

# Mass Adoption of Augmented Reality

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Title

# Mass Adoption of Augmented Reality:

## Feasibility, Prospects, Implications, and Alternatives

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## ABSTRACT

Augmented reality as a concept and technology has been in existence for decades, but has so far remained the preserve of select groups of users for specific, limited purposes. With the I.T. giant Google poised to release an augmented-reality-dedicated device in 2014, applications of A.R. as seen in science fiction shows such as the Terminator are now on the verge of being popularized. This work examines the question of whether A.R. is in fact ready for mass adoption by users.

It does so by first investigating the technologies involved, particularly the availability of A.R.-ready devices and connectivity standards. Next, it scrutinizes the current and potential availability of the data content for use in A.R. applications, also touching on the relevant legal and ethical issues. It speculates on the likelihood of A.R. benefitting the majority of the populace rather than reinforcing the "digital gap." Practical or theoretical solutions are suggested in cases where obstacles and difficulties are identified.

The Paper finds that the most common expectation of A.R. is at present not achievable, and proceeds to examine more plausible immediate alternatives as well as the forthcoming A.R. projects and initiatives. It is concluded that the success of A.R. on a wide scale is in a very large part contingent upon the success of Google's Project Glass. If its quality fails to garner sufficient support and imagination of users, partners, and competitors, augmented reality may well never catch on.

# TABLE OF CONTENTS

# CHAPTER 1. INTRODUCTION

It has often been remarked that the technological evolution of the human race has been accelerating exponentially in the modern era. When printing press was invented in mid-15th century, it took the best part of four subsequent centuries to spread globally. In contrast, humanity witnessed the computer (in its contemporary, digital form) go from ponderous, task-limited room-sized behemoths to palm-sized devices running people's lives in a matter of decades. Since the mass adoption of personal computers in the 1980s and 1990s, the world of computers has undergone drastic changes as far as speed, capacity, and features. Arguably the most valuable development has been the ability to connect terminals into networks, particularly the global network known as the Internet. Much discourse has taken place concerning the benefits of the Internet and it would serve little purpose rehearsing them. One of those benefits, however, is important for this Paper and it is the facility of vast information storage and easy retrieval.

Computer users have come to expect various types of information to be readily available to them at all times. Indeed, "computer users" is an anachronism in this context: It is users of many types of digital devices who have such expectations. Laptops, notebooks, netbooks and tablets, as well as smartphones, media players and, albeit more of a curiosity item for the time being, even refrigerators require continuous access to online data. Ordinary people walking down a street avail of their smartphone to check how to reach their destination via a real-time map application or to choose the nearest entertainment or eating venue utilizing a review website and the device's G.P.S. locator.

Nor is this digital revolution drawing to a close. Technology experts and pioneers are discussing and even testing concepts such as quantum processors, 3-D printing, network-enhanced telepathy, and many others. More realistic a concept, given the current stage of development, and one that is being actively pursued by some of the biggest protagonists in the world of technology, is augmented reality.

# <u>CHAPTER 2. DEFINITION AND BACKGROUND</u>

Augmented reality can be comprehensively defined thus:

"Augmented Reality is essentially the combination of both real and virtual objects into a real environment. It links real and virtual objects with each other, typically in an overlay of sorts that runs interactively, in three dimensions, and in real time. [It is] not limited to certain display technologies like a head mounted format, nor is it only limited to the sense of sight. Augmented reality applies to all senses – hearing, touch, smell, and so on. It seems only a matter of time before it is integrated widely into consumer products.

"Occasionally, virtual objects overlay real objects. This technique is known as mediated or diminished reality, and also qualifies as augmented reality under industry definition." ("A brief history...," 2010)

Sources (Sung, 2011; van Krevelen & Poelman, 2010) trace the earliest vestiges of A.R. as far back as the late 1960s, when the first ever head-mounted display (H.M.D.) was developed at Harvard University. Though a cumbersome piece of machinery so heavy it had to be "suspended from the ceiling," it was the precursor to what is still a vital component in A.R. applications: A head visor. Just like an earlier contraption – a device called *Sensorama*, which took its user on a bicycle ride through Brooklyn, together with the sights, sounds, seat vibrations, and even wind – the Harvard team's apparatus aimed to project a virtual reality environment rather than provide a composite of it and the real world.

The same sources chart the next notable development as coming almost three whole decades later: In the early 1990s Boeing designed software, which furnished virtual overlays of cable positions onto real-world environments. Coincidentally, two of the scientists working on that project – Caudell and Mizell – were the first to use the term “augmented reality.” The U.S. Air Force contemporaneously developed what it termed *Virtual Fixtures*, in which “fixtures” (i.e. instructions) were superimposed on a screen to guide users. A third team, from Columbia University, produced a paper on a prototype named *Knowledge-based Augmented Reality for Maintenance Assistance* (*K.A.R.M.A.*), which was to provide guided instructions on an H.M.D. to users operating a printer as they were using it. (ibid.)

However, the sources conclude, the true revolution came just at the turn of the last century, when in 1999 *ARToolKit* was released as open source, allowing users to capture the real world in video and overlay it with virtual objects and three-dimensional graphics. The first A.R. mobile video game – ARQuake – came out just a year later, even if “mobile” did not quite carry the meaning it does today, necessitating a computer-equipment-laden backpack, gyroscope, H.M.D. and a G.P.S. tracker. (ibid.)

# CHAPTER 3. CURRENT STATUS OVERVIEW AND THESIS FORMULATION

In 2008 augmented reality began reaching the masses, with the release of the first A.R. applications for the burgeoning smartphone market. One of such pioneers was *Wikitude*, which is described by Marimon et al. as employing smartphones' geo-location feature to determine where the user is physically standing and then overlays the user's view through the camera with information downloaded in real time from Wikipedia and Qype (the latter being a European user-generated review service) (Marimon et al., 2010). It is available on the Android, iOS and Symbian platforms, thus covering almost 90% of the global smartphone users (Pepitone, 2012). *Layar* and *Acrossair* are two examples of very similar applications (Marimon et al., 2010).

While the foregoing describes a relatively linear history of A.R., the technology's present status is far more diverse. It is utilized for such disparate purposes as education (Dunleavy et al., 2009; Kaufmann & Csisinko, 2011), science and medicine (Teber et al., 2009), military (Henderson, 2009), industry (Neumann, 1998; Prochazka et al., 2011), commerce (Dubois, 2011; "Simplify the act...", 2012), and entertainment (Miles, 2011). When a technology experiences such a revolution, it is only natural that there should be some fallout expected, and that unforeseen questions and issues should arise. The advent of the Internet – which was merely evolutionary in comparison – evinced dilemmas such as intellectual property, security and privacy concerns, and child protection, all of which are still apparently far from being resolved (Leavitt, 2011; Reichman, 2009; Young & Quan-Haase, 2009).

Moreover, unlike Internet connectivity – which can be achieved with a single device and at a small cost –, many A.R. applications require at a minimum multiple sophisticated and expensive pieces of hardware or add-ons, paid-for software, and a fast and reliable connection (Sziebig, 2009). Being that even in developed countries there is still a prodigious "digital gap" (Cruz-Jesus et al., 2012), it is not incongruous to ponder the practicality and potential adverse repercussions if yet another incarnation of digital technology was to be adopted by a certain section of the global populace but not others.

This Paper, therefore, will examine augmented reality's current and short-term status from the perspective of technological, commercial, social implications. In particular, it will endeavor to answer the following questions:—

1. How will the existing I.C.T. infrastructure be utilized for A.R. devices, and might new infrastructure elements be necessary?
2. Given the antecedent, what penetration is A.R. likely to have on a global level, and within what timeframe?
3. Who will benefit from A.R. and how?
4. Who could be the losers of a quick A.R. adoption by users, why, and how to preempt it?
5. What legal and ethical problems could A.R. entail?
6. How might the problems identified in #5 be resolved or at least mitigated?
7. What are the most prominent likely uses of A.R. in the first instance?
8. How viable are A.R. applications in the short- and medium-term, and what are their alternatives?

The work will rely on secondary sources rather than empirical data. Given the nature of the topic, where information changes rapidly and even data from a year ago border on obsolete, popular literature will perforce constitute a considerable portion of the sources. That is difficult to avoid; however, extra care will be taken to ensure the reliability and authority of such information.

# CHAPTER 4. FUNDAMENTALS OF AUGMENTED REALITY

Augmented reality is a co-located, synthetic protocol (Haller et al., 2006). The "co-located" part means that – unlike in virtual reality, where the user and the environment can be physically separated by any distance, and, indeed, the environment projected to the user need not even be real – in A.R. the user has to be physically present at the location to which the A.R.-supplied data pertain. In other words, for the "augmented" information about an object to be made available to the user, the user has to be looking at that object in real time. "Synthetic" is somewhat of a misnomer, however: Though in V.R. the entire visual image is synthetized, in A.R. only the supplementary information is, whereas the environment itself remains natural.

Accordingly, for an A.R. apparatus to work, two requirements must be met: (1) The user has to be present at the location for which additional data are sought, and (2) the data have to be retrieved and presented to the user accurately with regard to the location in question. Satisfying the first requirement is contingent on the user: He or she moves to the desired position on their own initiative. The technology is supposed to address the second requirement, to wit, determine exactly what the user is espying at any given time, and relay the appropriate data. Since the data have to be apposite to the object being viewed and since people naturally move their heads continually and sometimes fast, this, then, raises the following two issues: (1) How can an A.R. device ascertain with reasonable accuracy what object the user is surveying, and (2) how can it ensure that the data are updated quickly enough to account for the user's variance of viewpoint?

## 4.1 Classification of augmented reality

The antecedent points will be addressed in turn, but before they are, it is necessary to distinguish between two A.R. standards or usage modes. For the purposes of this work, they will be termed *controlled-environment A.R.* and *free-environment A.R.* Both are *location-dependent*, to be distinguished from *location-independent* scenarios, which are not the focus of this Paper. The latter include largely entertainment applications, such as games, of which there are increasingly many (*v*. Hendricks, 2012 or Nuñal, 2012 for some examples). For instance, in the *AR Soccer* game a user points an A.R.-enabled device's camera at his/her feet, a virtual soccer ball is materialized in the vicinity, and the user kicks it; that can be done anywhere and is, as such, not location-dependent. It should be noted that some games indeed are location-dependent (such as treasure hunts), and those are subsumed in the said free-environment A.R. category, albeit cautiously being that the necessity for real-time sensitivity and localization precision in such contexts can be deemed to be lesser than in the more serious circumstances such as will be exemplified shortly.

### 4.1.1 Controlled-environment augmented reality

Controlled environment A.R. involves situations in which A.R. is used on a routine, regular basis, such as the Boeing engineers of old, surgeons in an operating theater, or visitors to a museum (Lamata et al., 2010; Wojciechowski, 2004). In these cases, the selection of objects, angles from which they are observed, the users' position, etc. are all relatively limited and predictable. So are, importantly, the quality and quantity of the data used as overlays on the surrounding objects while an A.R. device is in operation. To illustrate: A visitor to a museum using an A.R. device to acquire additional information on the exhibits only uses that device to view the *objets d'art* within the confines of that museum. He/she moves through the museum slowly while appreciating the art pieces. The amount of data is, therefore, comparatively small, which means it can be stored, retrieved and updated easily. Determining the user's exact position is also comparatively simple, as will be shown later.

As narrated *supra*, the technology involved in controlled-environment A.R. contexts has been extant for several decades. A.R. data are typically relayed via a head-mounted display, handheld display, or spatial display (Carmigniani, 2011). Early applications required the user to be stationary and the viewpoint was severely restricted, but later on freer movement became possible, although this required a way for the user to be tracked and accurately localized. Various localization technologies have been developed for this purpose, including infrared, R.F.I.D. (Zhang et al.), and ultra-wide-band sensors (Klopschitz, 2010). More recently, with the advent of wireless networking and digital cameras, image-based localization standards were developed, whereby a camera's image is wirelessly relayed to a server and compared against its database records to identify what the user is looking at (Wagner & Barakonyi, 2003). This, naturally, requires extensive site preparation, not least hardwiring the localization sensors (if used) and maintaining the database.

Though the A.R. data are usually transmitted wirelessly from a server, technologically there is nothing to prevent the provider from storing the data in the A.R. apparatus itself: With ultra-high density memory it is possible to store gigabytes of data into a space of a fraction of an inch squared. Rather than depending on a possibly unreliable wireless connection for data relay (Lo et al., 2010), whose quality and costs are also impacted by the number of simultaneous users (especially if the A.R. experience involves streaming audio and video), overlay information could be tapped into instantly from the memory on the A.R. device itself. If used at all, the wireless link would only be used for localization purposes. Such an approach entails an obstacle though: Updating the information requires updating each device individually and manually – unless they contain even just rudimentary firmware, which carries costs implications – rather than merely changing the relevant entry once in the central database.

