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Augmented Reality Smart Glasses: Definition, Conceptual Insights, and Managerial Importance

Philipp A. Rauschnabel, Alexander Brem, Young K. Ro

Abstract:

During the last years, the developments of new media have revolutionized individuals' behavior tremendously. Particularly mobile devices have developed an 'always and everywhere online' mentality. But what comes next? Recent developments and forecasts propose the rise of a new technology that is termed 'Wearable Augmented Reality Devices", where smart glasses (such as Microsoft Hololens or Google Glass) represent prominent examples. These technologies offer much potential for companies and societies, which are discussed in this article. By doing so, this paper provides managers and researchers an applied description of the technology and a discussion of how it differs from existing mobile and augmented reality technologies. Finally, a discussion of how smart glasses can increase firm value is provided.

Keywords:

Smart Glasses, Media Evolution, Augmented Reality, AR, Wearables, Technology

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Augmented Reality Smart Glasses: Definition, Conceptual Insights, and Managerial Importance

1. THE MERGING OF TWO WORLDS

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

In line with these forecasts, new startups specializing in smart glasses have been founded. As a final point, consumers and media discuss the advantages and potential concerns of this technology for individuals, and societies as a whole. Although there is a huge potential for smart glasses to create value for consumers, companies, and societies as a whole, surprisingly little research has been published. Not surprisingly, academics and managers alike call for early market knowledge to better understand the mechanisms that drive this promising technology (Rauschnabel et al., 2015a, 2015b, Olsson et al., 2012)

Knowledge about new technologies is important in the early stages of the diffusion, as this knowledge might increase the probability of successful implementation, decrease the probability of product failures, and thus increase diffusion speed (Attewell, 1992). Likewise, early knowledge can provide an advantage for companies who might increase efficiency by using smart glasses,

and also help policy makers focusing on laws that cover the specific characteristics of smart glasses – e.g., that smart glasses could distract people from driving a car, or that wearing smart glasses in public might violate privacy and copyright laws.

In this article, we address this research gap as follows: First, we provide a new classification of online technologies, and by doing so, integrate smart glasses in the evolution of media technologies and discuss its distinctiveness compared to other technologies, such as virtual reality glasses. Then an outline including a research agenda of how smart glasses can increase firm value is presented (Yadav & Pavlou, 2014). Besides enhancing or improving the performance of existing tasks better, the potential for new business models for innovative applications arise. To develop successful smart glasses and applications, knowledge about the motivations of potential consumers are needed. Therefore, findings from research are discussed and extended and thus provide readers an overview about promising strategies. By doing so, the aim is to prompt readers to think of new and innovative business ideas by integrating smart glasses. The provided discussion also stimulates ideas for managerially important academic research.

2. VIRTUAL AND AUGMENTED REALITY DEVICES

2.1. Overview

Through the lens of the evolution of media devices, smart glasses are a combination of wearable devices and augmented reality technologies, as shown in Table 1. Particularly, based on prior research, a media evolution framework of five media generations is proposed, as shown in Figure 1. The x-axis in this figure reflects the time, and the y-axis the influence of each generations' technologies on users' lives.

The first generation of media is termed offline media, and includes uni-directional offline media such as newspapers, television, Teletex, and others. These technologies were mostly stationary, and digital technologies from that time received their information either from internal storages, cartridges (e.g., game consoles), CD Roms, or via analog radio frequencies (e.g., TV or Radio).

The second generation, dubbed as Web 1.0, describes early online technologies, where static websites are prominent examples. Consumers' roles in this generation of media were primarily passive, i.e., consuming content that was produced and published by professional organizations – e.g., companies. Although technically two-way communications were possible, most of the technologies of Web 1.0 were still uni-directional. Broadly speaking, these early websites were digital brochures, and most content was produced by professional organizations. Only a few very innovative users created personal websites, primarily by manually programming HTML code, and hosting these websites and free web hosting services such as geocities.com.

