




The Ten Commandments for Responsible Augmented Reality

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Abstract. Augmented reality (AR) brings us into a new phase in the information society, whereby the virtual domain spills over into the physical domain. Precisely because of the direct link between AR and the physical world, the technology raises new ethical and societal issues. In this paper, we highlight the main developments in AR that put pressure on seven public values from our analysis of the scientific literature: privacy, safety, autonomy, balance of power, human dignity, justice, and rights over augmented space. Furthermore, in order to safeguard these public values, we formulate ten rules to shape AR in a socially and ethically responsible way. These rules should form the point of departure for the drafting of governmental policy for a livable hybrid world.

Keywords: Augmented reality · Ethics · Disruptive technology

1 Introduction

Augmented reality (AR) is, together with virtual reality, a key technology of the next decade. It is a socially disruptive technology that has the potential to radically alter everyday life, cultural practices, and social and economic institutions.

AR is best understood as a new type of environment that is fundamentally different from both the physical and the virtual environment. We experience the physical environment directly with our senses, in contrast to the virtual environment which is created with digital technology and can only be experienced with digital devices, ranging from smartphones and tablets to personal computers and VR (virtual reality)-headsets. Experiencing that environment requires the use of a special system – a VR system – which submerges the user in a simulated, virtual environment. VR is largely separate from the existing physical context and also has a different social context. The main feature of AR is that the physical and virtual environments blend together to create a new type of hybrid environment, which is simultaneously physical and virtual. In experiencing this type of hybrid environment, the user is physically present in the environment and is aware of it, but is also able to experience virtual elements. Thus, in contrast to the

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placeless VR, AR is an environment in which people are (also) physically present and which is always connected to a particular place, time and social context. The physical and social context in which AR is applied is, therefore, a crucial factor in studying the societal and ethical aspects of AR.

In [16], six public values are distinguished which are challenged as a result of digitization in general: privacy, safety, autonomy, balance of power, human dignity, and justice. In Sect. 2, we will use these public values to structure our discussion to describe the range of ethical and societal issues relating to the existing uses of AR. However, AR also challenges another public value in contrast to other digital technologies. Because AR links the digital world directly to the physical environment by its superimposition of new layers of perception over geospatial locations, it also raises issues in relation to spatial planning, and therefore, challenges the public value ‘rights over augmented space’ [19]. In Sect. 3, we will formulate ten design rules for a livable hybrid world. These rules should be considered as social and ethical guidance for the drafting of governmental policy for the embedding of a responsible AR in our society. Section 4, finally, presents some conclusions.

2 Public Values at Stake

2.1 Privacy

The question of privacy receives particular attention in literature on AR (see, for example, [1, 7]). This relates not only to the collection and processing of personal (often biometric) data of AR users (e.g., those wearing AR-headsets), but also anyone who enters the field of vision of AR systems. AR systems collect data about the user and the user’s physical environment (which also includes other persons). To do this, AR uses advanced sensors, such as cameras for facial and behaviour recognition, smart microphones and sensors, which can register people’s location, the steps they take, their eye movement and facial expressions, their hand movements and posture. With powerful cameras, these systems can identify persons at increasingly large distances.

These intimate data can be collected, stored and shared without others noticing. According to Kotsios, the registration process in AR is, therefore, ‘completely seamless and surreptitious’ [7, p. 168]. The device is mounted on the user’s head and points in precisely the same direction as the head, making it almost impossible for the subject to know that he or she is being filmed or photographed. This development and application of AR in social contexts raises concerns for a ‘Little-Big-Brother’ scenario, where not only governments, but also citizens and companies constantly use technology to monitor one another and try to influence each other’s behaviour [16].

Behaviour recognition raises similar issues. Motoric data collected and analyzed by the AR system can be combined to produce a unique ‘kinematic fingerprint’, with which individuals can be identified [8]. This kinematic profile can also be used for other purposes. This process is referred to as *function creep*. A dataset that has been collected in a game situation could be sold to security firms to identify people in semi-public spaces with cameras. By linking behavioural data to data from online databases or details of a person’s search history on the internet, information can be gathered about a person’s purchasing behavior, relationship status, network of friends, political preferences or

other private data [22]. The linking of big data, in particular, makes unique identification of persons possible. The collected dataset can threaten human rights, including privacy.