Further, the above is applicable largely to an indoor environment. Outdoor sites, even if limited in terms of area, present much more of a logistical challenge. For one, it is much more difficult – if not impossible – to install sensors, chip readers or wireless emitters, which would be exposed to the elements. Depending on the location, a wireless network of the Wi-Fi type might not even be possible. An article provides an interesting overview of how even remote archeological locales can indeed be made A.R.-ready. The model involves reliance on G.P.S. and D.G.P.S. for localization, a self-contained Wi-Fi system (together with self-powering access points), and at least one site information server boasting the object content data. A.R. data are made available for the most salient points of interest, and then only from specific viewing angles, and these points are envisioned to be followed in a particular sequence. Information is given through hand-held devices. Given that the area in question is only about 250 sq.m, questions might legitimately be raised about the viability of such a setup for larger places (Vlahakis et al., 2002).

### 4.1.2 Free-environment augmented reality

By contrast, free-environment A.R. are all other situations, particularly the archetypal example of members of the public randomly strolling through cities or countryside, best exemplified in the illustrious *Terminator* movie (figure 1). There are countless objects that may arouse interest; it is difficult to predict the angle from which those will be viewed or the order in which they will be encountered; it is likely that the objects will be observed with less attention and hence the viewpoint will change more quickly and frequently, etc. Vlahakis et al. call this "real-time applications," and are quick to note the "abrupt and unpredictable motion" associated with them (ibid.). Lo et al. (ibid.) enumerate the challenges encountered by the prospect of making even small indoor locations A.R.-ready; it is not a stretch to imagine doing the same for entire cities, countries, and continents being exponentially more difficult.


Figure 1: A scene from the movie *Terminator* epitomizing free-environment A.R.

# CHAPTER 5. ISSUES IN FREE-ENVIRONMENT A.R. APPLICATIONS

At this stage it is appropriate to address the questions posed *ante*, regarding correctly identifying the object viewed, and relaying the required data to the user quickly enough.

## 5.1 Locationing

Doing the former can be done in two ways: Using technology such as satellites or cellular towers to verify the user's location. The Global Positioning System (as well as its Russian alternative: the GLONASS) is accurate to 10 meters at best although usually closer to 30m or more (Ben Abdesslem, 2009), which may not be good enough in a tightly-packed urban environment. The Wide Area Augmentation System improves that accuracy to around four meters (van Krevelen & Poelman, 2010). Differential G.P.S. enhances the margin to within three meters (Chiang, 2009), but requires stations *à la* cell towers to be installed at frequent intervals; as it would entail establishing an entirely new infrastructure, it cannot but be discounted as a feasible alternative. Using cellular towers for localization is even less reliable, particularly in rural and remote locales, as comprehensively demonstrated by Yang et al. (2010), with a margin of error as high as an astounding 600 meters (Zandbergen, 2009). A source mentions "WiFi triangulation, Bluetooth vicinity, [and] audio-visual sensing" as additional localization methods used by handheld devices but dismiss these as impractical and hence only of ancillary benefit (Lin et al., 2010). The G.P.S. method, therefore, purports to be the best of the available options, and there are indications it will be further improved, with its accuracy narrowed down to less than a meter (Schmidt, 2011). There remains, however, the issue of unreliable G.P.S. reception in areas with tall buildings as well as inside edifices such as shopping malls (Kjærgaard et al., 2010).

Another problem arises, however: Which way the user is facing. Many smartphones are equipped with a compass (though other handheld devices may not be), but these require occasional recalibration (Grothaus, 2011). The user's orientation is also yet another datum required to be transmitted in order to track him/her correctly. Theoretically, therefore, the process would unfold thus: The user requests A.R. data from an apparatus, the latter requests its exact location from a locationing system and waits for a response, it takes the response and relays both it and its compass reading to an information server, it waits for the server to transmit whatever information it may store for that particular viewpoint (*v.* figure 2).

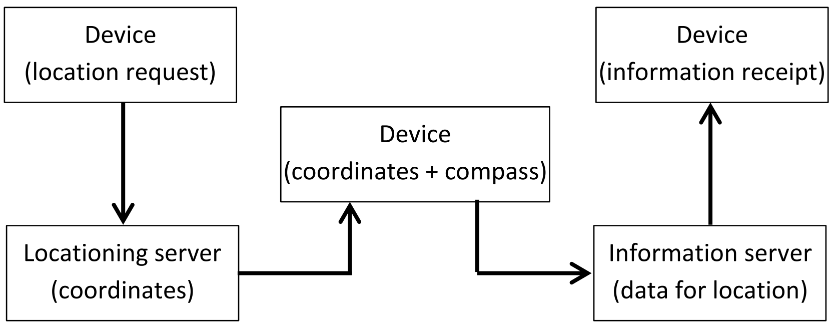


Figure 2: Process of ascertaining user's precise location and orientation in order to to retrieve pertinent information

If the locationing and information servers were to be integrated, the process could be simplified:

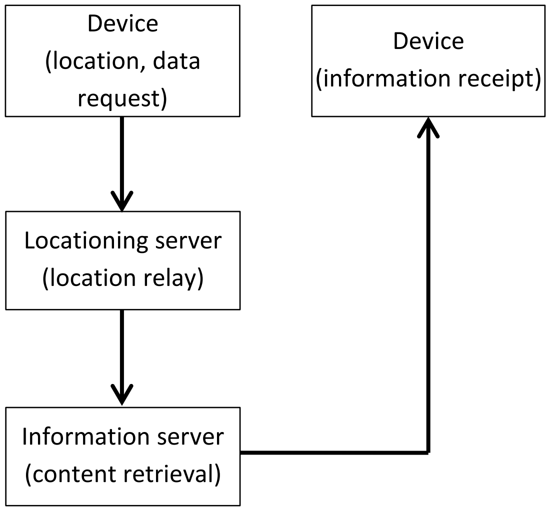


Figure 3: Simpler process of information retrieval if request is sent simultaneously with location data

It is not difficult to recognize multiple potential failure points and weak links in such a system. Firstly, even with the fastest of networks (on which more later), it is a protracted process, which requires the user to be stationary the entire time, and which hence rather negatives the notion of real-time A.R. Secondly, all these data transmissions are onerous on the device's battery capacity (Lin et al., 2010). Thirdly, G.P.S. is as inaccurate with elevation as it is with 2D plane location, with a margin of error of ca. 15m (Mukherjee et al., 2013): What happens if the user is not at street-level?

Another technique is the aforementioned image-based localization (Mulloni & Drummond, 2010). This is preferable for a number of reasons: It eliminates the location accuracy problem, it leaves no doubt as to the user's perspective, and it requires only two data transmissions, namely, the image being viewed sent to the server, and the server responding with any data it may hold for that locale. There is, however, a trade-off: An image is much more voluminous data-wise than a set of coordinates. So, the opportunity cost of not having to communicate with satellites or cell towers is having to transmit a data-intensive image instead. Moreover, once the image is transmitted, there is a delay while it is compared to the images in the database until a match is found. In a developed urban environment, there are likely to be millions of images; even the most modern computers serving a single user would evidence major delays returning the result. Taking into account the fact that such an environment will likely have many contemporaneous users as well as the possibility that, once matched, there might not actually be any A.R. information for that location anyway, there can be little doubt that relying solely on image-based localization would be impossible.

A hybrid system, therefore, is the most preferred answer: Client-side use of satellites and/or cell towers for general and server-side object-recognition for the exact localization purposes (Gammeter, 2010).

## 5.2 Connection standards

In figures 2 and 3, each arrow represents a point where a network has to be utilized to relay information. Each arrow also has to be relied on to communicate information dependably and expeditiously. Each arrow, therefore, is a potential vulnerability. Even if the transmitted data are merely textual, there is some delay, but if multimedia data are streamed over the network, too, it raises the problem of speed as well as network congestion. What networking standards exist already, which can lend themselves to A.R. applications? The qualification in that question is of considerable import: Though Bluetooth and W.P.A.Ns provide good rates of data transfer, they are impractical for free-environment A.R. (Papagiannakis et al., 2008). To be otherwise, a connectivity standard has to be widely available, affordable, and reliable. It must accept data download as well as upload (which, incidentally, excludes television and radio signals, too).

### 5.2.1 Satellites

There are several possibilities, beginning with satellites. While they would be ideal from the point of view of truly global availability, they suffer from an unacceptably high latency for a real-time application of at least 0.25 seconds propagation delay each way (Davern et al., 2012; Glover & Allman, 1999), which – alongside their considerably higher cost when compared to Internet or cell telephony standards (Allen, N.D.) – means that they are perforce discounted.

### 5.2.2 WiMax

Another potential contender is WiMax: It operates on a system of transmitter towers – similar to cell towers – with each providing coverage across a staggering 30 sq. mi. (Faust & Hafner, 2011). Its biggest limitation at the moment is a sorely undeveloped infrastructure: Even in the United States, its availability is severely restricted to a smattering of highly urbanized areas ("Check coverage," N.D.) and the situation in the rest of the world is even worse ("List of deployed...," 2012).

### 5.2.3 Wide Local Area Networks

W.L.A.Ns benefit from high data transfer rates but an access point only provides coverage of up to a 100-meter radius. Although an increasing number of cities are planning to cover their territories with W.L.A.N. access (Glans, 2012; Kharif, N.D.), municipal WiFi has been described as a "flop" (Wu, 2007) and shows much less promise than WiMax.

### 5.2.4 Cellular networks

The choice is, then, perforce that offered by cellular network providers: Cell networks are the only standard that has developed enough an infrastructure to furnish universally wide coverage. Papagiannakis et al. provide a solid overview of Wireless Wide Area Networks based on cell telecommunications and conclude that only the 3G incarnation of cell telephony (and, naturally, its successor: 4G L.T.E.) theoretically boast the speed and reliability necessary for free environment A.R. applications (ibid.). The 3G standard supports a maximum throughput of 384 kb/s, while its improved iteration (H.S.D.P.A.) enhances that tenfold to as high as 14.4 Mb/s ("3G/UMTS evolution...," 2006). 4G L.T.E. claims to offer throughput rates of up to 1 Gb/s. Those, however, are very much theoretical speeds. In the very few parts of the world where 4G has been activated, users report far lower speeds than those aforesaid: between 4.46 and 19.37 Mb/s in London, England (Cellan-Jones, 2012) and between 2.81 and 9.12 in America (Sullivan, 2012). Those are downlink values; upload speeds are between 10% and 75% of their download counterparts', with about half being the most typical. That is not necessarily cause for concern, because an upstream allowing a 2 Mb/s transfer, and even a downstream with the same value can be deemed sufficient for free-environment A.R. purposes, insofar as these require transfer of simple pictorial and textual information. Empirical data for latency, too, seem propitious at around 100 msec. in the United States ("We test AT&T...," 2012).

Though encouraging, these figures neglect to factor in an exceedingly important element, which is congestion. According to an analysis, the impetus for upgrading the cell infrastructure to the 4G standard was given by the proliferation of smartphones, the iPhone in particular. This type of devices requires constant transfer of data and, even if those data are individually not too onerous, the sheer number of users was beginning to seriously impair the quality of the extant networks (Fleishman, 2010). 4G is going to address that obstacle. However, as even more people acquire devices such as smartphones and tablets, and if augmented reality applications do get embraced by a mass audience, it is not at all a stretch to imagine the 4G standard being rendered inadequate in the foreseeable future as well. Furthermore, even if the network infrastructure is able to withstand the ever-increasing appetite for data consumption, this is unlikely to come cheaply. All the cellular carriers in the U.S. impose some form of data limits ("caps") on their users (Metz, 2011; Ramon, 2012), which serve to actively discourage users from employing their handheld devices precisely for the types of activity for which 4G was designed and rolled out in the first place (Weinberg, 2011)!

Moreover, cellular networks are not necessarily reliable. Almost two decades after mass-adoption of mobile devices, between a third and a half of cell phone users even in the U.S. still experience dropped calls and slow Internet speeds (Ahonen, 2011; Yates, 2012).

In more developed areas, a study suggests that utilizing multiple networking protocols (e.g. WiFi, cellular, and WiMax) would provide for a seamless connectivity (Yap et al., 2012), but this ignores the fact that most such options – or even all of them – are simply not even available in less developed locales. That may not be much of a problem though, because users will typically be more desirous of information in densely-populated as opposed to isolated areas for which there might not be much location-specific data anyway.

## 5.3 Energy supply

Of more concern is the impact of utilizing multiple connectivity protocols on devices' battery life. Smartphones and tablets have multiple applications running in the background, many of which continuously communicate with the network, downloading and uploading updates and information. While these are mostly exiguous stock market, weather, or short textual message updates, A.R. applications traffic is more frequent and more voluminous, having a deleterious effect on the longevity of a battery charge (Grubert et al., 2011).

Google's current prototypes house the battery in the frame of the spectacles, or more precisely, at the back of one of their arms (LaMonica, 2012). It is surmised to provide up to six hours of use (Gannes, 2012; Smith, 2012), but there is no indication whether that time refers to stand-by or entails some degree of usage. Even if the six hours refers to continuous use, that would be grossly insufficient for most touristic activities or day-trips. Battery technology as it stands today – and their dangers, *q.v.* a disturbing incidence of exploding batteries (Demerjian, 2004; Torralba, 2012; and a cursory search through news reports) – cannot cope with a day-long continuous streaming of data over a network. There are two possible remedies. The first is inductive wireless energy charging. Although it would certainly solve the problem of users running out of battery power midway through their A.R.-enhanced perambulation and, more generally, a world finally devoid of electric cables is an exciting concept, it has to be noted that technology is still very much in the earliest incipient stages ("Imagine a future...," N.D.; Wei et al., 2009; Yang et al., 2011), and viable at very short distances only (RamRakhyani & Lazzi, 2012).