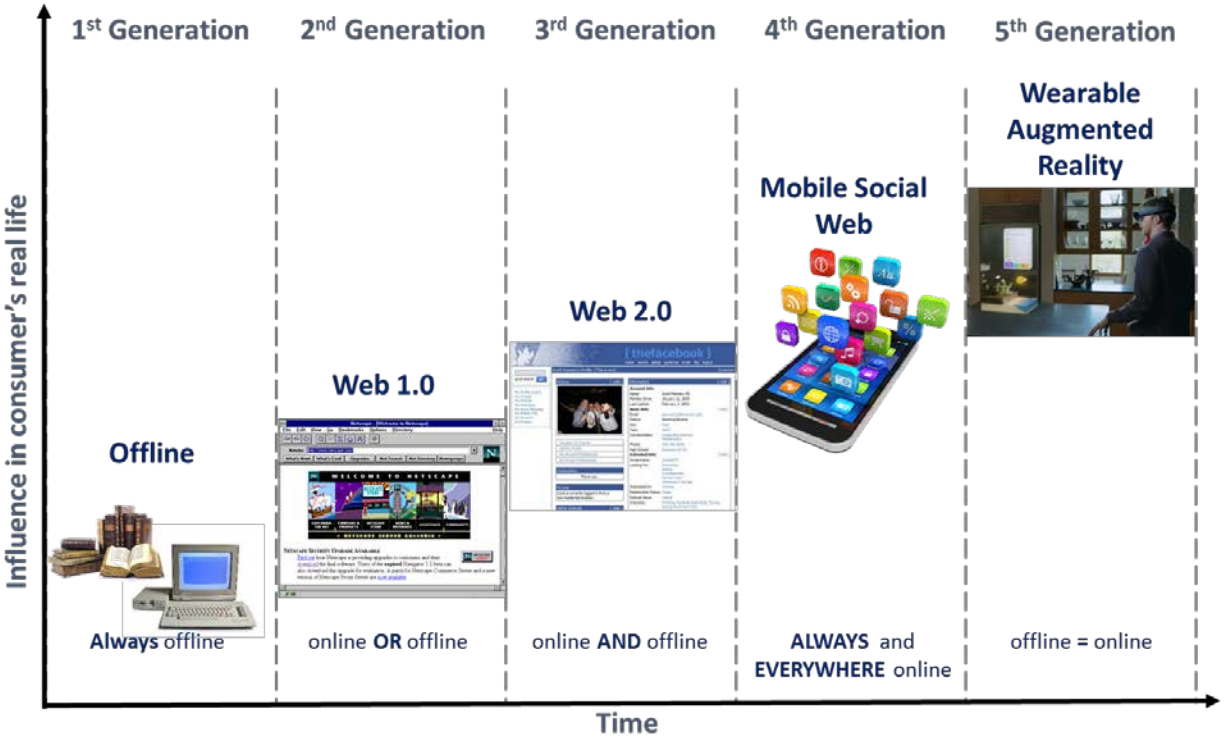
The third generation, starting in the early 2000s, has been dubbed Web 2.0, or social media (Kaplan & Haenlein, 2010). Social media is characterized by complex and multi-directional communications. Users serve as both the consumers and producers of content (thus they are also termed 'prosumers'). Faster internet connections, higher user-friendliness among devices, and higher levels of trust and acceptance of the Internet represent examples of why people were more likely to experiment with and use Web 2.0 technologies. Examples of early Web 2.0 technologies are Facebook (that time TheFacebook), SecondLife, or Myspace.

The fourth generation of media extended social media from static devices to mobile devices, such as laptop computers, tablets, and smart phones. However, other forms of wearable devices, such as smart watches, smart cloths, or smart wristbands, are also covered by this generation of media. These mobile technologies enable users to have access to their 'social media environment'

anytime and anywhere. Not surprisingly, social media applications – such as Facebook or Instagram – are the most popular smartphone apps.

The fifth generation of media are so called wearable augmented reality devices (WARD), i.e., wearable technologies that merge virtual and physical realities. In other words, these technologies meld the real world with virtual elements. One example of this fifth generation of media are augmented reality smart glasses, the focus of this research.

Figure 1: Evolution of Media Devices



However, the idea of augmented reality is not new; these technologies have been developed and researched during the last years. As shown in Table 1, an example of an established AR

technology are “virtual mirrors” that are often used by fashion retailers. Technically, virtual mirrors are displays with an integrated camera that film a consumer, and can chose the cloths he/she is wearing on the screen. Mobile AR applications can be used on most mobile devices, such as tablets or smart phones. For example, users can capture a building in a city with their camera, and a mobile AR-app, such as Cyclopedia, recognizes the building and provides the corresponding information from Wikipedia about this building. However, extant AR examples are either just applications for mobile or stationary devices, or, devices that were specifically developed for professional contexts (e.g., virtual mirrors). Smart Glasses, in contrast, are conceptualized as a new generation of media, as they are (a) specifically developed AR technologies, and (b) also made for the masses.