An important question here is whether the AR user has exclusive rights to data relating to what he does, thinks or observes [2]. Google, for instance, applied for, and was granted, a patent for technology with which it can be identified what Google Glass users look at by monitoring their eye movements [15]. This means that the company can not only access the image seen by the wearer of the glasses, but can also acquire information about precisely what the wearer is looking at, and when. Data of this type can be very lucrative and useful, for example, for profiling and manipulating users (see Sect. 2.4). It might seem obvious that what the user sees in the hybrid environment belongs to her – but that is not the case.

2.2 Safety

Concerns about the physical safety of AR users and others in their vicinity from the use of AR mainly apply with respect to the use of AR wearables and AR games, because they demand a lot of attention from the users, can be addictive and are also frequently used in public spaces or in traffic. Players of Pokémon GO, for example, have been involved in numerous traffic accidents since 2016. At the end of 2019, a website that tracks fatal incidents involving Pokémon GO put the number at 21 [13].

Another cause for apprehension is the potential impact of digital filters on a person's self-image. With apps like Snapchat, it is easy to apply filters to selfies and videos. This can prompt users to cultivate an attractive, but distorted, self-image, as well as a distorted image of others. This incongruity between what one sees in the mirror and the self-image on the smartphone can cause mental problems for users. Rajanala et al. [14] assert that frequent use of AR filters sometimes leads to body dysmorphic disorder (BDD). People with this mental disorder find certain aspects of their appearance flawed and have obsessive thoughts about altering or fixing such aspects. There have been a growing number of cases where people have undergone plastic surgery with the aim of mimicking their filtered self-image. In that context, a British cosmetic surgeon coined the term 'Snapchat dysmorphia' after some clients brought filtered Snapchat images of themselves to their treatment consults, rather than pictures of celebrities as used to be the case [5].

Madary and Metzinger [8] voice the danger that frequent AR users can develop symptoms resembling depersonalization disorder, whereby they shift their attention exclusively to the virtual environment and come to disregard the real world and their bodies. They can end up neglecting their actual physical and social environment, which can lead to social isolation.

2.3 Autonomy

AR can be understood as a form of human augmentation that virtually expands our senses and can determine what we experience: see, hear and feel. The user's experience depends on which senses are addressed by AR and by the number of the senses that are addressed simultaneously. By monitoring people's eye movements, changes in the pupil size and movements of facial muscles, AR companies can analyze what users are looking at, how

long they focus on something and their physical and emotional response. By processing these data and linking them to online databases, the experiences of users (consumers, employees or citizens) can be subtly manipulated, which raises various issues about autonomy.

In their experimental study, Miller et al. discovered that experiences in AR can have a direct impact on behaviour in the physical environment [10]. For example, test subjects avoided sitting on a chair on which they had just seen a seated virtual person. Furthermore, the presence of a virtual person had practically the same effect on their behaviour as when a real person was standing beside them. AR is therefore necessarily persuasive in the sense that they provide the user with alternative experiences that seem real and that can change the perception, especially if the virtual world is ‘superrealistic’ [18] which impairs the user’s awareness of the differences between the physical and the virtual world. Pase states that AR devices are better persuaders than humans, because AR devices “know things” and “can do” things humans cannot, and can be more persistent in how they communicate [12]. When dealing with an AR device there is limited or no ability for a true encounter. The only engagement available is what is programmed into the device. This makes the persuasive intent one-sided and takes away a lot of control from the user. The persuasion is especially unethical if it is directed at modifying someone’s emotions or behaviour for detrimental ends.

2.4 Balance of Power

An ethical issue relating to the balance of power is the degree of control users have over the system. How much control do they have over the functioning of an AR device or application that is used by themselves or by others? For example, can a person register or deregister for biometric registration with a specific application? What control does one have over the information that is shared or processed? Is one able to ascertain where, when and who is using data from the application to identify people? Is it possible to switch off particular functionalities or is one entirely at the mercy of the technology?

