The Bumpy Road of Bringing Wearable Augmented Reality Systems to Market

Christian Buergy
teXXmo Mobile Solution GmbH & Co. KG
Otto-Lilienthal-Strasse 36
71034 Boeblingen, GERMANY
c.buergy@texxmo.com

DHBW Mannheim
Cooperative State University
Coblitzallee 1-9
68163 Mannheim, GERMANY
christian.buergy@dhbw-mannheim.de

Joerg Seitz
teXXmo Mobile Solution GmbH & Co. KG
Otto-Lilienthal-Strasse 36
71034 Boeblingen, GERMANY
j.seitz@texxmo.com

UBICOMP '13, SEPTEMBER 08 - 12 2013, ZURICH, SWITZERLAND
COPYRIGHT 2013 ACM 978-1-4503-2215-7/13/09...$15.00.
HTTP://DX.DOI.ORG/10.1145/2494091.2499573

Abstract
Wearable Augmented Reality systems are still expensive niche products and not yet widespread. Three main components need to be available for a successful market entry: affordable and user-friendly hardware; reliably and easy to use software and SDKs; and the necessary data structure for exact and informative augmentation. This paper lists some lessons-learned along the road to a wearable AR market.

Author Keywords
Mobile Computing; Wearable Computing; Augmented Reality; User Interfaces; Industrial Applications.

ACM Classification Keywords
D.2.2 Software Engineering - User interfaces; H.5.1. Multimedia Information Systems - Artificial, augmented; H.5.2 User Interfaces - Voice I/O;

Introduction
Since decades, we are used to Star Trek's human-computer interaction with sentences, such as "Computer [do this and that]". Nowadays, in Californian streets you might hear "Glass [do this and that]" by people using Google's wearable consumer appliance. Surely, this similarity is chosen rather purposely than in coincidence, but it simply reflects the urge for artificial

Wearable AR Systems...
… are with you all the time, could be worn somewhere at your body. They react on (natural) language requests and analyze the environment and try to identify the context and location. They support human users or wearers with information, which augments the users' environment.

Road to Wearable AR:
[Sources: company material]

Fig.1: 1999, Xybernaut MA IV

Fig.2: 2005, Vocollect Talkman

systems, which we can communicate with as if they were human. A wearable Augmented Reality system might be the ultimate goal and Star Trek and Google Glass set high expectations, which so far could not be brought to market. Since nearly 15 years, the authors patiently accept constantly the same statement "wearable computers will hit the market within the next 3-5 years". To take the irony out of this running gag, we decided to analyze and present the lessons-learned.

Late 1990ies: Xybernaut Mobile Assistant
In the late 1990ies, Xybernaut Corporation set the base for industrial wearable computing and brought to market one of the first commercial wearable computers with a head-worn display. As competitive devices have been available in military applications or in academic research programs, this Xybernaut wearable was an off-the-shelf commercial product. Given the fact that Tablet PCs and PDAs have not been widespread and laptops had a weight above two kilograms, the Mobile Assistant [Fig.1] was a quite light-weight wearable computer system. It had a see-through head-mounted display with a bright and clear picture, although with a mirror system that was not too much of industrial grade. The see-though capability enabled users to retrieve information directly in the field-of-view, but not in the sense of Augmented Reality as congruent overlay on real-world objects. There simply was no such AR software and the performance of that wearable system would not have been sufficient either. Yet still, many customers already asked for such systems.

2000 and later: the HMD decade
Wearable computing in the first decade of this millennium was mostly driven by HMD manufacturers. There was quite a number of HMD developers, mostly start-up companies, supported by venture capital. Many of those start-ups had promising technology, enough money to develop first prototypes, but no market to serve. The challenge: with the low number of devices sold, the price of HMDs and consequently the price of complete wearable systems, were too high to successfully create a market. Especially see-through HMDs, which would be needed for (optical see-through) Augmented Reality had a price tag of up to €10.000,-.

During that time, the authors worked in different companies developing and dealing with (x86-based) wearable computers [e.g. Fig. 4]. Those systems relied on third-party HMDs. Besides the pricing issue, those HMDs were developed mostly around the core optical technology and could neither fulfill demands by users, such as integrated camera, speakers and microphone, nor have these HMDs been ruggedized for industrial use. Although there was a niche market for tele maintenance based on video and audio communication, we could not reach enough volume to open up the market for HMD-based wearable computing.

With the introduction of Smartphones, the pace of miniaturization and the performance gains sky-rocketed. Mobile AR applications became feasible.

Today: Smartphone, the new wearable
Today, Smartphones offer more performance than desktop computers a few years ago. With focus on graphical and touch user interfaces and heavy use of multi-megapixel cameras, these mobile devices are equipped with excellent graphics chips. While the hardware seems to get ready for wearable AR systems, software needs to be developed and underlying AR data to be generated, edited and mapped.