1.2. Definition of Augmented Reality Smart Glasses

Based on our theorizing and prior research (Rauschnabel, Brem & Ivens, 2015a, 2015b; Glauser, 2013), we develop the following definition of smart glasses (synonym: data glasses):

> Augmented Reality Smart Glasses are defined as wearable Augmented Reality (AR) devices that are worn like regular glasses and merge virtual information with physical information in a user’s view field.

Smart Glasses are usually worn like glasses, or are devices mounted on regular glasses. Several technologies (e.g., camera, GPS, microphones etc.) capture physical information and augment them with virtual information that can be gathered from the internet and/or stored on the smart glasses memory, primarily accomplished through location-, object, facial, and image-based recognition technologies. This virtual information is then displayed in real-time on a display,

which, in brief, is a plastic screen in front of a user's eye(s). A user can see both the offline and the virtual and the real-world through these displays[1]. Prominent examples of smart glasses are Microsoft Hololens or Google Glass.

Table 1: Virtual versus Augmented Reality

Technology Generation			
	Wearable	smart watches, VR-Glasses	AR Smart Glasses
	Mobile	mobile phones, laptop computers, tablets	Mobile AR software applications
	Stationary	desktop computers, gaming consoles	Virtual Mirrors (AR-mirrors)
	Offline	TV, Teletex, newspapers	N/A
		Virtual Reality (VR)	**Augmented Reality (AR)**
		Realities	

3. VALUE CREATION WITH SMART GLASSES

The core proposition of this article is that smart glasses can be a means to create corporate value for businesses, and also for society as a whole. Therefore, it is necessary to distinguish between internal and external value creation factors. Internal value creation factors cover aspects where

[1] It is worth noting that two related technologies, virtual reality glasses (VR Glasses) and Smart Lens, need to be distinguished. Unlike AR smart glasses, where digital content is overlaid onto the real world, VR glasses are completely closed off from the real, physical world, and instead present only a virtual world.
Smart Lens is a commonly used term to discuss the possibility of having smart glasses on a contact lens-sized device (e.g., 'in-body-AR-device'), but also as a medical device in contact lenses that, for example, measures a user's glucose level in their tears constantly.

smart glasses can be used by a firm's employees to work more effectively. External value creation means that companies can increase revenues by offering applications for smart glasses that can be used by consumers. Important to note is that, due to the novelty of the technology, not all of the potentials have been addressed in prior research or practice. Thus, this overview also provides suggestions for future research.

3.1 Internal value creation

Research and Development: Smart Glasses offer new methods of market research for firms. Consider, for example, survey applications that cover physical information – such as a product or a store – and integrate surveys. Extended versions of smart glasses could combine the advantages of mobile surveys and eye-tracking (as well as other forms of observational data) and provide marketers new methods of market research. Prior research has also focused on new technologies for product testing. For example, prior research has investigated virtual 3D-screens as a means to test packaging, and shown its benefits compared to 2D-tests (Berneburg, 2007), with the limitation of artificial laboratory situations. AR smart glasses could be used to present products more realistically. For example, new forms of a bottle could be virtually displayed on a respondent's dining table at home and evaluated in a realistic situation, thus increasing the external validity of product tests.

Collaboration: First attempts have been made to use smart glasses as a means to working collaboratively. For example, Muensterer and colleagues (2014) tested the acceptance of Google Glass in a pediatric hospital and used it for telemonitoring with colleagues all over the world. Similarly, manufacturers of smart glasses, such as Microsoft (2015), highlight the benefits of collaborations – in a personal setting (a men helping a friend fixing a drain) or in a professional

setting (researchers analyze rocks on Mars). Similarly, collaborations in customer-firm interactions are possible, for example, for functions such as customer service and product support.