There are especially major concerns about the information asymmetry between AR users and the companies that sell these systems and applications. These are often large, multinational IT companies [22]. While people are profiled in numerous ways by these companies, it is difficult for individuals to keep track of all the information that is collected about them, how that information is used online and precisely how they are then influenced by it. While individuals are becoming increasingly transparent for large IT companies, the conduct of those companies is becoming increasingly obscure to citizens. This could lead to manipulative power of companies which can curtail people’s autonomy – their freedom to make independent decisions.

On the internet, this form of active behavioural manipulation is found mainly in the consumer domain. Zuboff describes how tech companies, such as Google, Facebook and Microsoft, automatically collect large amounts of information on the internet about people’s behaviour, and use that data to predict and modify behaviour [22]. With AR apps and glasses, details of where users are, how long they stay somewhere, what they are looking at and what they buy can be registered. People are monitored over lengthy periods of time with cookies. They can be influenced by presenting them with specific information at specific times. By means of AR, persuasive techniques of this type are

penetrating the physical space. Companies can monitor and manipulate people in their homes or on the street. Accordingly, AR provides an extensive market platform, in which money is earned by analyzing, and making predictions out of personal data, which can be sold to commercial parties wishing to influence the behaviour of users. Zuboff refers in this context to ‘surveillance capitalism’ [22]. Consequently, not only the appearance of the environment can be commercialized, but what one observes, what one does, what one says and how one relates to others in the hybrid environment can gain commercial significance (see also [4]).

2.5 Dignity

The use of AR in professional settings brings with it the risk of the dehumanization and instrumentalization of humans. People could be seen as an instrument that can be controlled by the organization by means of commands that appear directly in their field of vision. Since AR-systems are linked almost directly to the employee’s senses, they capture a great deal of the worker’s attention. That leaves less room for the individual’s own cognitive experiences. This risk arises mainly with intensive AR experiences, where the employee’s attention is controlled with dynamic layers and gamification techniques. One of the issues that this raises is whether people have a choice in whether to use AR at work, or whether it is a requirement. The use of AR data to monitor employees and to manage or evaluate their performance has prompted concerns about the impairment of employees’ autonomy. The use of AR already raises issues relating to automation and the deployment of personnel. It could, for instance, lead to a new situation where fewer personnel are required to perform the same work, or to the replacement of existing employees by differently skilled employees.

The virtual layers of AR generally add something to the physical or material environment, but they can also remove something from it by modifying or hiding components of the environment. The result is referred to as diminished reality, which can raise other issues concerning dignity [7]. A software programmer in Silicon Valley, for example, created a distasteful AR algorithm with which homeless people could be filtered out of the streetscape in San Francisco [3]. This can be seen as digital dehumanization. This type of filtering also has political relevance, because a world in which homeless people are rendered invisible with filters is one in which ‘the political importance of homelessness is low’ [20, p. 150].

Some AR applications allow the user to ‘decorate’ others by adding virtual elements to the appearance of other persons [21]. In such cases, a person’s hybrid identity is not determined solely by that person. This can lead to new forms of cyber-bullying. One example is the DeepNude app, which removes the clothing from images of women and leaves them looking realistically naked. The app was quickly removed from the internet in response to public uproar. Although the digitally modified naked body is not a ‘real’ body, removing clothing in this way can be regarded as an ‘invasion of sexual privacy’.

2.6 Justice

AR can enhance the cognitive capacities of its users, which can have an uplifting effect. Smart glasses enable users to gather information about their environment and about other people. Accordingly, AR users could possibly also exercise power over others – often non-users – and do so without their knowledge [6, p. 300]. This could create a digital divide between users and non-users of AR.

With the introduction of AR to new emerging technologies, AR could potentially widen the gap of the digital divide even more due to an invisible overlay of additional information visible only to those who can afford the devices. The information can only be seen by expensive modern mobile computing devices, such as smart glasses and head-mounted displays with wireless Internet connections. The cost of AR could cause a lack of access to information primarily in low-income households, as well as to older generations who lack access to new tools or digital skills [17]. Restricting access to information to only those who can afford and are able to use it poses a dangerous threat of stratifying social structures with the potential to emphasize the digital divide.

