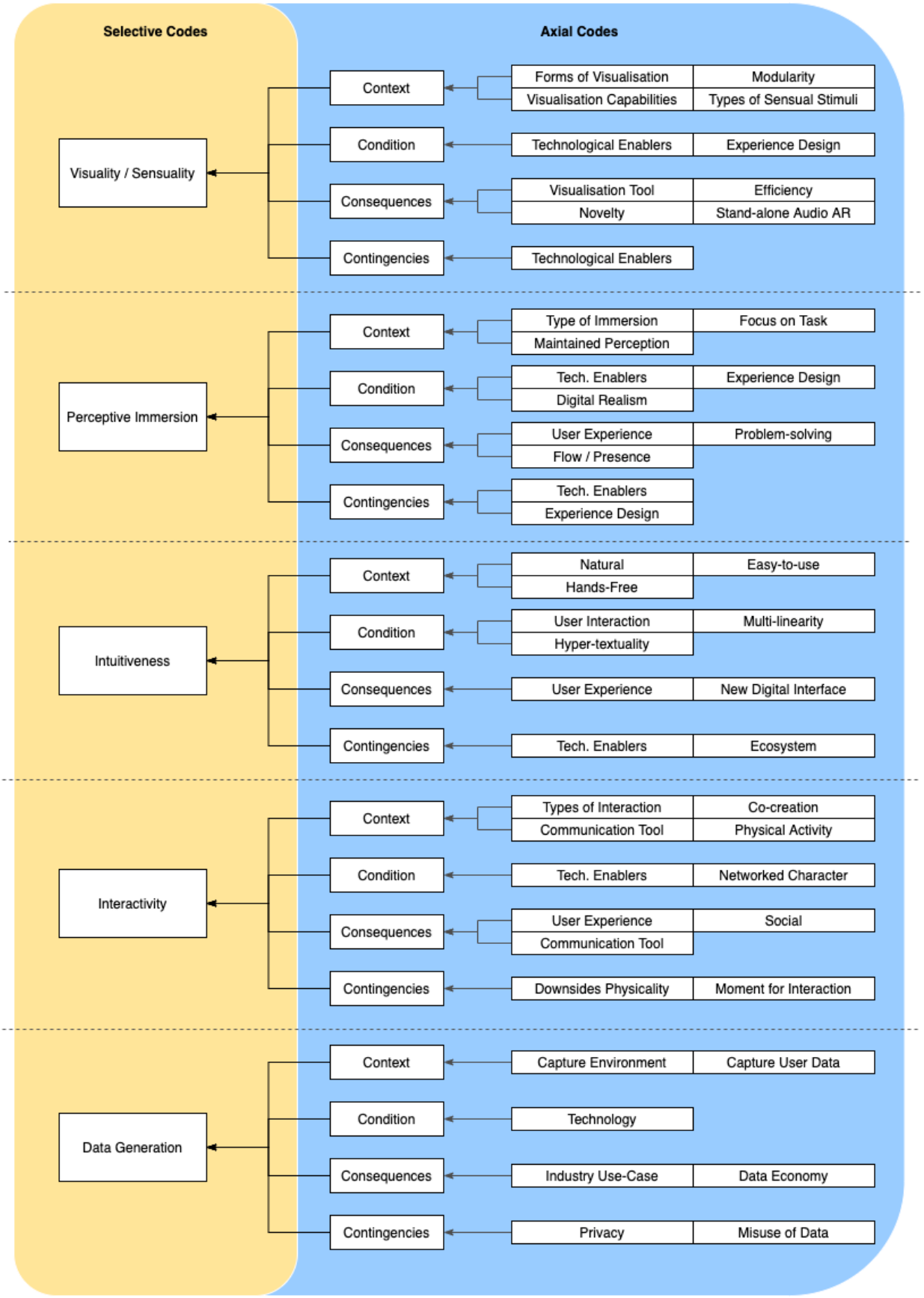
How do you see the future of AR in 5/10 yrs? Will it reach mainstream?