Process Effectiveness: Using smart glasses at work could increase an employee's efficiency, as information is always accessible. This is possible, as in times of big data, digitalization, and the Internet of Things (Lee & Lee, 2015), products and systems can communicate autonomously with each other and provide employees with the relevant information. The advantages of smart glasses compared to other forms of devices are threefold: First, only relevant information is displayed. For example, a cook could have the information about the next ingredients that are necessary for a recipe, rather than the whole recipe at once, because smart glasses would recognize in which step of the cooking process the cook is in. Likewise, smart glasses can help improve the logistical function in supply chains by aiding workers in a retailer's warehouse search for and find the right products that are ordered by for a consumer, and navigate the worker through the warehouse in the most effective way. Second, information is automatically available when needed, and can be enriched with additional online information, if desired. For example, designers and engineers can work on collaborative product development projects from virtually any dispersed location around the globe and make changes or alterations to parts of a product or component design in real time for all members of the product development team to see. If a service technician has problems installing or repairing a machine, additional information can be received by the smart glasses in real-time, or colleagues can virtually join. Similarly, face recognition could help police officers identify wanted criminals and fugitives, and provide them with additional information, such as criminal records. Third, in contrast to other mobile AR devices, smart glasses can be used hands-free, offering workers greater flexibility. This can, for example, be helpful for documentation in medical settings (e.g., forensic medicine; c.f. Albrecht et al., 2014).

3.2 External Value Creation

Companies can also increase value for customers in service functions. Currently, many companies use virtual reality applications. For example, the Swedish furniture chain IKEA offers a 3D Kitchenplanner on their website, in which consumers can plan their purchases virtually. In the future, augmented reality could even go a step further. Consider, for example, consumers wearing smart glasses while walking through an empty room, and planning their new fittings by placing virtual furniture in a real room. Likewise, consumers with service requests could contact a company via smart glasses. For example, consider a customer's service request from an automotive company, where the customer has problems in programming a car computer. A service representative could then see what the consumer sees, and give particular advice on what to do.

3.3 New Business Models

Whereas the aforementioned benefits focused on the use of smart glasses in firms, smart glasses also offer the potential for new applications. Consumers tend to be more likely to adopt particular technologies and media when they address particular needs. For example, consumers use social media to obtain gratifications such as entertainment, socializing, self-presentation, information, and others. With regards to smart glasses, there are three clusters of needs that can be addressed by smart glasses applications.

3.3.1 Effectivity Factors

Effectiveness, in this case, describes how 'useful' smart glasses are for consumers by making their life more efficient, and thus address more utilitarian needs and wants. Prior research, such as the widely cited technology acceptance model (Davis, 1989), have shown that the perceived usefulness of a new technology is a core determinant of the adoption intention of new

technologies. With regards to smart glasses, Rauschnabel et al. (2015b) showed that people who perceive smart glasses as a technology that makes their lives more efficient are more likely to adopt them. Also, consumers who perceive that using smart glasses does not require large mental effort due to their use being self-explanatory perceive higher levels of effectivity benefits.

In line with this, commonly discussed applications include navigation systems and organizers. In fact, from a technological perspective, navigation apps could be more effective than common navigation systems, as they are able to capture real-world information – such as construction-induced speed reductions, detours, or providing accurate directions in complex situations.

3.3.2 Hedonic Factors

Hedonic factors can be, in everyday language, simply described as ‘fun’. Not surprisingly, people often use particular media for hedonic purposes. These include entertainment, passing time, playing games, or escaping from reality. Smart Glasses offer many opportunities for consumers to receive hedonic benefits. Consider, for example virtual games that can be played in a real environment. Current computer games are applied in famous environments from movies, such as Tomb Raider or James Bond. Games on Smart Glasses offer the opportunity to play these games in familiar, real environments. For instance, a re-launch of the famous Tamagotchi game in the 1990s is possible, where users care about a realistically looking and behaving, virtual ‘pet’ that is (virtually) walking in a user’s room. Likewise, the popular workout smartphone apps could be applied on smart glasses, and offer additional benefits, such as showing joggers the exact way in the view-field. An important distinction between smart glasses and other technologies (e.g., smart phones or Laptop computers) is that they can be used while the user is doing something else. For example, playing a game on a smart phone or a laptop computer usually requires high levels of a user’s physical and mental concentration, and thus hinders the development of applications that

require a user's physical play. For example, one could consider the idea of an ego-shooter game that can be played in a user's yard or house, in which a user chases enemies in his or her house or garden. Finally, smart glasses can also be used to document one's life.

3.3.3 Social Factors

Consumer researchers have long known that products or brands that are used in public are linked to social aspects (e. g., Bearden & Etzel, 1982). It is also a well-known finding from fashion marketing that people dress themselves in a way to present themselves in a particular way (e. g., Cass, 2001;). Smart glasses are, as any wearable, also a new form of fashion accessories for their users. Thus, psychological similarities between what is known from fashion adoption and smart glasses are very likely, although research in this domain remains scare. However, Rauschnabel et al. (2015) showed that people who perceive that using and wearing smart glasses will be common among their peers are more likely to adopt these smart glasses.