2.7 Rights Over Augmented Space

With AR, the digital domain colonizes the physical world, and with it the communal public space. As a result, the public character of the public sphere could come under pressure, especially if the augmentation interfered with the intended use of the public space. Consequently, spaces are no longer constructed within a framework of tacit agreement, but become dependent on individual experiences and expectations. For example, augmenting a daycare with sexual images would likely strike many people as problematic [11]. Or AR games, such as Pokémon Go, which draw players to ‘inappropriate’ locations, such as protected nature reserves and cemeteries, have created many (legal) conflicts.

Users can also quite abruptly give new meanings to private property or interfere with the owners’ reasonable use of their property. Physical properties, like someone’s house or car, can easily be digitally modified or tarnished in the hybrid world. For example, in AR one could label houses with symbols that refer to the religions of the people occupying them.

At present, almost all popular AR systems and hybrid environments are developed by large technology companies, which are profit-driven. Consequently, there is a serious possibility that the existing and future applications on the market will contribute to the commercialization of our public space, but also our private and personal space. For example, it is generally prohibited to erect billboards or construct buildings with advertising texts in a nature reserve. Within the hybrid environment, there is no regulation in this respect and there is no recognition yet of the public interest in hybrid public spaces. The complicating factor is here that the creator of the augmentation need not be the owner of the physical property [11]. While many locations in the physical world are public property, the digital world is mainly privatized. As a result, in the hybrid world, public and private property can become intertwined. We saw the effect of that in the case of the game Pokémon GO, which was created by the American company and Google spin-off Niantic. In releasing the game, Niantic turned almost the entire world

into a game board for a commercial application. The business model of Pokémon GO is similar to that of Google's online advertising market. Companies pay Google 'per click' for every potential customer who visits their site via the search engine. Pokémon GO translates this technique from the online advertising world directly to the physical world. Businesses pay Niantic 'per visit' for every customer that enters the shop via its mobile game. Niantic demonstrated for the first time that through AR, digital online business models can also generate income in the physical world.

3 Design Rules

In this section, we formulate ten design rules for a livable hybrid world based on our findings in the previous section. These design rules should form the point of departure for the drafting of government policy. They call for action by various government actors. Addressing the issues raised, however, is not a task for the government alone. Tackling social challenges calls for collective action. The rules are therefore also intended to initiate public debate between politicians and businesses, knowledge institutes, social institutions and the general public.

Design rule 1 (regarding privacy): Guarantee the privacy of AR users

AR devices are surveillance machines that use sensors to collect numerous data about the AR user, non-users and the physical environment. This can only be done in a socially responsible manner if the privacy of the AR user and the anonymity of non-users is guaranteed in the process. Because people's personal privacy should be protected and people have the right to be left in peace, it is important to protect the privacy of AR users. Under the current legislation (such as the General Data Protection Regulation (GDPR), a regulation on data protection and privacy in the European Union), privacy ought to be a guiding principle in the design of IT systems. Privacy-by-design is a method by which AR devices can and should be designed in such a way as to minimize the use of sensor data, automatically anonymize data and properly safeguard data.

A related question is whether users have exclusive rights to their own observation or movement profiles. Data about facial and eye movements can provide insights into what users observe. These data are useful for AR companies in helping them to create hybrid worlds, but they are also lucrative, because the data can be used to profile and influence users for commercial purposes. It is essential to formulate explicit legal provisions on this type of data.

Design rule 2 (regarding privacy): Guarantee the anonymity and privacy of non-users

The use of AR glasses with cameras can threaten people's anonymity everywhere. Biometric technologies pose a particular threat in that respect. AR glasses with facial recognition enable users to identify other people. AR devices with emotion recognition enable users to acquire information about a person's mental state. Furthermore, the platforms and applications on AR systems can collect data and share them with third parties. Guaranteeing the anonymity and privacy of citizens is an important design principle for

the public space. The possibility of giving consent to various forms of AR registration is therefore a subject that demands special attention. Until rules are adopted, governments should impose a moratorium on the use of AR applications in the public space with which citizens can be uniquely identified through biometrics.