The second possibility are portable, personal solar recharge packs. Currently such packs are either risibly large (several times the size of the Glass) and hence totally impractical for the purpose (Heimbuch, 2012) or take a long time to produce only a very modest charge (e.g. "Portable Petal-like Universal...," N.D.). More promising is the idea of solar panels of sorts being interwoven in people's apparel (Quick, 2010, or – for more stylish alternatives – Jolly, 2012). With solar panels becoming smaller, less conspicuous, and more effective (James, 2012), it is this technology that will likely supplant or at least complement electrical chargers in the medium-term, including for the purposes of wearable A.R. devices.

## 5.4 Technology penetration

For argument's sake, be it assumed that the technological hurdles can be obviated or completely overcome. Thus, users with handheld devices are roaming around city sites, countryside ruins, looking for good restaurants among a choice of dozens or checking out reviews of a village bed and breakfast. Their device uses its G.P.S. capability to determine their approximate location, and then sends the camera image to a system information server to match their exact location and viewpoint, which responds with the available data about the object observed, all via a 3G or 4G cellular connection. Though the experience is unlikely to be comparable to the *Terminator*-style real-time detailed data retrieval, current and future technology theoretically enables such an endeavor to be achieved satisfactorily. It does make several presuppositions though, which are the wide availability and utilization of (1) handheld devices equipped with the G.P.S. and cellular technologies, and (2) 3G or faster cellular networks. Both of these assumptions may be quite fanciful and diverge from the reality to a considerable degree.

### 5.4.1 Smartphone representation

Much has been written about the so-called “digital divide” or “digital gap,” i.e. the separation in terms of communication standards, access to services, commercial parameters, etc. between those who have embraced modern technology wholeheartedly, and those who have not (Belanger & Carter, 2009; Goldfarb & Prince, 2007; Jackson et al., 2008). In particular, older people and minorities (the latter generally by virtue of weaker purchasing power) tend to lag behind the younger and the wealthier social strata (Vicente & Lopez, 2011). A comprehensive and instructive study by Pew Internet (under the auspices of the renowned Pew Research Center), revealed information that can only prove sobering to anyone garnering hopes of an interconnected world liberally exchanging knowledge and ideas, let alone embracing advanced technology such as augmented reality. For instance: Even though it determined that more than 88% of Americans owned a mobile device in 2011, that figure was barely two thirds in the case of the over-65-year-olds. Far more stunning is the revelation that fewer than half of mobile device owners actually had a smartphone (46% against 41% of those who had a “lesser” type of cell phone). As one might have expected, those middle-aged and older had the lowest adoption rate: On average, about a fifth of those above 47 years of age owned a smartphone. Even among Generation X’ers (35-46 years old), smartphone ownership stood at 53% (Rainie, 2012). Singapore is the world’s leader in smartphone ownership, at 90% of its population, but the rates for the rest are much lower, with even the runner-up, Hong Kong, at only 61%. With the exception of Sweden (52%), for all other surveyed countries the figure is below 50%. The U.S. is in the 16th place in this regard, at 35%. Australia fares better at 47% (Ahonen, 2011).

Rainie of Pew Internet also found that among smartphone owners (so, around 40% of Americans), in early 2012, 74% used their device to access location-based information services, of which free-environment A.R. applications are a type. That is an increase of 37% on less than a year before, demonstrating that there is considerable demand for services of this nature. More than half used their device to obtain information about a destination they were visiting or an event they were attending. A fourth of them employed their device to avail of reviews about a product they were in the process of purchasing in a physical store (ibid.).

The research data can be viewed as encouraging: Adoption of smartphone and similar devices is increasing, and a fair number of those consumers utilize their device to engage in activities that would fit in well with A.R. applications. However, this ignores those on the outside of that group. Between 2011 and 2012 the rate of smartphone owners increased by less than 30% and is still below 50% of all mobile device owners. Considering the fact that smartphones have been available for the best part of the past decade, that is curious. The rest will eventually acquire a smartphone or similar, too, but – just as a considerable proportion of current smartphone owners – they are unlikely to start using more advanced features such as A.R. in the short- or medium-term. Accordingly, there is a real risk here that, if the A.R. technology is popularized too quickly, a sizeable portion of the American and global citizenry will be left excluded. When the television was invented, those without it could gather at a neighbor's house and partake in the experience. Those without a personal computer were able to access both it and the Internet at their school, workplace, public library, etc. With the smartphone being a personal, customized accessory, one either has it or one does not, and the latter are not able to vicariously enjoy the benefits of owning one. As will be shown later, free-environment A.R. can yield a multiplicity of benefits and advantages: Access to knowledge, commerce, and culture. The ramification of a significantly large portion of the society being excluded from such opportunities could well lead to their alienation and disenfranchisement, and considering they tend to be the most vulnerable sectors of the society as it is, such a scenario is doubly worrisome.

### 5.4.2 Global-level disparity

The digital divide covered in the previous section is not an issue at national levels only. There is prodigious difference between the Western and Third Worlds in this respect. Internet penetration in general in places like Africa is documented to be low, with great disparities on national and interstate levels (Fuchs & Horak, 2008). Though approximately 65% of Africans own a mobile device, only 15% of them are forecast to have a smartphone through 2014, and barely 40% by 2017 (Evans, 2012). In China and India – two of the world's most populous countries – only 6% and 3% respectively of the population owns a smartphone. The rest of the eponymous B.R.I.C. states do not fare much better: Brazil is 14% and Russia at 18% (Ahonen, 2011).

One may ascribe such dismal figures to the high cost of smartphones and tablets. However, even if the devices themselves were cheaper, the developing world's populations could ill-afford subscriptions to cellular data plans, without which no features other than voice and text messaging can be employed (Fatokun, 2011; Kochi, 2012). Some inroads have been made in addressing this issue, however: The Chinese electronics manufacturer Huawei and Microsoft are reported to have partnered to release a smartphone customized for the African market, including in terms of third-party applications available for the device. Not only will the *4Afrika* phone be inexpensive; it will also be more relevant to African consumers with content build by members of the local population. The partners' aim is not merely to penetrate the scarcely-tapped African market, but also to promote Africa's "overall economic development and competitiveness" ("Windows and Huawei...," 2013).

Even if both smartphones and data plans were more affordable, and hence more rapidly adopted in the developing world, what cellular infrastructure would they be able to use? A world coverage map shows large swaths of Asia and the entirety of Africa still relying on 3G or even slower G.S.M. standards ("4G LTE world...," 2012 – figure 4). Moreover, even where more advanced cellular networks exist, few users subscribe to them. For instance, in China, which has 3G infrastructure, fewer than 20% of subscribers use the 3G network (Kwang, 2012). The rate in India is a paltry 2% (Prasad, 2012).

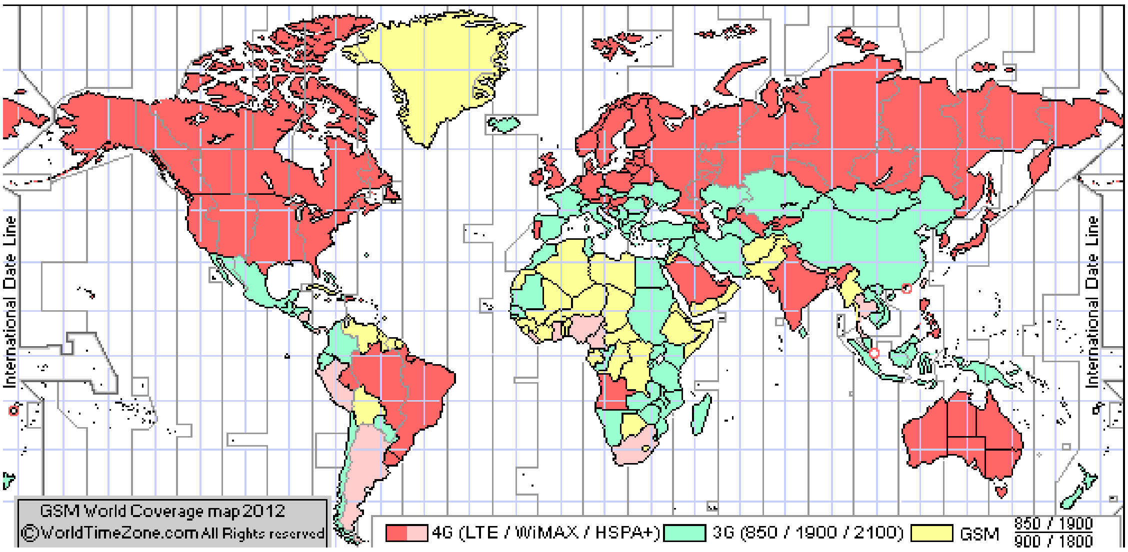

Figure 4: Map showing prevalence of cellular technologies

There is thus evidently a veritable chasm both globally and locally between those with access to the technology necessary to utilize A.R. applications and those without it. That is not, at this juncture, necessarily as calamitous as the stark economic inequalities or a total inability to access the wealth and breadth of the Internet, but – depending on how A.R. applications develop and evolve –, it may deprive masses of already-vulnerable individuals of a valuable tool, particularly in the context of controlled-environment A.R. for education, scientific and similar purposes.

## 5.5 User experience to date

From the antecedent it is clear that quite a few hurdles are yet to be overcome before free-environment A.R. can be used by the mass audience. As mentioned previously, some progress has been made developing real-time, location-dependent free-environment A.R. programs (or "apps"), of which probably the most illustrious example is *Wikitude*. An article describes this app, available on all major smartphone platforms, as using the localization technology described *supra* to determine the user's position and annotate the nearby landscape. It does that by drawing on publicly-available data drawn from Wikipedia or Panoramio. The user can then elect to download additional information about specific points of interest or "P.O.Is." That information is retrieved from various existing databases, which are often created, updated, and improved by users, i.e. the general public, and which are usually not connected to one another, so that information about nearby restaurants is gleaned from a different database than information about local transportation options (Schall et al., 2011). *Layar* is another relatively popular A.R. browser app. Combined, Wikitude and Layar boast a user base of around four million, of whom up to a half are active on a monthly basis ("Augmented reality...," 2011).

Those figures are on the one hand not impressive; on the other hand, they indicate that augmented reality is still very much in its infancy and its shortcomings, both forthcoming and those adverted to already, can be resolved without alienating unhappy users later. That is important: This author's experience with Wikitude has been less than salutary. Its interface is somewhat unimpressive but, more importantly, the quality and quantity of the information available is parsimonious and underwhelming, to phrase it charitably. As a result, after a handful of instances using Wikitude in several different locales, the author never deployed the app again. Users without technological nous may well let such an experience sour their entire perception of A.R., causing them to uninstall the app and never try it again.

## 5.6 Augmented reality data

This last notion conveniently segues into this work's next question. Apart from the issues of geolocation accuracy, speed of data retrieval, and A.R.-equipped device penetration, there is another, which is arguably even more important: The availability, currency, and accuracy of the data themselves. An article describes a hypothetical scenario of A.R. use, which is worth quoting in full—

"Anthony tells his mobile device: 'I'm hungry and only got 20 bucks – find me something to eat, not far away'. The mobile device, equipped with an advanced AR browser, shows three matches in a 500m radius, overlaid on the image the device's camera captures. A local Indian restaurant is prioritised above others by the browser which has built up a profile of Anthony's favourite cuisines after previous searches. However today Anthony is feeling adventurous and decides against the restaurant which was highlighted. He asks the AR browser: 'anything around my friends would recommend?'. The device pulls in restaurant reviews from Anthony's contacts and comes up with a new proposal: a nice Vietnamese restaurant, some 5min away. Anthony walks down the road, holding the device towards the restaurant. He remembers that recently there were some hygienic issues reported regarding some restaurants, downtown. Just to make sure he asks his device: ‘anything to worry about here?’. The AR browser queries Public Sector Information provided by the town and the state and reports back to Anthony. The device shows two restaurants in the same street that had been shut down last week due to health inspection, but not the Vietnamese restaurant Anthony fancied. Now, Anthony is happy and relieved and has a decent meal there.” (Reynolds et al., 2010)

The process described is much more involved than the archetypal *Terminator*-style free roaming with any and all available information being directly streamed onto a user’s viewscreen. As an aside, the closest that has been gotten to such an implementation is Project Glass by Google, although even more advanced plans are afoot, such as those to embed an A.R.-capable device in contact lenses (Crum, 2012). These and others (both Microsoft and Apple have filed patents for A.R. technology (Pemberton, 2012; Oremus, 2012)) are at best in prototype stages, of which Google’s Glass is at the most advanced level and is projected to begin retailing sometime in 2014 with a price tag of more than $1,000 (Fitzgerald, 2012). These notions will be covered later.