Also, prior research has shown that users of (new) technologies often form communities, and in communities, ties between the members are an important determinant (McAlexander, Schouten, & Koenig, 2002; Muñiz & O'Guinn, 2001; Algesheimer, Dholakia, & Herrmann, 2005). In fact, several communities of smart glasses have been developed. For example, *EduGlasses.com* is a resource center and online community for educators that use smart glasses in classrooms and other educational settings. GoogleGlassForum.net is another example of online communities that focus on Google's smart glasses program. These examples enable registered users to engage in discussion about everything related to smart glasses. Research about online communities has revealed the importance of social factors that drive user participation (e.g., Hennig-Thurau et al., 2004; Muntinga et al., 2011).

Assuming that corresponding apps will be developed in the future, for example dating apps, smart glasses can be a means to satisfy unmet social needs. These apps offer various benefits as compared to regular online dating websites or mobile apps, as users could, for example, see and identify potential partners in real life, and identify them via smart glasses. Likewise, smart glasses can also help members maintaining existing social relationships in a similar manner as social networks. For example, Google promotes the benefits of Google Glasses by showing examples where users identify friends nearby and motivates them to meet in person, and by displaying relevant information about their friends (e.g. a person's birthday).

3.4 Value for Society

When it comes to new technologies, many consumers are skeptical and discuss potential negative consequences for a society. For example, in the early days of the Internet, Kraut et al. (1998), concluded that using the Internet influences people negatively, particularly with regards to their social lives and depression. Follow-up studies revealed that the initial findings were not as dramatic as proposed (Tyler 2002). Besides potential negative consequences that will be discussed in the next paragraph, various positive effects for a society as a whole can emerge.

For example, smart glasses can make rescue teams more efficient, and support doctors at work, as discussed above. Although potential privacy concerns exist, smart glasses can be used to record one's environment, and thus help law enforcement personnel solve crimes. Research has also found that smart glasses can facilitate the everyday life of patients with Parkinson's disease (McNaney et al., 2014). Recent discussions about the use of smart glasses in classrooms and education indicate further positive effects on society as a whole.

4. BARRIERS

Like any technology, the growth of smart glasses might be limited due to some factors. From a technological perspective, especially the short duration of the batteries, a limited number of applications, and lack of ubiquitous high high-speed internet connection are crucial. However, it is likely that further developments in technology will address these barriers. From a more psychological perspective, users often criticize the design of the extant models, which could be one reason why Google stopped distributing its 'Explorer Program'. Likewise, fear of electro smog, or negative influences on the eyes, are other criticisms that are often discussed among consumers, although current research does not support these fears.

Important to note is also the fact that several legal, ethical and political challenges arise that might hinder the development of smart glasses. For example, wearing smart glasses in public could violate privacy and copyright laws. Both the National Association of Theatre Owners (NATO) and the Motion Picture Association of America (MPAA) have allied themselves to prohibit the use of smart glasses in cinemas due to concerns regarding movie piracy by illegal recording (Barrie, 2014). To reduce potential conflicts with regards to individual privacy concerns, some manufacturers, such as Google, announced not to develop facial recognition apps, but it might be a matter of time until other developers program such applications.

Manufacturers of smart glasses also advertise the benefits of using smart glasses as navigation systems, but whether this distracts drivers and thus provides a risk for other traffic participants is yet unknown. Analogous to older technologies, people might criticize that use of smart glasses might make society more unsocial. For example, the popular Walkman-Effect describes the criticism surrounding Sony's portable cassette player in the 1980s, where people were afraid that

Walkman users would become distracted in everyday life. Regarding health issues, Yung et al. (2015) mentioned potential concerns regarding addictive smart glasses usage behavior.

Not surprising is the fact that, because of public criticism (e. g., privacy concerns), not all people perceive smart glasses in a positive way. In particular, the user image of smart glasses is often expressed in a negative manner. In online discussion boards, many users call smart glass users 'glassholes'.