Design rule 3 (regarding rights over augmented space): Clarify issues of both physical and virtual ownership in the hybrid world

Besides privacy issues, AR also raises various issues with regard to rights over augmented space (see also design rules 8 and 9). With AR, virtual layers can be superimposed over the physical reality – and thus over the individual’s personal, most intimate, space. People can use digital filters to create their own hybrid identity, but also to do something similar to the identities of others. To ensure that people retain control over their physical-virtual identity, there has to be certainty about the precise meaning of the right to physical integrity in the context of AR. In the age of AR, it is important to provide legal certainty that people can be protected against unwanted digital interventions on their body, and how that protection will be provided.

AR applications can lead to infringements of property rights, or to destruction of private or public property by encouraging people to go to locations that they would not otherwise visit. It is also possible to digitally modify physical property with AR, which raises the question of whether virtual spray painting, for example of another person’s house or a public building, is permissible. According to McClure, a so-called ‘Do-Not-Locate’ register could help to exclude specific locations from the use of AR [9]. In Germany, members of the public have that option with Google Maps. At the moment, however, it is not yet possible to prevent your home from being used for an AR advertising text.

Design rule 4 (regarding safety): Protect the mental and physical health of AR users

AR can affect the physical and mental well-being of its users. The technology is developing rapidly and provides increasingly powerful immersive experiences, making it more and more difficult for users to make the distinction between virtual and physical, and between fake and real. In the entertainment domain, for example, apps such as Snapchat can provide enjoyment, but they also encourage users to create an ideal digital image of themselves. There are therefore concerns that frequent use of AR not only creates the risk of addiction, but can also distort a person’s self-image or even lead to forms of body dysmorphic disorder (BDD).

There is a need for scientific reflection on and public discussion of the social significance of AR as a technology that comes between us and reality and which mixes reality with fiction. From the perspective of ‘digital literacy’ – the collection of competencies that people need to contribute to our digitalizing society – people need to learn how to deal with the phenomenon of augmented reality in a healthy and responsible manner.

Design rule 5 (regarding dignity and justice): Strengthen human capacities in a fair and dignified manner

If it is not used properly, AR could degrade human labour to robotic work, whereby the technology determines precisely when the employee has to perform specific actions. That is a prelude to deskilling, instrumentalization of people and dehumanization. Or it could lead to indecent practices. For example, using AR to undress other people digitally or to algorithmically filter homeless people out of the field of view of the AR user. These types of behaviour can be seen as forms of social discrimination or even digital dehumanization. Government should therefore promote research and debate on social standards and values (social etiquette) in the hybrid world.

In the long term, AR will possibly become a normal part of life, although the place that AR will ultimately occupy in human life is difficult to predict. Twenty years ago, few people could imagine that many of us would now be walking around with a smartphone in our pocket. We, therefore, have to start asking ourselves now whether everyone will benefit proportionately from the new opportunities created by AR. There is a risk of a new digital divide emerging. Companies in the forefront have a social responsibility to mind the digital divide, which will prove key in minimizing social harm. Developers, practitioners, and researchers in the field must acknowledge digital inequalities and provide older adults with training tools, support services, and digital solutions that consider their heterogeneous backgrounds and needs.

Design rule 6 (regarding autonomy): Protect people's cognitive autonomy

With AR, it is not only the supply of information that can be personalized, but also the perception and experience of reality. Broader than fake news, AR is therefore about a fake reality and the question of who determines what reality the user experiences. With AR, everything we see, hear or feel can be 'fake'. The algorithms used for AR determine how our immediate sensory experience of reality is filtered and pre-programmed. Ensuring that AR enhances people's cognitive autonomy, or at least does not harm it, is, therefore, one of the biggest challenges of the AR era.