Fig.3: 2007 SN-Technics i-boro

Fig.4: 2010: teXXmo tX-1000; CeBIT, Hanover [Source: dpa]

Fig.5: 2010, Brückner Callisto (teXXmo-based)

The challenge: software and data

So far, we looked at the hardware development as the main enabler for wearable AR. At the same time, Augmented Reality software evolved and is now running on Smartphones and Tablet PCs. There are a lot of consumer applications, e.g. used for mobile marketing and location-based information provision. Such applications have a broader market than industrial applications and thus, more potential users. At the same time, the requirements towards the exactness of AR overlay are higher in industrial settings. It is more difficult to have the AR system point to a specific screw of a car engine than to augment the direction of the nearest hotel or pop up an AR advertisement on top of a magazine. Stationary systems can use laser pointers to show welding points [1] in the range of millimeters. With HMDs not being firmly fixed to the user's head and the mobile systems not being able to provide enough performance, we might not be able to fulfill the expectations, which grew over time.

Once we know and accept the limits of wearable AR, we still need to set up the underlying data structure and keep this data up-to-date. If geometric and descriptive information shall be used for AR, this information needs to be generated, edited and mapped to an appropriate AR context. There are approaches to generate such data right from the development of products, such as vehicles, aircraft or buildings.

Expectations: R&D, marketing and reality

Important is to differentiate the expectations between the stakeholders in wearable AR systems. Marketing sets high expectations by implying that wearable AR systems are readily available and usable. For example, there are many videos, which show the use of an ideal system, raising the expectation of potential users that they can purchase and use such systems, even today [2][3][4]. The intention of this approach is twofold: painting the picture of an innovative company and trying to open up a market for such systems. While this will surely drive the awareness and demand of such systems, sometimes it raises the expectations higher than the state-of-the-art, affordable technology. Reality is driven by the actual users, who will only accept products, which facility their private or work life. In reality, we are further away from wearable AR systems than R&D and marketing imply. The following aspects are our lessens-learned, supported by some examples.

Lesson-learned: integration and usefulness

System integration: hands-free operation

One of Xybernaut's faults was that the system was marketed as hands-free computer, but hands-free user interfaces, such as speech recognition had to be developed by ISVs. At least the basic functionality to start, control or manage the system's OS must be provided as hands-free user interfaces [Fig. 1].

System integration: application software

With our system teXXmo ONE [Fig. 5], we designed hardware purposely for partners, who developed integrated software, which would make it a useful tool. Such specialized industrial software applications could have driven the market, but in the end, those partners could not successfully introduce their system. Ideal for wearable AR systems would be a kind of hardware and software ecosystem, such as today's smartphone with their corresponding application stores, might have helped back then.

Fig.6: 2012, Google Glass

Fig.7: 2013: Vuzix, M100

Fig.8: 2013: Motorola HC1

Usefulness: building tools

Successful wearable systems in industrial settings need to be useful tools, such as e.g. pick-by-voice systems. These show simple hands-free user interfaces, a completely closed, integrated hardware and software system, as well as seamless connectivity to the stationary infrastructure. The success of pick-by-voice currently drives approaches to use AR as the alternative hands-free user interface [Fig. 2].

Usefulness: marketing vs. reality

Adding wearability to Smartphones causes excitement and trouble. During the current marketing effort, Google Glass [Fig. 6] is often times reduced to a wearable camera, which raises privacy issues. The huge potential of a hands-free wearable device unfortunately is drawn out of focus.

Usefulness: reaching ROI

While Smartphones sell in millions, wearable AR systems are calculated in the hundreds to thousands. Thus, the unit price is much higher and it's more difficult to reach an ROI. For example, a system price of approximately €15.000,- for a tele maintenance wearable served a very small niche market [Fig. 3] and pricing of consumer products definitely set prices of industrial devices under pressure.

Usefulness: ease of implementation

Customers got used to accept that an implementation of larger-scale system need consulting and systems integration. With the emergence "an app for anything you need" there is no motivation for paying consulting fees; thus, Google's approach to use the Smartphone as the base – with the apps ecosystem already implemented. Alternatively, we could reduce functionality and improve the traditional concept. Motorola's HC1 [Fig. 8] e.g. goes back to the promises of Xybernaut, now without cables and with complete speech control for all functions. The system offers basic applications, such as document viewers and telephony, which offer enough support for some work processes, without further software development.

Conclusion: it takes time

Which conclusion do we draw from our lessons-learned? In comparison to the sentence in the introduction, we believe the time for wearables to broadly hit the market is reduced to "within the next 2-3 years". There is still a lot to do in terms of R&D and finding the right applications. Wearable AR might take the same road as RFID technology. It is around for many years. We saw RFID applications in many marketing stories. And although it seems to be much easier to stick RFID labels to products than setting up an AR infrastructure, RFID still is not as wide-spread as it could or should be. Who knows since how many years RFID researchers hear that breakthrough will come in 2-3 years?

References

[1] Extend3D Welding Example http://www.extend3d.de/en/solutions/welding/

[2] KNAPP, Kisoft Vision http://www.youtube.com/watch?v=BWY8uFlteIM

[3] Google Glass http://www.youtube.com/watch?v=9c6W4CCU9M4

[4] SAP, Vuzix – AR Picking http://www.youtube.com/watch?v=9Wv9k_ssLcI