Returning to the hypothetical scenario, for it to be feasible, data about those restaurants have to be readily available. This raises a number of issues, namely:—

1. How detailed information about restaurants there is, viz, does it include merely their names and contact details, or is there anything additional, such as reviews, images of the interior, menus, etc.
2. How is such information sourced; how objective and trustworthy is it (particularly the reviews)?

3. How representative and comprehensive are the data: Are all the eateries in the area represented or only those that, for whatever reason, are present in the database?
4. How current and accurate is the information?

These questions are not autonomous and overlap to some extent. They can be distilled to two points: (1) How do data enter a database on a system information server, and (2) what mechanisms are there to maintain the integrity and currency of those data?

### 5.6.1 Content representation in databases

Research suggests that there are two principal ways for information to become part of databases for use in A.R. applications: extant databases such as Wikipedia or booking.com, and user-generated information (Hardt, 2011). The leading A.R. browsers also provide A.P.I. tools whereby third-party developers can plug their information into the app, but there are no statistics available to suggest to what extent this has hitherto been utilized.

#### 5.6.1.1 Existing databases

The problems with such approaches are obvious: The information may be incomplete, skewed, and subjective. For instance, both price-comparison and aggregator websites omit certain airlines, auto-insurance providers, or energy companies – whether by design or inadvertently – causing users to not even consider them and thus be deprived of getting all the required data to make an informed decision (Eliasson, 2009; "Future comparisons...," 2009; Norling & Lee, 2004; Wall, 2012). There is no reason to believe the case with eateries or accommodations providers is not similar (Schaal, 2012). This presupposes that the omissions are predicated on technical problems or insufficiently alacritous updating of the information; however, outright skullduggery may play a part, too (Rutt, 2011), as these websites may well enter into agreements with providers in return for monetary compensation, in which case they will have a motive to promote one provider over another (Lipman, 2012).

Further, many such websites operate on an opt-in basis (Ghaffar, N.D.), placing the onus on the provider to get itself listed. Not all businesses, particularly the smaller ones, possess sufficient knowledge and technical expertise to be able to do that. The smaller and/or less developed the community, the more doubtful anyone but the biggest providers (such as e.g. hotel chains) will be represented. For instance, bookings.com shows only two hotels in the town of Safi (Morocco), one of which is a major international chain and the other a family guesthouse. On the author's visit several years ago, at least five medium-sized hotels and inns were observed in a single neighborhood, none of which is represented on bookings.com. Looking for accommodations in Liverpool, England, though more than sixty hotels and providers are listed, none of the three small B&Bs at which the author stayed on separate occasions are represented. This, admittedly anecdotal and very limited, evidence indicates that the databases used by the pioneering A.R. applications to furnish information to users are grossly lacking as far as completeness.

Even the information that does exist is subject to suspicion. For instance, users who post reviews and ratings to websites such as *TripAdvisor* have been found to have a greater propensity to post negative than positive reviews (Trigg, 2012). Reviews may also be fraudulent and malicious, posted by a business's competitor as opposed to a *bona fide* user (Raphael, 2011) with a view to damaging the competition, or bogus positive reviews can be made by a business owner or aficionado, keen to enhance its reputation (Keates, 2007). Indeed, TripAdvisor has been taken to court by hoteliers who incurred losses resultant from poor reviews ("Hotels prepare to do battle...," 2010) and Amazon has been lambasted due to fake positive reviews by the works' authors having been found to have been made on its website (Charman-Anderson, 2012). Even advertisements for part-time false review writers on Amazon have been uncovered (Cochran, 2009). As it would be next to impossible for such websites to ensure that their users' reviews are objective and genuine, they have instead resigned themselves to defeat. TripAdvisor, for instance, has changed its motto from "reviews you can trust" to "reviews from our community" (Raphael, 2011). Research has concluded that reviews of this type have a strong effect on consumers (Stead, 2012), given which fact it is appropriate to wonder if and how, provided that A.R. "catches on," it will be ensured that the information relayed to users is transparent and trustworthy.

An alternative may be professional reviews, such as those provided by restaurant critics or the equivalent of "mystery shoppers" staying in hotels (Zhang et al., 2010). The most obvious difficulty with this is the sheer impossibility for all the providers to be reviewed initially as well as continually (Akehurst, 2009).

#### 5.6.1.2 User-generated databases

The second way – i.e. other than mining extant databases – for A.R. programs to get data on P.O.Is, is via user-submitted content, also known as "crowd-sourcing" or user-contributed content (U.C.C.) (Coffin, 2011; Mashhadi et al., N.D.). Wikipedia is probably the most famous collaborative project of this type, and notwithstanding high-profile instances of scurrilous and incorrect edits to its entries ("10 Most Notorious...," N.D.), it has been repeatedly adjudged as a remarkably accurate and comprehensive resource (Hsu, 2009; Rosen, 2012; Terdiman, 2005). In a study of the accuracy of the crowd-sourced OpenStreetMap project, Mashhadi et al. conclude that accuracy was high, which owed to the presence and efforts of "consistently conscientious editors" who make the majority of the contributors (ibid.). Wikitude has been criticized for not enabling "support for tailored content authoring by nonsoftware developers" (Chapman et al., 2009). On the other hand, even a cursory survey of sources such as *Wikimapia* – which is a user-generated, open-source project where users edit Google Maps by delineating and annotating sites of their choosing – shows that the data available so far are sparse in some locales (Armidale itself being an example) and that quite a number of entries (e.g. "Rajan Menon's residence" – Mr. Menon not being a celebrity but a regular user, member of the public) are simply frivolous (figure 5).

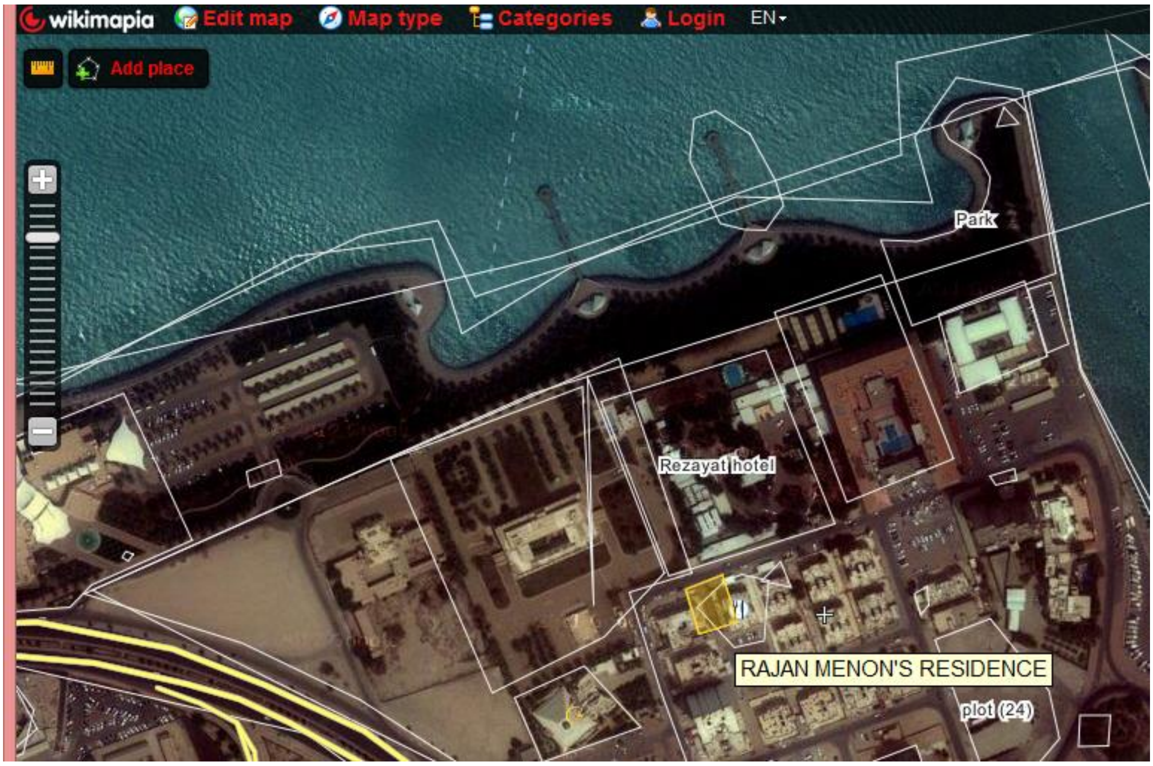


Figure 5: Example of irrelevant "crowdsourced" content (Wikimapia)
The plot immediately adjacent to that highlighted reads "fanous Restaurant مطعم فانوس الازرق"
and the one next to that "Ayman (Best Mechanic in Kuwait)"

The conclusion is that there does not appear to be a single comprehensive source containing all the information that would be of interest to A.R. developers, viz, transportation, restaurants, accommodations, businesses and commercial entities, civic infrastructure, sites of cultural, touristic and leisure interests, etc. Likewise, neither is there a comprehensive, trustworthy database for each one of the foregoing, which would then – it has been suggested (Reynolds, ibid.) – be integrated into a unitary resource and tapped into by an A.R. application.

#### 5.6.1.3 Unified database creation

Could there be and, if so, how? The answer would be a yes, albeit a very cautious one. It would be achieved, to borrow terms used in marketing, by *push* and/or *pull*, whereby providers (the categories mentioned in the preceding paragraph) respectively either ask or are asked to join a database, which should also accept submissions from members of the public. The task of compiling such a unified data source is extremely daunting, however. If merely having an Internet presence is an indication of the size of the task, the omens are discouraging: Only 40% of Australian businesses have an online presence ("ABS: Latest statistics," 2011; "The case for...," 2012). That figure for New York City is 60% (Rodriguez, 2012) and likely less for America as a whole (e.g. 40% in Minnesota ("Google: 60 percent...," 2011)), but for England only a third ("UK could be...," 2012). In the rest of the world, the number is likely to be dramatically lower. Therefore, if businesses, for whatever reason, take what might be called a nonchalant view toward establishing themselves online, even by way of a static placeholder website, then it is unrealistic to expect many to take the initiative to "push" themselves onto a database.

Another entity would thus have to seize that initiative and "pull" providers instead. Easily the most famous example of this is Google Maps: Google decided, to put it simply, to go out and take pictures of the planet – together with subsequent annotations –, whether aerial or street-level. This required an immense initial investment, which Google is only now starting to recuperate by charging for the maps' use by high-volume users (Peterson, 2012) and for which it is being roundly castigated on privacy grounds (Constine, 2012). In any event, gleaning data from sources such as Google Maps and Yellow Pages (Yelp); aggregator, booking, and review sites databases; and through general Internet trawling; then amalgamating those with user-submitted content (whether providers' or the public's), just might produce a source of data that is sufficiently extensive, expansive, and detailed for real-time, free-environment A.R. applications. It would inevitably be a constant work-in-progress, as even the above techniques could not conceivably cover everything within a definite period of time, but also because such information is changes frequently: Businesses move, change names, get new area codes assigned, etc.

### 5.6.2 Data reliability

The latter point raises a further issue with this approach: The reliability of such data. Google Maps' cartographic images – i.e. excluding the actual annotations – are between one and three years old (Thomas, 2012). To adduce two examples: The eponymous Pearl Roundabout in the capital of the Kingdom of Bahrain – one of its foremost landmarks –, which was razed by the government in March, 2011, is still shown standing and is charted on Google Maps. The author's apartment building, located in a densely populated, urban area of Kuwait, which was constructed in 2009, is yet shown as a completely empty lot. The antecedent are merely aerial, rather general images.

StreetView, which provides closer, street-level, continual street-by-street pictures, was launched in mid-2007 and received an extensive update in late 2012 (Cooper, 2012). It still, however, does not provide the facility for most parts of the world, including almost entire continents ("In which parts...," N.D.). Even in the best of times, businesses and sites open, close, change their names, locations and contact details, etc. The latest economic downturn in America caused 170,000 businesses to shut down permanently in the space of just two years: 2008-2010 (Thomas, 2012).

It is not a stretch, therefore, to imagine the hypothetical Anthony looking for a restaurant with an A.R.-equipped device to be shown as available restaurants that may no longer be in business and to not be shown some that opened more recently. Alternatively, mistakes and oversights are made due to ignorance or other human error; e.g. Box Hill College Kuwait is on Google Maps labeled as the "Radisson SAS Hotel," even though two are more than 20 miles away from one another. Despite multiple error reports, the first of which in 2010, submitted to Google to correct the error, the site is still mislabeled at the time of writing. One, limited, remedy is the collaboration Google does with third parties: It has partnered with many entities to improve the currency of its data, and even provide real-time updates of e.g. transit data ("Skylands ride partners...," 2012; "York Region Transit...," 2012;).