5. DISCUSSION AND CONTRIBUTION

In this paper, we addressed a topic that has the potential to be very influential in research, companies, and for new business models: Augmented Reality Smart Glasses. Therefore, we started with a definition and integration of AR smart glasses into the current media and technology landscape. According to this, AR smart glasses are the logical next step of media development, as they combine wearable devices with AR technologies. In line with this assumption, various forecasts predict high growth rates within the next few years, and thus indicate that smart glasses could be the next 'big thing'. Whereas most research on technology and new media investigates research questions of existing devices or applications, the aim of this research was to discuss a new and promising technology in the very early stage of development. Therefore, we provided relevant definitions, and discussed potential success factors of smart glasses adoption by theorizing psychological drivers of end users, societal factors, and applications in businesses.

This leads to the question of what needs to be done to support the growth of smart glasses within the near future. We propose four implications of particular importance:

(1) Design and Identification

As discussed, smart glasses share similarities with fashion accessories. Manufacturers targeting private consumers (rather than companies) have to focus on fashionable designs. A common criticism of Google Glasses, for example, is its 'nerdy' design. This could be one main reason why Google halted its 'Explorer Program' in 2015 to reinvent their smart glasses, and also why Google has begun collaborating with fashionable sunglass makers such as Oakley and RayBan. Additionally, people who feel attached to new technologies often wish to show these technologies to others, and talk about them. This is enabled if smart glasses have an aesthetically pleasing design that people enjoy wearing in public. In line with this, manufacturers have to work on improving the user images – from 'glassholes' to, for example, fashionable and innovative consumers.

(2) User Friendliness

Especially less innovative consumers are often skeptical about their own skills of technology use. For example, users who think that smart glasses are difficult to handle perceive them as less useful (Rauschnabel et al., 2015b). High levels of user-friendliness, and an appealing design, were also core drivers of Apple's success, for example, with the iPod.

(3) Killer-Apps

Killer apps are essentially technologies or applications that significantly alter the way we live and do business (Hu, Li, and Hu, 2008). With regards to smart glasses, 'killer' apps are applications that motivate consumers to buy the yet expensive smart glasses just to use this app. For example, the AR navigation apps or particular AR smart glasses games have the potential to become a killer app for smart glasses.

(4) Price

New products and technologies are often introduced by a skimming strategy (Dean, 1950a, 1951; Tellis, 1986), which begins with a high price that is constantly reduced over time. Little is yet known about the long-term pricing strategy of smart glasses. However, the history of media technologies shows that prices drop quite fast once the first competitors enter the markets, and that high prices represent adoption barriers for less technology-oriented, or less innovative, consumers.

(5) Personal data

Smart glasses are by definition becoming a part of one's personality. They are interacting with other personal technologies like smartphones, smartwatches, etc., and at the same time with non-personal technologies from its surrounding environment (such as sensors and other wearable devices). Hence, the question arises of who owns which data, and how end users can keep control of this information such as personal identifiers, pictures, and so forth.

For managers, we recommend thinking about smart glasses in detail, particularly before their market penetration is high. From our perspective, finding answers on the following four questions is particularly important:

(1) Are there any growth potentials both in existing and potentially new markets by applying smart glasses? The history of other media technologies shows that new market players can quickly and dramatically influence existing markets with disruptive innovations (e. g., Wikipedia cut out traditional encyclopedias, or the What'sApp messenger threatened the market for traditional SMS/MMS in many countries). Also, can we increase value for stakeholders through value-added services, for example, in customer service?

(2) Can we use our capabilities and resources to grow in new markets, for example, by developing commercial applications that provide value for consumers? For instance, if your company is specialized on face recognition tools, there could be a potential to develop and offer particular apps that use face recognition. Likewise, if your company offers translation software, consider offering an application that captures texts in the physical world, and overlay the physical text with a virtual translation.

(3) Can we make existing processes better? For example, can we increase the efficiency of sales personnel, product development personnel working collaboratively, and logistics personnel such as warehouse workers and truck drivers, among others? First commercial applications are already available. However, we can foresee particular competitive advantages in developing firm-specific applications that can reduce waste, increase speed or quality, and foster collaborations.

(4) How should we deal with employees' personal use of smart glasses? Many companies, for example, had to deal with challenges arising from employees' wrongful use of social media in situations where employees posted confidential information on the internet or got distracted from work. Should your employees be allowed to use their personal smart glasses at work?

We hope that these discussions stimulate managers in considering smart glasses for their business, and for scholars to place emphasis on this new and promising technology – both as a research tool, and as a research object. Finally, we conclude with a call for policy makers to be aware of the characteristics of smart glasses, and the need for corresponding laws and regulations – ideally, before smart glasses become more ubiquitous in the general population.

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