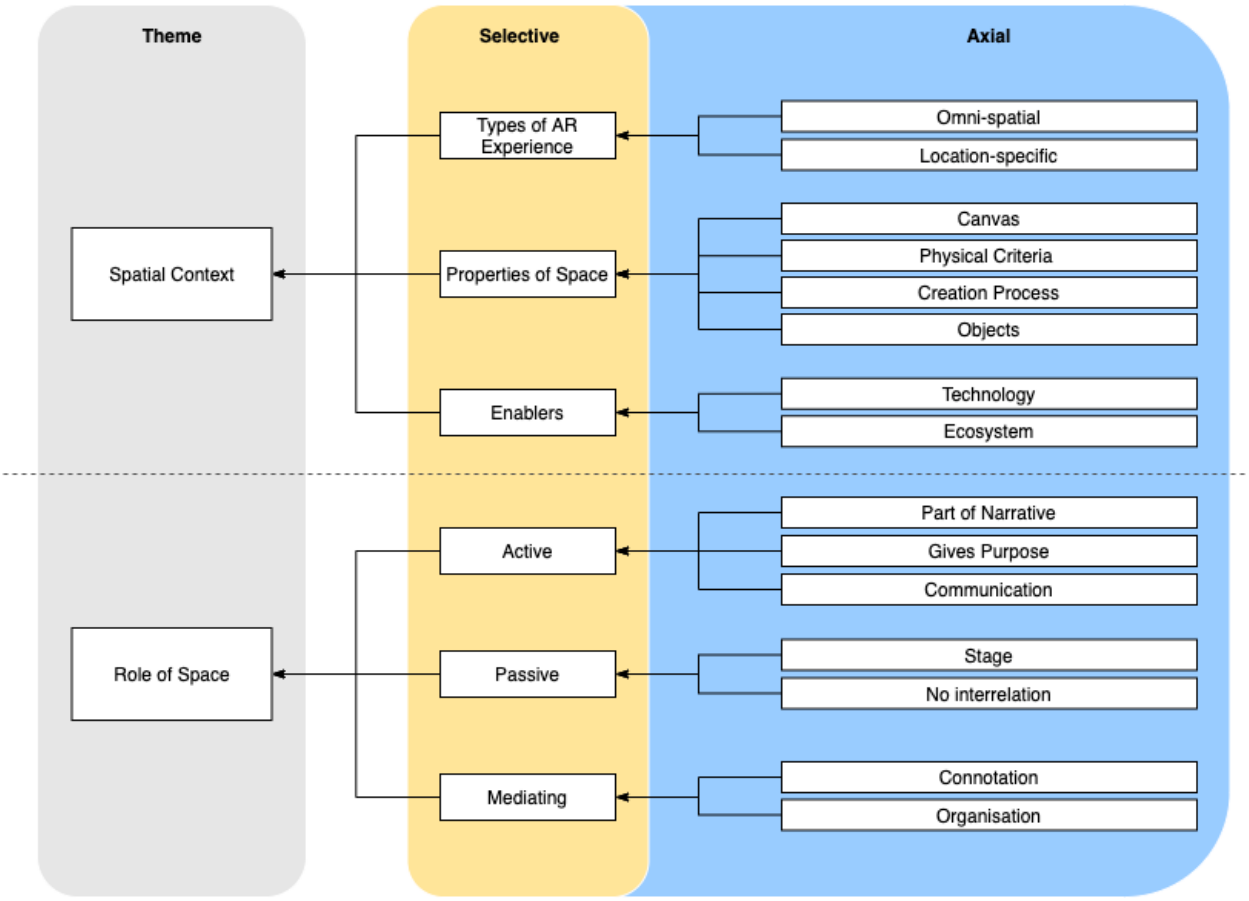
(What future use-cases of AR do you believe have high potential?)

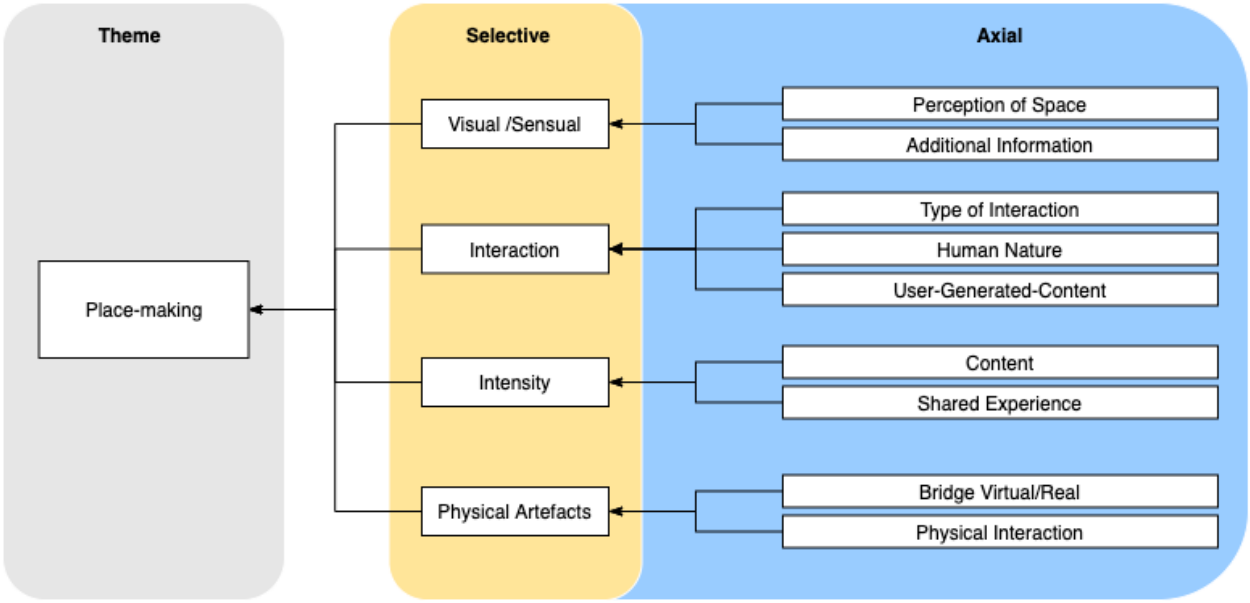
Will AR become a constant element of spatial awareness?

Will there be more AR experiences in public spaces?

9. Appendix C: Axial and Selective Codes




Theme
Selective
Axial
Spatial Context
Types of AR Experience
Properties of Space
Enablers
Omni-spatial
Location-specific
Canvas
Physical Criteria
Creation Process
Objects
Technology
Ecosystem
Role of Space
Active
Passive
Mediating
Part of Narrative
Gives Purpose
Communication
Stage
No interrelation
Connotation
Organisation


Theme
Selective
Axial
Place-making
Visual /Sensual
Interaction
Intensity
Physical Artefacts
Perception of Space
Additional Information
Type of Interaction
Human Nature
User-Generated-Content
Content
Shared Experience
Bridge Virtual/Real
Physical Interaction

10 Appendix D: Projects

Rembrandt Project: https://dorukeker.com/projects/rembrandt-prive/

Versailles Project: https://www.metmuseum.org/exhibitions/listings/2018/visitors-to-versailles/audio-experience