### 5.6.3 Data uniformity and fairness

Regardless of how comprehensive an eventual agglomerated A.R. database should become, the providers on it will obviously be in competition with each other. As users walk down a street, businesses will want to attract the users' attention and somehow entice them for custom. How that could happen is open to speculation. Providers might furnish extra payment to the database managers to make the overlaid information for their business somehow more prominent on the users' A.R. devices – something akin to a flashing neon sign, perhaps with an additional sound – although users might not respond favorably to such an assault on their senses, especially if they are receiving A.R. data straight to the front of their eyes. Alternatively or additionally, businesses may seek to enhance the quality and quantity of the information the database holds on them. For instance, instead of contenting themselves with having only the name and basic details of their business on the database, they may want to add multimedia content that users can access on demand. Restaurants could provide images of their dishes and ambience, hotels videos of their facilities, etc. They might also make real-time data available to users: A hotel could give information to a passing user about available rooms and their prices or provide special or customized offers to the user. This point will be revisited later in the context of privacy concerns. If these scenarios should materialize, one may begin to question if the proverbial playing field could ever be level. Providing such an enhanced level of marketing and advertising would necessitate considerable additional finances, technological prowess, and manpower. Small and medium-sized enterprises particularly the quixotic "Ma and Pa" stores are far less likely to be able to participate in such an incarnation of the A.R. revolution than established, moneyed conglomerates.

Already, fragmentation represents difficulties to the former types of enterprise. In the past marketing used to mean careful consideration of what type of advertisement to place and where, and how to create an eye-catching store-front. With the advent of the Internet and success of e-commerce, not investing in an Internet site has been tantamount to sounding the death knell for many enterprises (Hayes, 2008). The proliferation of mobile devices now means that even a website *per se* is insufficient, as a website created for a standard personal computer displays and feels very differently on a mobile device. As mobile Internet usage is set to overtake its desktop counterpart as soon as in 2014 ("Infographic: Mobile statistics...," 2011), a business wanting to compete now has to invest into developing a mobile version of its website, barely a few years after producing a standard website. A source explains that doing so is not difficult for well-heeled companies, such as eBay or Facebook; however, for small enterprises it is next to impossible, particularly considering that mobile Internet is not homogenous and an Android O.S. device may require a completely separate development from an iOS device (Mangalindan, 2012).

#### 5.6.4 Implications of substandard A.R. data

To assay to respond to one of the original questions of this work, regarding the possible "losers" of a quick A.R. adoption, the most apparent group would be those providers who lack the finances or sufficient expertise (as well as interest) to enter the arena of A.R. and attempt to compete in it. The second group would be the users and consumers who would depend on incomplete and flawed A.R. data, and miss out on the good providers not included in the database – just as drivers who over-rely on G.P.S. for navigation, at times leading to unsalutary consequences. The last group are users in those parts of the world where the volume of A.R.-ready data is meager: Their purchasing a device such as Google's Glass would invariably lead to disappointment, as strolling down a street in Accra, Karachi, Quito or even Bucharest would yield very little, if any, information on the A.R. overlay. Figure 6 neatly illustrates all the three points above: Is it likely that in downtown New York City there are no eateries other than the four global mega-corporation chain outlets shown?

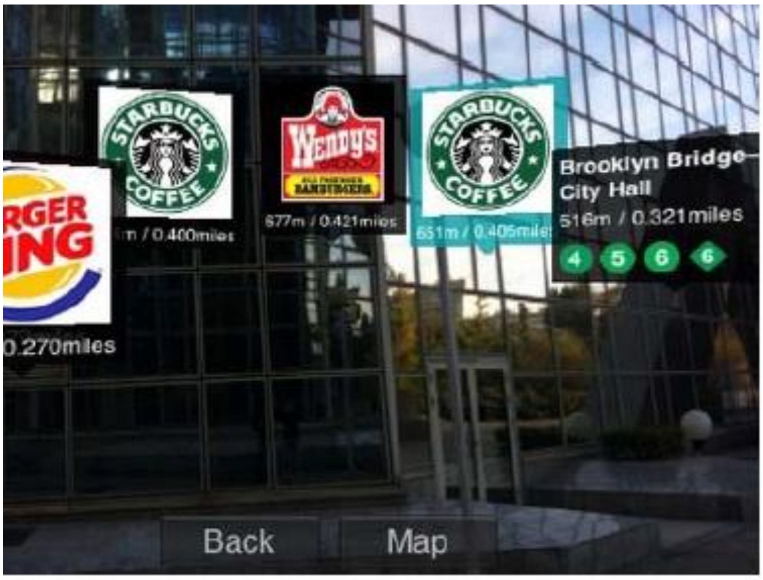


Figure 6: Example of slow uptake of A.R. potential by potential stakeholders:
Money apparently buys prominence

These three groups constitute a sizeable part of the global population; indeed, they are the overwhelming majority in most parts of the world, and the potential for A.R. to "flop" must not be ignored. If companies begin churning out A.R. devices, which sorely underperform on the "augmented" part, the entire free-environment A.R. notion could find itself suffering the fate of 3D television sets whose undoing has been precisely a lack of worthwhile three-dimensional cinematic content (Moses, 2011). Even if motion picture studios took up 3D content development, negative word-of-mouth from disillusioned early adopters would stymie a more widespread acquisition of 3D T.V. sets. The same could happen to A.R.: Users who rush out to purchase Google Glass or an equivalent device and find the content available to be parsimonious, incorrect, incomplete or otherwise unsatisfactory are unlikely to conceal their dissatisfaction and, even if the quality and quantity of information is rapidly improved in the intervening period, further user adoption will be forestalled.

#### 5.6.4.1 Solutions to substandard A.R. data

How to preempt such a scenario? Acquiring, amalgamating, verifying, and standardizing A.R. content has to be concomitant to the development of A.R. hardware and software. Indeed, it should be attributed even more importance because A.R. hardware without the "augmented" information is little more than a camera. The geographical scope and the depth of the data required make collating those data impossible at a grassroots level. Continuous storage alone of all those data would necessitate farms of servers, the cost of which (the hardware, maintenance, power supply, etc.) would be exorbitant. It has to be performed – or at a very minimum overseen and coordinated – by a major player or even a consortium of global companies. It is imperative it be done on free and nonprofit bases so as to thwart favoritism and achieve the creation of a truly representative and thorough data source. Google pioneered this approach with its Maps, Apps, Books, and other free features and utilities; Microsoft had a similar notion with its free Hotmail (now Outlook) service. More recently, Microsoft and Huawei – as part of their *4Afrika* initiative adverted to *ante* – undertook a project to connect and digitally empower remote parts of Kenya (Graham, 2013), which may be a harbinger of further similar initiatives as well as a model for collating and building A.R. data.

In an extreme case, this endeavor could be operated as a loss leader, with a view to gaining profitability later by providing premium services to certain types of user. The main objectives are to be as inclusive and far-reaching as possible, which mandates no (or only nominal) fees charges to service providers, acceptance of user-generated content that is vetted, and a global presence.

This last proviso is not merely incidental: If an entity takes on this type of task, it is likely to focus on those parts of the world where I.T. literacy and electronic device ownership are high, and leave the Third World lagging behind again, which ought to be avoided. It can be justifiably argued that some nations need potable water, regular food sources, and education more than they need augmented reality! However, apart from providing this type of pioneering technology to the neglected parts of the world, an endeavor of this kind could be used to simultaneously promote a technological revolution in the majority parts of the planet where feature phones still rule supreme: If, say, Google made an effort to catalog P.O.Is in Sierra Leone, that might provide an impetus to the government and the users to upgrade their technology altogether, including a reduction in the prices for equipment and data plans, and an improved telecommunications infrastructure. Moreover, "encyclopediazing" this kind of real-world, street-level information about daily human activity would enhance the overall corpus of human knowledge and the manner in which such information is accessed. Doing so would be in almost everyone's interest, which is why governments might like to lend their support, too.

What of the first group of possible losers adverted to above, viz, those entities that, for whatever reason, fail to find themselves included in this proposed database? It is with lament that one cannot but conclude that they will remain excluded, ultimately with probably dire consequences. If they fail to take initiative themselves, fail to respond to "pulls" from the database builders, and even casual users somehow miss them, then little can be done to preclude them from suffering the fate of blacksmiths of old.

### 5.6.5 Data relevance and filtering

Now that the matters of technology and content have been considered, it behooves to examine how they might operate in tandem. Be it supposed that a comprehensive database – or multiple, relational databases – such as that describe *supra* exists. Be it further supposed that the aforementioned Anthony owns a Google's Glass, which is connected to the network (astonishingly the Glass prototype does not boast 3G or 4G connectivity, but only WiFi and Bluetooth (Davies, 2012), so cellular connectivity is expected to be possible only by means of "tethering" (Tsui, 2012)). As he walks down a typical street in a bustling city, he should expect to be bombarded with data. The street boasts numerous stores and other businesses, a few restaurants, maybe a hotel, clubs and theaters, bus stops and subway stations, and perhaps a historical point of interest, all in the space of a single block. All of these would be liable to be overlaid on the Glass, each building's name and address, too. Many of these will have additional data, e.g. reviews, images, or multimedia.

Other than the speed of persistent download of those data, a further matter immediately arises: How will the user eschew a total information overload?

As far as the potential data overload on the user, Google provides an answer in the form of content control. Users will be able to issue commands to their Glass via hand gestures, which – according to the patents Google has filed – operate in tandem with one or more rings and invisible markers on one's hands (Briones, 2012). The Glass might also be controlled by way of tracking eye movements (Nichols, 2012) and head tilts to denote scrolls and clicks equivalents (Kahn, 2012). Though dozens of people wildly gesticulating and waving their arms, vigorously rolling their eyes, and jerking their heads as they stroll down sidewalks would be quite a spectacle, these are innovative methods far superior to, for instance, a separate Bluetooth-connected control device.

This ability of the user to somehow manage the A.R. content on the viewscreen does not, however, necessarily enable him/her to control that content. In other words, the theoretical Anthony *ante* might detest junk food; yet, the system would show him fast food joints just as readily as other eateries. Similarly, Anthony may be using public transportation in the form of a specific bus line to get to work; yet, on approaching his usual bus stop he would receive messages for all the bus routes serving that stop. Put simply, the A.R. content would not be contextualized or customized to the users' needs and interests in any form. Irrelevant, decontextualized content veers into the dangerous territory of borderline spam, and should thus be avoided. Tailoring A.R. content to the users can be achieved in two principal ways: Personalization client-side or server-side (Cingil et al., 2000).

#### 5.6.5.1 Client-side personalization

Client-side personalization is the traditional *Tools => Preferences* type of approach. The onus is on the users to adjust whatever settings are made available to them to achieve an agreeable level of information type and presence. While such a technique works for desktop computer applications and on devices where the main concerns are the size of the text and wallpaper picture, having to tweak options pertaining to many facets of the user's life, interests, and habits might be too cumbersome. One of the main reasons for the popularity of the iPhone has been its putative simplicity, encapsulated in Apple's mantra of "It just works!" (Siegler, 2011). The impatient user of today is not desirous of spending time with interminable settings and instructions, which, incidentally, is why an increasing number of appliances provide barebones “quick start” guides (Mayer, 2003).

#### 5.6.5.2 Server-side personalization

The alternative is server-side personalization, which has actually been practiced for longer than one might imagine. It involves tracking a user’s habit (e.g. search terms) in order to descry his/her likely interests and provide items likely to be of interest to that particular user. A study gives an expose on how search engines have been undertaking that (Teevan et al., 2005). Targeted content has been a fact for a long time. Major websites have been tailoring content to users in different locations by surveying their I.P. address (Anastacio et al., 2010). Google, again, took this to another level when it began mining users’ email content to obtain information to better target ads (Stein, 2011), which entailed a considerable amount of controversy (Bukher, 2011). As G.P.S.-enabled devices witnessed mass popularization, the concept of “geotagging” evolved. Initially, it involved embedding the geographical coordinates (viz, the longitude and latitude) at which a photograph was taken in the image as metadata (Pattison, 2009), although today it encompasses a wider array of applications (Cao et al., 2012), principally “location-based social network[s]”, e.g. FourSquare (“Geotags and Location...,” N.D.). Advertising and geotagging are now being merged in order to provide users with information and advertising relevant to his/her present location (Hristova & O'Hare, 2004). Indeed, “geomarketing” is a rapidly growing branch of marketing, which even influences important strategic investment decisions (Casier et al., 2011; Evans et al., 2012), and which will be revisited shortly.

As far as server-side personalization for A.R. purposes, it would entail heuristics: The device would extensively log its user's movements, habits, tastes, and such in order to construct his/her profile. An A.R. device would thus "know" which of the available data are likely to be of interest of the user. The user's A.R. device would send his/her location to a system information server. The data available thence would be compared against the user's profile and filtered according to his/her preferences, before being superimposed on the device's viewscreen. That way, Anthony – who may have a distaste for fast food but neither does he patronize expensive establishments – would be apprised of the existence of a sandwich restaurant but information about a nearby McDonald's or a five-star gourmet restaurant would be omitted. Furthermore, if the profile shows that Anthony frequents entertainment venues mostly on weekend evenings, then strolling down a street during his lunch break he would not immediately be given information about the clubs and theaters in the vicinity. All the omitted information, however, would not be unavailable to Anthony; he could still access it if he elected to do so. He could flip to a second overlay, which would contain some of the omitted data, or he could switch features on and off in the same way Google Maps permits users to turn on and off street labels or traffic data. Employing this approach would ensure that the user's viewscreen – which is necessarily going to be small and on which "real estate" is hence going to be precious – remains clutter-free, but that all the information server's data pertinent to the user's location would be relayed to the device and available on request.