Design rule 7 (regarding balance of power): Ensure fair power relations in the hybrid world

Many companies, large and small, regard AR as an attractive technology to develop and invest in. Especially companies like Google, Microsoft, Facebook, Bytedance and Huawei dominate the current internet economy and are icons of surveillance capitalism, which is characterized by large-scale monitoring and influencing of the behaviour of consumers. There is an enormous information asymmetry between these internet companies and consumers, but also other companies. These multinationals see AR as a key element of their future business model. We should not allow the now skewed power relationships on the internet – between companies and between companies and users – to also determine relationships in the field of AR. People give away, often unwittingly, their most intimate data, making them vulnerable to market parties. Consumers need to be informed about their vulnerable position in this new market-dominated environment. Governments should therefore clarify how fair relationships between companies and between companies and users in the field of AR will be guaranteed.

Design rule 8 (regarding rights over augmented space): Create public spaces in the hybrid world

Public space is public property and is in principle accessible to everyone. Pleasant public spaces help to create a good living environment and lay the basis for the development of citizens and their relationship with each other. With AR, the digital domain colonizes the physical world, and with it the communal public space. As a result, the public character of the public sphere could come under pressure in two interconnected ways. In the first place, AR could lead to the commercialization of every physical space – including public spaces such as nature reserves, beaches and squares. We have seen how the company Niantic appropriated public space with the game Pokémon GO.

Secondly, the experience of public space could come to be digitally personalized through AR. Because AR can further personalize the perception of reality, there is a risk that the notion of a public sphere rooted in common experience will disappear. To guarantee the livability of the hybrid world, the government must attempt to safeguard its public character in the long term. The government should investigate how the public character of hybrid spaces can be safeguarded in the long term.

Design rule 9 (regarding rights over augmented space): Design the hybrid environment in a socially responsible manner

We often treat our physical environment with care. For example, municipalities have committees to advise on aesthetics and heritage, whose task is to verify that building plans are consistent with the public interest of the typical character of neighbourhoods, districts and regions. What requirements should be stipulated for the quality of the hybrid environment? A specific issue in relation to spatial planning is deciding on those environments in which particular forms of AR should or should not be permitted. We have seen that AR games can clash with the legal and social rules that apply at particular locations, for example in a nature reserve or a cemetery. AR can also create safety risks. The use of Pokémon GO at hazardous locations has led to fatal accidents, for example. Because the use of AR will influence the use of public space in a variety of ways, it is important for governments to explore how the hybrid physical-virtual environment can be designed in a socially responsible manner.

Design rule 10: Make a joint effort to create responsible AR

The hybrid world must not be designed and constructed exclusively by (large) tech companies according to their own private interests. Politics and society must lead the way in designing a livable hybrid world based on the public interest. We see public discussion as an essential ingredient for increasing political and public awareness about the social significance of this technology. Greater awareness could ensure that we identify outstanding knowledge gaps, essential normative and regulatory frameworks and possibilities for a more inclusive manner of innovation. As in the case of artificial intelligence, the social embedding of AR should receive more public and political attention in the coming years.

4 Conclusions

Our research shows that there is a lot at stake with AR. It profoundly influences our perception of reality. There is far too little reflection on and discussion on the future of the hybrid, physical-virtual world. It is therefore time for a broad public debate about AR in society. To initiate such a debate, this article formulated ten design rules for a responsible and livable digitally augmented world. These rules were inspired by the societal and ethical issues that we see emerging in relation to the use of AR: privacy, safety, autonomy, balance of power, human dignity, justice, and rights over augmented space.

Other digital technologies also challenge these public values in a way, except with regard to rights over space which is typically related to AR. Because AR links the digital world directly to the physical environment, including our bodies, AR will have a major impact on how spaces, places and human bodies take meaning for both users and non-users.

From a democratic perspective, it is essential that the design of our current and future hybrid environment is guided by the above-mentioned public values. If we want to fashion a livable hybrid world that is democratic, we have to invest in social innovation. We need to find a common language to talk about this new world, the social etiquette there and relevant economic and legal rules. We need to do this together, which means with the general public, knowledge institutes, civil-society organizations and businesses. Especially citizens should have a say, because they will be living in the hybrid worlds of the future and therefore have a great interest in the quality of life.

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