#### 5.6.5.3 A.R. heuristics technological implications

Contextualizing and customizing the content for users automatically (i.e. server-side) is therefore a significantly better method than forcing them to spend considerable time managing and fine-tuning the settings themselves. However, it gives rise to a number of concerns, technological as well as legal and ethical. From the technology point of view, building such an extensive and detailed profile of each A.R. device user would necessitate further ample server farms to store and relay the data. Even a simple Customer Information File used by a company's loyalty scheme contains hundreds of kilobytes of textual data per customer; such A.R. files detailing, essentially, the users' lives would require a prodigious hardware investment. Moreover, constructing these files would be a protracted process. At least several months of tracking would be necessary to glean even remotely apposite data, as people have different habits in different seasons; they also change jobs, break off old and form new relationships, take up hobbies, etc. It would scarcely be hyperbolic to state that, just as with the databases containing location-specific information, this database comprising users' preferences would also be a perpetual work in progress, commanding considerable financial expenditure with little prospect of a quick return on that investment.

## 5.7 A.R. heuristics legal implications

More importantly, in order to even commence constructing such a database, a user would need to consent to having his/her every move tracked and logged. People profess to be highly privacy-conscious, even if they do not necessarily act that way in every given situation (Spiekermann et al., 2001). Even without doing a specific search, dozens of examples readily come to mind of scandals created by the media when Apple, Google, Facebook, Amazon, and various app manufacturers were discovered to be logging users' movements and harvesting some type of their personal – even if not financially-sensitive – data without their explicit consent. A comprehensive study on the users' psychology discovered that users demand to know who is seeking information on them, for what reason, and what kind of information it is, before deciding whether to disclose that information. Even then only 77% of the respondents consented to divulge the requested information (Consolvo et al., 2005) (wherefore the maelstrom over the *Carrier IQ* case: It was not so much that highly personal data were being surreptitiously collected, but that relatively innocuous data were being collected without the users having been made aware of it (Snyder, 2012)).

If those statistics were projected to the server-side A.R. data personalization, it means roughly a fourth of potential users could end up with A.R. devices that would probably not present them with data relevant to their interests, habits, lifestyle, and needs. Moreover, the said study was done almost a decade ago, and since then there are strong indications that people have become even more privacy-conscious (Epstein, 2012). Irrelevant information inundating the users' viewscreen could be viewed as nothing short of spam, which – just as the data being too parsimonious, adverted to previously – might dissuade potential users from fully embracing or even trying the free-environment A.R. technology.

### 5.7.1 Privacy

What might be done to preempt such a corollary? Faced with continual broadsides for supposedly taking a cavalier attitude toward its users' privacy, Facebook overhauled its privacy settings (Barnes, 2006) to the extent that users can now fine-tune the visibility of every datum they upload or create, which – paradoxically – many now find overwhelming (Choney, 2012; Strater & Lipford, 2008). Google took a different approach: It acknowledged that it harvests massive amounts of data on its users (Velazco, 2012) but its erstwhile C.E.O. stated quite candidly that there is a tradeoff between privacy and functionality ("Google growth yields...," 2005). In other words, on Google's view, consumers have a stark choice: Either relinquish much of their privacy in order to benefit from revolutionary and, crucially, free services, or retain the former and lose the latter. Although California's Attorney General has forced some of the biggest protagonists in the world of technology to subscribe to a new privacy policy, which mandates that they disclose to their users each incidence of their being tracked, the notion that users can retain their anonymity but still avail of personalized content and free utilities can hardly be viewed as realistic. How, then, can a potential A.R. user's mind be put to ease? Most likely by employing both of the said strategies: Inculcating into the users the fact that without sacrificing their privacy they will miss out on an exciting new technology, but also make it clear and simple which aspects of their privacy they will be sacrificing and why.

### 5.7.2 Security

The foregoing though is only one, rather small, part of this section. Users may be uncomfortable with Google collecting their data with(out) their knowledge because doing so is evocative of a "big brother" (Bowater, 2012), but notwithstanding such misgivings, mobile apps continue to gain in popularity (Scott, 2012). The users' primary concern, rather, are their personal data, as these can be misused and abused causing anything from spam to identity theft to burglary (Cavoukian, 2008). A sources recounts how even an innocuous geotagged image caused a security and privacy concern for a television personality (Murphy, 2010), while another describes how such a picture combined with A.R. data could cause one's home to be burglarized ("Do you care...," 2009). The type of server-side personalized data as outlined *supra* would be a very tempting target for any number of miscreants, from petty opportunistic larcenists to organized identity theft felons. Security of the data while being stored as well as being transmitted wirelessly is therefore of paramount importance. Encryption is *sine qua non*, but it comes at the expense of speed of retrieval, which – combined with a network infrastructure in which speed of data transmission is already a concern, as discussed earlier – erects yet another obstacle to the feasibility of *Terminator*-style free-environment A.R. applications.

### 5.7.3 Data ownership

From a purely legal perspective, it behooves to posit the question: To whom would the information in the second database (i.e. the one storing data about the users' habits, etc.) actually belong? Twitter, for example, has been involved in a bitter legal battle over the ownership of tweets, which are user-generated content (Shih, 2012), as has Facebook (Parr, 2009). Google does not lay claim to the data uploaded to its cloud storage utility (Lincoln, 2012), but its new privacy policy appears to state that information gathered about users by way of their search history, etc. is its to retain in perpetuity (Ghitis, 2012)... – or not (Guth, 2012). If the aforesaid database did proceed, then the very least that would be necessary to inspire user confidence would be the ability to opt out of it at a later stage, completely, permanently, and irrevocably. That might assuage some qualms potential users may have regarding the permanence of their relationship with the service provider should they wish to withdraw subsequently.

### 5.7.4 User anonymity

A final thought regarding privacy, and one not often considered. Much has been said about users' privacy being violated by service providers, but what about the users themselves violating each other's privacy? An A.R. device must of a necessity contain a camera and scope exists for its misuse, such as illicit or inadvisable recordings. These days still, in order to make a video recording, one utilizes an easily-recognizable video camera or a mobile device. If the latter, then it is held and maneuvered in such a manner that it is instantly obvious that the user is recording a video. In conservative countries where, for instance, women or the elderly object to being filmed, or in places where image recording is prohibited, anyone making such recordings is instantly recognized and subject to reproach or legal consequences. A wearable A.R. device, particularly once it became so popular as to be almost ubiquitous, could not be readily identified as being passive (i.e. used merely to receive A.R. data) or actively making a recording. That might cause discomfort to either innocent users (who could feel subject to suspicion in certain contexts) or those sensitive to being photographed (as they would always be scanning for a potential violator of their sensitivities).

Furthermore, how long would it be before an entrepreneurial spirit devised an app for an A.R. device, which facilitates facial recognition of individuals encountered on the street? Facebook's example could be instructive: Despite the opprobrium is received on matters of privacy, it had no compunction rolling out a facial recognition facility for photographs uploaded by users, and, critically, doing so without users' consent. Following an outcry it did disable the feature ("Facebook to switch off...," 2012); however, a smaller enterprise, not as susceptible to public pressure, might not be as accommodating.

### 5.7.5 A.R. general potential for misuse

Somewhat disconcertingly, Google recently acquired a facial recognition business (Young, 2011), its second acquisition of the type, in addition to filing patents concerning facial recognition and already providing a facility to match objects (such as buildings) against its image database (Storm, 2011). An article provides a few scenarios, which are worth quoting in full:—

"Obviously, though, the repercussions of a wearable computer that a) knows where you are, and b) what you're looking at, will require a lot more than a blinking red "record" light on the front of the specs. The phrase "tracking cookie" takes on a whole new meaning when Google also correlates your real-world activities with your online presence. Remember, Google is ultimately an advertising company, where eyeballs directly translate into money — and it's hard to get any closer to your eyes than a pair of augmented reality glasses. When you look at a car dealership, Google will be able to display ads from a competitor. When you sit in front of a computer, or TV, or stare through a shop window, the glasses will be able to track your head movements and report back on the efficacy of display ads." (Anthony, 2012)

A recent popular article, only in part meant to be facetious, wonders if A.R. technology might be appropriated by racists seeking to, literally, whitewash their environment by using "reality filters." Far-fetched though as such fears may appear, the piece notes previous examples, as well as very real current possibilities (such as navigation software diverting a driver away from "undesirable" neighborhoods), for a realization of such scenarios (Selinger, 2012).

The antecedent are merely some of the more obvious real ways in which both users' and non-users' anonymity and privacy might be imperiled. As mobile devices continue to proliferate – and as various apps do so likewise –, it seems that the fight to preserve the *status quo* is rather futile, even without particular reference to A.R. devices. The ineluctable reality purports to be, as Tufekci famously remarked, that "[a]s we leave behind the 20th century, it is almost as if we have come full circle back to the village where everyone potentially knows your business" (2008).

# CHAPTER 6. FREE-ENVIRONMENT A.R. VIABILITY AND ALTERNATIVES

The points discussed so far appear to converge on the skeptical side of the argument about the viability of free-environment A.R. applications. The reasons are manifold: (1) The connectivity and networking standards available at present relay data too slowly; (2) the necessity to communicate with G.P.S. satellites, as well as at least two different databases at such slow speed is too complicated and energy-intensive; (3) the data available for sites of commercial and other interests are scant; (4) accumulating more of such data would be a protracted, arduous, and financially-taxing venture; (5) collecting data from users in order to provide a more relevant A.R. experience might be thwarted by their lingering privacy concerns, following high-profile scandals; and (6) the rate of readiness to adopt this kind of technology is low given a relatively poor ratio of smartphones : feature phones (i.e. “old” cell phones) even in developed countries. That being so, it may be more profitable to consider more realistic and viable alternatives to free-environment A.R. The remainder of this Paper will examine the current utilizations of A.R. technology as well as announced plans for short- and medium-term implementations.

## 6.1 General

The rather expected applications of A.R. in fields such as engineering, medicine, and education have been well documented: Raajana et al. (2012) provide an interesting exposé on the use of A.R. in architecture; Azuma (1997) mentions manufacturing and repair, and robotics. It is also increasingly utilized for cardiology and radiology purposes (Lamounier et al., 2010;Nakata et al., 2012), as well as in surgeries (Nakamoto et al., 2012), which all represents a minuscule sample of its wide variety of disciplinary applications. One study furnishes a comprehensive overview of A.R. usage for learning and education purposes (Wu et al., 2012), with Billinghurst & Duenser (2012) adding that A.R. is primarily used to accomplish logistically difficult or dangerous tasks in the safety and comfort of the classroom. A source lists a few other A.R. possibilities, such as utilization in combat, broadcasting, sport, and collaborative office work (Van Krevelen & Poelman, 2010). The foregoing examples, revolutionary though as they may be, were quite predictable. They have also been extensively covered in other works. This Paper will dedicate the following sections to the more peripheral and ingenious utilizations of A.R. with a focus on the everyday end-user.

## 6.2 Marker-based applications

Rose et al. distinguish between "markerless" and "marker-based" applications. The former are in many ways synonymous with free-environment A.R., whereas the latter – which will be the subject of this section – in some manner correspond to what has been termed controlled-environment A.R. in this work. It involves some form of token, which interacts with an A.R.-equipped device to provide and manipulate A.R. content when acquired. It traces its origins to the Quick Response (Q.R.) codes that companies include in their ads and scanning which e.g. opens up a website or plays multimedia content (Rose et al., 2010). In this case, once a marker is identified through a camera, the viewfinder overlays the real-time image with external content. In figure 7 *post*, a regular pack of chewing gum "comes to life" once a smartphone running an app called *BlippAR* is directed at it. The app recognizes a marker – either the image itself or the logo (Blippar's trigger closely resembles the Twitter logo but with a "b" instead of

Twitter's "t") – and retrieves additional content, such as product information, a movie, a game, etc.

Figure 7: An app on a cellphone brings a pack of chewing gums to life through A.R.

This new method of advertising and engaging with consumers is more ubiquitous than might be imagined and has been adopted by some of the world's leading brands (Russell, 2012). Some examples of markers employed for this type of use are shown in figure 8:

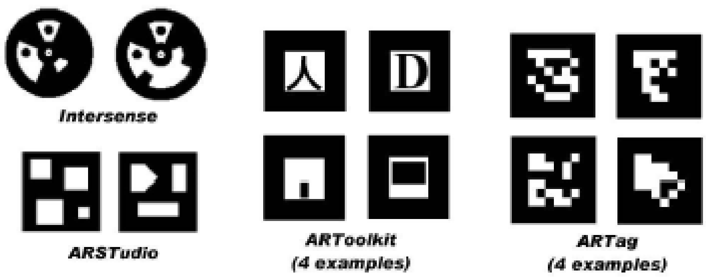


Figure 8: Some markers employed by brands in mobile A.R. applications

Marker-based A.R. applications are not synonymous with controlled-environment A.R., because – unlike with a museum or operating theater context – they can be encountered anywhere. However, the conditions in and under which they are used are very much controlled: The content is available only while a marker is within the viewfinder's range, and it is subject to the availability of some form of network connection. There are two serious drawbacks of this approach to A.R. though. Firstly, it requires users to install and run an application on their device, which is capable to recognizing these markers. Blippar and Cachetown are just some of a number of similar programs, including individual companies' own-branded A.R. apps solely for their own products. Downloading, installing, and running such a bevy of apps just for this purpose would be overwhelming for both users and their memory- and space-limited devices. Secondly, the onus is on the user to recognize an A.R. marker or to identify when and where A.R. content is available. The user thus is required to be permanently vigilant and, once an A.R. opportunity is detected, activate his/her A.R.-equipped device, work out which application covers that particular A.R. context, launch it, position the device as necessary, and then wait for the data to download to the device. That may be acceptable to some people in some circumstances, but does severely limit the potential audience. It can be relatively easily improved, however: If the A.R.-enabled device was permanently worn and running an application capable of recognizing a wide variety of markers, most of those hindrances would be obviated.

Indeed, with reference to the problems adverted to *supra* concerning the lack of resources of small enterprises and entities to make themselves represented in a unified free-environment A.R. database, this option might be their salvation. Investing in an A.R. marker (and, naturally, some content-creation necessary for it to be usable) may be more convenient and feasible than endeavoring to compete with better financed companies for annotations and content on devices' viewfinders.

## 6.3 A.R. in marketing: Users as brand ambassadors

Augmented reality is beginning to change the very foundations of advertising: Whereas the responsibility for brand recognition and penetration always lay with the companies, some are now challenging that. *GoldRun* taps into general users' well-evidenced propensity to take and share photos (q.v. the success of *Instagram* and similar applications) to enable them to interact with retailers' items and create unique photo opportunities, which they then proceed to share with their contacts (Pan, 2012). Naturally, the brand name and logo feature prominently in such shots, effectively making the customer an ambassador for the company.

## 6.4 A.R. facilitating mundane shopping

### 6.4.1 Saving time

A simpler, yet inventive, concept has been developed by I.B.M. It devised an application where a user enters his/her shopping preferences (e.g. flavors and desired nutritional criteria for a food item) and then scans the multiple items and brands on offer in the store. The program recognizes and proceeds to recommend the most suitable products based on the user's desires and dynamically provides any coupons or offers, too ("Personalizing the in-store...," N.D.). While it saves consumer time and effort – particularly in the era of increasing health-consciousness as well as proliferation of consumer choices –, it also provides valuable data to marketing companies and retailers (the latter get information useful for product placement and floor utilization purposes). Although not augmented reality in the strictest sense of virtual content being overlain on the physical view, the technological concepts involved used do stem from A.R.

### 6.4.2 Online apparel shopping

Continuing with the theme of consumerism, other than advertising, A.R. can and is already being utilized in shopping. Shopping online for apparel has long been fraught with difficulties: Colors, sizes, fabric texture, overall fit, and other factors are often miscalculated when buying a garment on a computer screen. "Augmented reality dressing rooms" have been in existence for several years (Kincaid, 2009), which only slightly mitigated those problems. A harbinger of things to come could be seen at the Consumer Electronics Show 2012 when a company called Bodymetrics premiered technology that enhanced an A.R. fitting room to a usable standard. It takes the original concept of simply superimposing a piece of attire onto a user's body, but it scans the user's body (height, curves, etc.) first and then attempts to overlay the user's body with the clothing as it is likely to look on them (Aamoth, 2012).

Though reviews have been underwhelming (Laird, 2012), it must be noted that this application is still in its nascent stages. Lacking at the moment is the ability to portray to the user how a garment will look on their body with respect to its contours, the principal reason for which is that such information is not available in the manufacturer's or outlet's database. However, if each item of clothing were initially scanned under all possible body shape conditions, then such an image could be easily matched with the user's body mapped at home. Since the technology exists at the user's end for such a system to be implemented, the burden is now on the retailers or even manufacturers to record the appearance of their attire on all different body size permutations. Taxing though as such an endeavor is, it could well prove to be cost-effective if it results in fewer returns and write-offs as well as an increased customer base. Obstacles are even fewer for non-clothing types of personal purchases, such as accessories: Duryee (2011) explains how buying e.g. sunglasses online is greatly facilitated using A.R.

## 6.5 Real estate

Yet another customer-oriented A.R. use is in real estate. Early A.R. attempts in this context involved three-dimensional objects "popping" out of magazine pages, similar to the Blippar experienced described above. They involved additional information or models of existing properties or, especially, future developments. That was subsequently enhanced further so that a marker (whether in printed material or *in situ* such as when walking down a street and spying a house for sale) triggered additional information about that property, e.g. the selling price, contact details, photographs, and tours of the interior (Josh, 2012). Although this can be beneficial to a prospective buyer in terms of better organization and saving time, such an application is hardly revolutionary, and does little what could not be accomplished using more traditional methods (visiting a realtor's website or calling them). In addition, virtual tours are more in the realm of virtual than augmented reality. Where A.R. could, however, prove useful is home décor and furnishing (figure 9). When touring a property on sale, a prospective buyer could use A.R. to envision how the home would look with his/her furniture in it or how the place might appear if it was painted a different color. Combining that with the A.R. fitting room idea, furniture and appliances, too, could be virtually put in their desired locations prior to purchase. Though the necessary technology exists and would be relatively simple to implement, few inroads have been made into this: The relatively obscure YOUReality is the only application that assays to perform this function (Kennedy, 2010).

Virtually testing or trying out appliances for ease of use, convenience, efficaciousness, etc. prior to buying is another possibility.

Figure 9: Example of A.R. use for home furnishing:
A real room and desk, with two virtual chairs and a lamp

## 6.6 Home management and tasks

Other than furnishings, A.R. has many other potential uses in the home itself. An article shows how augmented reality can assist in operating increasingly digitalized households by providing information about e.g. the current energy consumption of digital appliances (Lapides et al., 2009).

A study discusses how A.R. can be of great help in food preparation. It also considers the challenges of markerless content recognition in such a context: How can the A.R. program identify the foodstuffs as well as the stage of preparation at which they are in order to display accurate and apposite information? It concludes that a template database catering to multiple contingencies, coupled with empirical data, produced solid results (Pham et al., 2010), which is the approach also taken by A.R. dressing rooms developers.

## 6.7 Personal computers user interface

Probably the most significant utilization of A.R., and one whose development and deployment have been inexplicably retarded, is everyday computing. Despite stupendous advances made in personal computing within the past couple of decades, the basic method of interacting with the machines has not changed from the 1980s: Users still input data by way of a keyboard (physical or touchscreen) and a mouse (or by "tapping" icons on a screen, which is the same in essence as clicking with a mouse). More recently, with the ascendancy of tablets, "gestures" are employed to perform certain tasks. However, the fundamental principle is the same: Physical contact is required. The possibility of a user interacting with a computer through air-gestures has not entered mainstream computing. Microsoft recently released Kinect for Windows but as a Software Development Kit, i.e. geared toward developers and programmers rather than the general public (Cruz et al., 2012).

The main impediment appears to be what Azuma calls the "registration problem," i.e. combining the real and virtual objects seamlessly and realistically, which are caused by static and dynamic errors in rendering, recording, depth perception, etc. (Azuma, 1997). Frati & Prattichizzo (2011) allude to it in their proposal to improve users' haptic (touch and touch-feedback) experience. Recognizing gestures, measuring their relative position and depth, and decoding them is relatively simple; the Xbox incarnation of Kinect and the PlayStation Eye have been successful doing it for several years. Tracking fingertips and blending virtual objects with real-world users' hands is exponentially more difficult. Research found that manipulating A.R. content has hitherto invariably required fiducial markers (e.g. Google's Glass's proposed ring) or "head-to-hand tracking equipment such as the WearTrack solution" (Lee & Hoellerer, 2007). The authors examined how the contours of the human hand could be used in lieu of artificial markers, and found that it was indeed possible but that it required multiple cameras – with significant cost implications – to account for the speed, change in shadowing and illumination, and other vagaries of human motion. Studies of successful finger-tracking have been ongoing since as far back as 1995 (Crowley et al.), which goes to demonstrate the scale of this challenge.

The physics of virtual objects' behavior is yet another facet to be considered: If a virtual glass held by a user is suddenly dropped, will it fall and crash (as would be realistic to expect), or will it simply vanish or remain floating in the air (as objects are programmed to do at the moment, and which detracts from the users' experience)? Even merely handling a non-rigid object presents its own challenges: How does a virtual rubber ball react to being squeezed (Haouchine et al., 2012)? A source demonstrates the difficulties of programming a relatively simple scenario of a real forklift handling virtual boxes (Beaney & MacNamee, 2009). This is not a major problem at the moment, as a typical computer user neither does nor expects to handle virtual objects; however, if the e-commerce applications covered in ss. 6.4-6.6 *supra* are to materialize, both hand-tracking and virtual object behavior are issues that will need to be satisfactorily addressed.

## 6.8 A.R.-based social networking

Also worth mentioning is the possibility of a new type of social networking to emerge. An A.R. application called *Wallit* constructs a location-based "wall" *à la* Facebook. Pointing a viewfinder at an object (such as a stadium, concert venue, restaurant, etc.) activates a virtual pane containing other attendees' dynamically-updated comments (*v.*

figure 10). Wallit is as of now available only on the iOS platform and is but yet another "app" in a virtual ocean of others; it does, nevertheless, provide a unique approach to human interaction, particularly in well-visited or crowded loci.


Figure 10: A.R. used with a mobile device at a sporting event

## 6.9 Distance communication

Pursuing this notion of human interaction further, Microsoft offers a glimpse into the possible future of human communication. Video-conferencing has been in existence for years, and even holographic projections are no longer considered revolutionary: Charles Windsor appeared at a symposium as a holographic image beamed from thousands of miles away in 2008 ("World Future Energy...," N.D.). Microsoft's *Holoflector* – among other uses – offers the possibility of interacting with one's collocutor, or several of them, in full size as well as utilizing virtual objects (Cheredar, 2012). That technology is still very much under development and one considerable hurdle to be overcome is the latency caused by both body mapping at each end-point and the inherent propagation delays between the users. Figure 11 shows that even with single-user applications there is significant sensor delay when following the user's motion (note the speaker's right arm: the red forearm and blue ball – which is supposed to be on "top" of the phone held the speaker's hand – have not caught up with his movement).

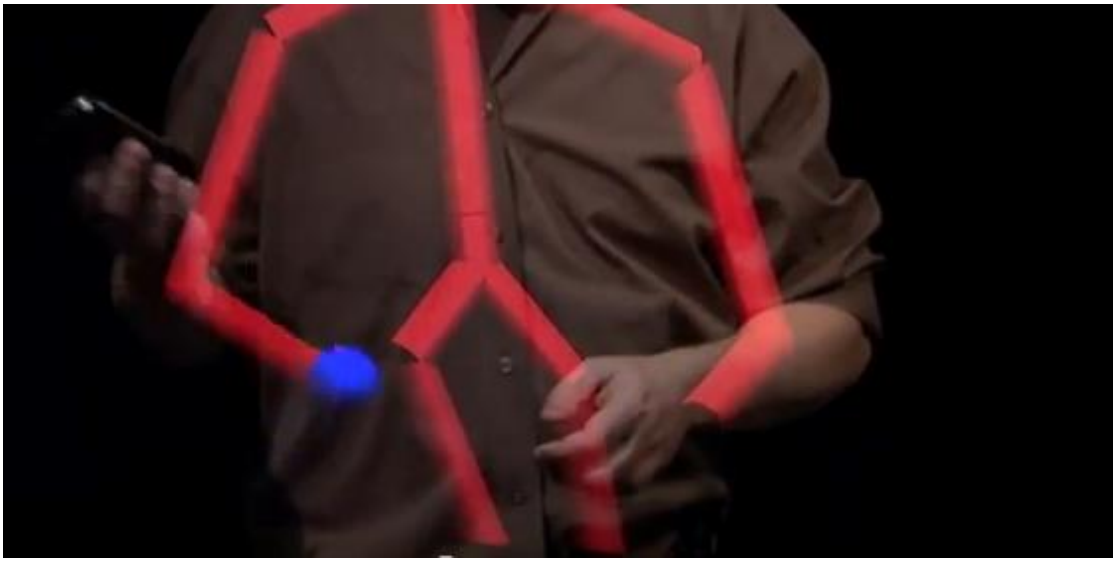

Figure 11: Microsoft's *Holoflector* still has a few kinks to be worked out (Cheredar, 2012)

## 6.10 Drawbacks

As alluded already, all the applications aforementioned share one feature: They are discrete, standalone programs. (Some of them are also prohibitively expensive for mainstream adoption.) Using them requires users to download them and manage them individually. With literally dozens of them available for different as well as overlapping purposes, the onus on the user to even remember which one is applicable to which context is likely to be too great for mass-market penetration. As already stated, *Wikitude* and *Layar*, by far the most popular A.R. applications only have a few million users between them. These facts have only served to solidify the perception of augmented reality as "gimmicky," which is the word used by countless commentators to describe it (the sources are too many to list; a few examples are Carson, 2012; Elgan, 2010; Merrill, 2012). Lord (2012) characterizes augmented reality as a "horizontal technology," meaning that its multitude of potential uses makes it difficult to develop a "killer app" that would subsume "Evernote-YouTube-Wordpress-Instagram of [A.R.]" into one. For A.R. to be embraced by the general public, therefore, similar conditions would have to be met as in previous similar instances. The smartphone, for example, was popularized by being made affordable, useful, and comprehensive, but also by very financially-intensive marketing (West & Mace, 2010). The iPhone is considered the trailblazer of smartphones; however, it was hardly the first smartphone on the market. It owes its success primarily to relentless marketing (Mickalowski et al., 2008), of the type few corporations can afford or envision.

# CHAPTER 7. REALISTIC PROSPECTS OF MASS A.R. ADOPTION

For the A.R. technology to achieve the same type of success, it is imperative it have a major backer. Such a sponsor will produce a complete A.R. solution where users do not have to unholster their device, fiddle with its camera, search for and fire up an app, and then end up with limited and disappointing results. The patron will have to produce an esthetically-attractive, affordable (including to consumers in less developed countries), multifaceted, and, above all, utilitarian device. Those criteria apply as much as to the software of the device as to the hardware.

## 7.1 Google's Glass

The aforementioned Google's Project Glass appears to have advanced the most in those terms. To summarize: It resembles a pair of reading glasses, albeit bulkier; without mobile connectivity, but WiFi- and Bluetooth-enabled; with an unobtrusive battery hidden in the frame, but with a capacity for only a few hours of use; still in the prototype testing stages, due to be released in 2014 at a projected price commensurate with that of a high-end tablet. It will be controlled via eye movements and head tilts, as well as hand gestures that will require the user to wear a fiducial marker. While innovative, such control methods entail significant flaws: The former causing spectacles or, worse, putting the user in potential danger if done while driving, crossing a road, or walking in a crowd or at a construction site; the latter because it means users will need two separate pieces of hardware (viz, the Glass itself and ring) for the device to be operational. Davies (2013) reports that a "side-mounted trackpad" and voice commands are also being considered. Google's recent application to the Federal

Communications Commission further revealed that the device would boast a U.S.B. and another – apparently proprietary – wire-connection standard, as well as an "integral vibrating element" to conduct the audio signal, based on the company's patented "bone conduction technology" (Moon, 2013).

None of that sounds particularly captivating, and would likely be insufficient to entice a mass audience to augmented reality or indeed dissociate A.R. from its reputation as "gimmicky." These drawbacks notwithstanding, what does Glass propose to offer users? One report contends that this is as of yet unclear. In Google's promotional video a user is depicted as seamlessly receiving real-time information about transportation, the weather, appointments, reminders, navigation, social networking, and more. Voices of dissent, however, are skeptical about the likelihood of the vision from the video materializing, at least in the first instance. They cite, *inter* alia, the size of the "screen," its distance from the wearer's eyes, and illumination issues. Google itself acknowledges these criticisms by stating the video merely shows "what this technology *could* look like [and] what it *might* enable you to do" (emphasis mine) (Rivington, 2012). The question is how big a gap there will be between such demonstrations and the actual product. If the gap is too large and the device underperforms, users may give up on A.R. altogether, which would cause the technology to remain the preserve of disciplinary applications and a select "geeky" crowd. Google is most assuredly the standard-bearer for augmented reality, and the pressure on it to produce a high-quality, useful product is considerable.

## 7.2 Other contenders

Microsoft and Apple purport to be willing to dabble in A.R., with both of them having patented head-mounted A.R. devices (basically, glasses). Neither has, however, released much information about the stage of development, capabilities, or specifications of their proposed device.

## 7.3 A.R. via contact lenses

Another major current development in the field of A.R. are A.R.-enhanced contact lenses. Apple has been the most alacritous of the developers in this regard, although there is surprisingly little mention of its *iLens* project and Apple has kept uncharacteristically mute about it (there have been none of the "leaks" and "rumors" that usually abound months in advance of an Apple's product's release). The iLens is to be worn as a regular contact lens, but provide the wearer with "photographic memory, binoculars, night vision, and augmented reality with a heads-up display" (Adams, 2010). Delving deeper into this type of device is beyond the scope of this Paper, and no known practical prototype has yet been produced. Further, A.R. contact lenses are geared toward gaming and emails (Crompton, 2011), which impugns how much of an A.R. device they are, as opposed to being more of an alternative user interface for personal computing applications.

Additionally, while a viable A.R. device is necessary and contact lenses are a tantalizing possibility, unless that device delivers useful content and services to a wide range of users, it is unlikely to be successful. It does not appear any major A.R. player has been making significant effort as far as accumulating A.R. content.

## 7.4 What NOT to do

Finally, a cautionary example of how A.R. could be misused despite good intentions. Figure 12 depicts a fictional (indeed, parodied) “smart windshield” overlaying the driver’s view with all manner of important, and some less so, information. The concept is laudable: Apprise the driver of data he/she might require immediately while driving. Done properly, it would even increase the driver’s and passengers’ safety: Rather than retrieving the information from alternative sources and even momentarily moving the eyes from the road in the process of doing so, the driver obtains the desired data on the windshield itself. How much data is too much? The provided example would be certain to cause a crash before long and is the epitome of technology being used for its own sake. However, if used astutely, A.R. has been shown to be of great benefit with no drawbacks to drivers (Rusch et al., 2013).


Figure 12: A.R. at some of its most extreme (Baker, 2007)

# CHAPTER 8. CONCLUSION AND FUTURE

This Paper began by outlining the technological development of augmented reality. It then proceeded to examine the question of how realistic and practical mass augmented reality adoption would be from both the technological point of view as well as from a legal perspective. To do the former, the paradigm developed by Schmalstieg et al. (figure 13) was followed.

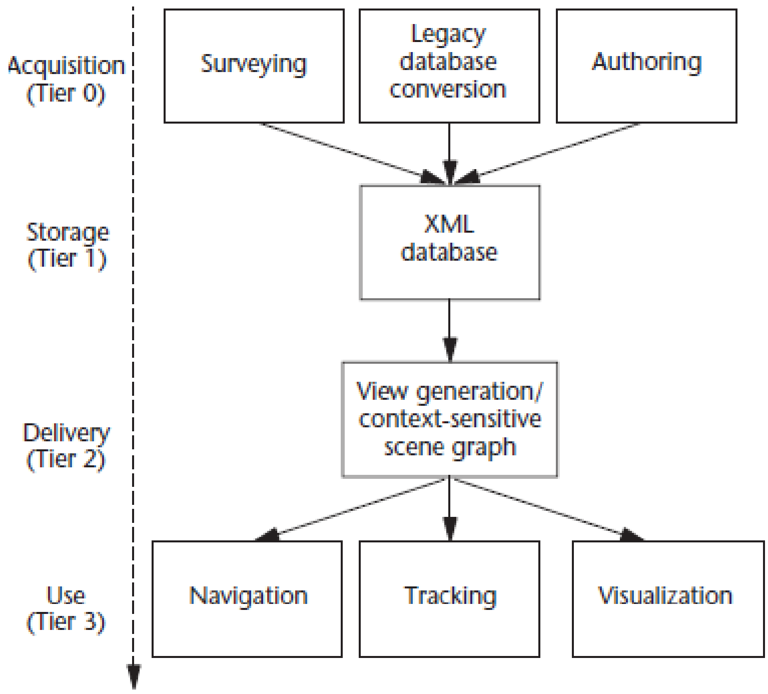


Figure 13: Schematic of A.R. operation (Schmalstieg et al., 2007)

Two usage types of A.R. were propounded: Free- and controlled-environment. The latter entails augmented reality being used in a strictly predefined space, usually indoors, involving limited, predetermined content. In free-environment A.R. users are not confined spatially and have access to information wherever it exists. Focusing on free environment A.R., it has been shown how there are severe obstacles at every one of the four tiers.

At Tier 0 the data currently available are at best patchy. Recording, categorizing, and ordering data would be a Herculean undertaking, necessitating immense funds, time, and geographical presence, as well as databank farms to store them (Tier 1). The information would have to be continuously updated. As it would be impossible to classify every object of interest, some would inevitably be excluded from the database. Given the manner in which entities are known to promote themselves, it is far more likely for major, successful, and moneyed entities to enter the database than for smaller, poorer, technologically-unsavvy ones. There are questions marks concerning the integrity, validity, trustworthiness, and currency of such a database.

Tier 2 is critical: The system has to determine the user's location and object viewed. This requires a reliable, accurate locationing standard. While this does exist and, coupled with image-based recognition, is accurate, it is dependent on the vicissitudes of the connectivity standard used. At Tier 3, users are meant to receive the virtual data as they are observing an object of interest. For that to happen, those data have to be available in the first place, as well as relayed quickly enough to be meaningful. Since the process between sending an A.R. request and receiving A.R. data is complicated and protracted, and involves several relay points (as shown in figures 2 and 3), the network infrastructure must be reliable and fast. For the moment, it cannot be averred with confidence that such a connectivity standard exists or is ready to service tens of millions of potential A.R. users.

As far as the practical side of A.R., even in developed countries there remains a prodigious "digital gap," which is all the more pronounced at the international level. While the urban dwellers in First World states are largely suitably equipped in terms of both devices and infrastructure for A.R. deployment, neither is the case with even non-urban inhabitants of developed states, let alone the populace in developing countries. That is perturbing, for one of the salutary side-effects of technology is that it facilitates tasks as well as human communication, rather than disenfranchise already disadvantaged people.

Even were these obstacles overcome, there are legal and ethical matters that arise, particularly with respect to intellectual property and users' privacy. The latter concerns not only being surreptitiously recorded, but also the disappearance of the line between one's physical and online presence: As useful a tool as an A.R. device would be, it would by its very nature be an implement to track the users themselves.

The corollary was adjudged to be that though mass A.R. roll-out is theoretically plausible, there are obstacles that ought to be addressed first. Unless done so, A.R. could incur the same fate that befell the 3D television industry, which assayed to accomplish too much too soon: Sales of 3D T.V. are nearing a plateau, with barely a fourth of all L.C.D. television sets purchases accounting for the 3D type ("3D TV share...," 2013; Lynch, 2012).

This Paper proceeded to enumerate some of the more realistic alternatives to free-environment A.R., especially those of benefit to consumers, but noted that they suffer from an inherent problem: The necessity for users to download and manage a myriad of different applications for often similar purposes. For A.R. to succeed, a powerful “sponsor” is required who will produce good-quality hardware, provide easy-to-use software and rich, meaningful content, and zealously and effectively promote the entire package.

The ascent of the augmented reality technology can be either an evolution or a revolution. If it is the former, there is a danger that it might dissipate just as many other devices and technologies did; Apple’s *Newton*, Microsoft’s *Zune*, Google’s *Buzz*, Toshiba’s HD-DVD, and Sony’s *MiniDisc* come to mind most readily, but there are countless others. Even if it is not an outright failure, a slow start for A.R. could dampen innovators’ enthusiasm and potential corporate support, as transpired with e.g. cordless telephones, where the adoption rate was slow (Albers, 2004). For A.R. that would be the equivalent of a death knell, because – as discussed *ante* – continual, comprehensive support by major backers is essential for collation and updating of content, provision of the necessary infrastructure, etc.

Alternatively, it could follow the path trodden by the iPhone: A quite solid, quality product done well (or well enough) on the first attempt. It offered users something new and different, and was backed by a concerted marketing effort, even if specifications-wise and cost-wise it was not the most competitive product available. Naturally, this second option is preferable.

The most suitable contender, by some distance, is Google. Its Glass is the first A.R.-optimized and A.R.-dedicated device that will be released on the market. Its performance will likely determine the future of augmented reality. If its performance is lackluster or worse, then its competitors' offerings – which are now presumed to be released relatively soon afterward – are unlikely to garner much excitement or interest. If it does well though, it could herald the start of a market war, primarily with Microsoft and Apple, bringing innovation and price reductions. It is worth recalling Anthony's admonition regarding potential advertising profit and tracking users (2012): Companies have a lot of incentive to invest in A.R., but only if there is a clear potential for popular adoption. Whether that will be the case remains to be seen: The fate of Google's Project Glass will be a portent of the fate of augmented reality in the short- and medium-term.

# INDEX OF FIGURES

Figure 12 (p. 68): Baker, C. (2007). Found: Artifacts from the future. Wired. Retrieved 2013-01-18 from http://www.wired.com/culture/culturereviews/magazine/16-01/found

Figure 13 (p. 69): Schmalstieg, D., Schall, G., Wagner, D., Barakonyi, I., Reitmayr, G., Newman, J., & Ledermann, F. (2007). Managing complex augmented reality models. Computer Graphics and Applications. IEEE. 27(4), pp. 48-57. Retrieved 2013-01-18 from http://www.icg.tu-graz.ac.at/publications/pdf/complexmodelscga/at_download/file

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