Use cases and architecture of an information system to integrate smart glasses in educational environments

Michael Spitzer
Graz University of Technology
Austria
michael.spitzer@tugraz.at

Martin Ebner
Educational Technology
Graz University of Technology
Austria
martin.ebner@tugraz.at

Abstract: Wearable devices, such as smart glasses, are nowadays easily available on the market; therefore, these devices could be used to evaluate more and more use cases in educational domain. After a short introduction to smart glasses functionality, features and user interaction techniques, several use cases are defined and described. To integrate smart glasses into the educational domain, specialized information systems and infrastructure is necessary. A basic concept of a suitable information system is defined and explained by a sample use case. The main advantage of using smart glasses in educational domain is that users can interact with the device hands-free therefore (fine motor skills) tasks can be performed while receiving visual and vocal support simultaneously. Additionally the teacher/observer can evaluate the performance remotely. Wearable devices become better available and cheaper, but should only be used in suitable use cases where the learning experience could be improved.

Introduction

Many new wearable devices hit the market every day. They become cheaper and easily available. This study elaborates on the features and use cases of smart glasses. The commercial device Recon Jet from Recon Instruments[1] will be exemplary used to introduce the features of smart glasses. Wearable devices such as smart glasses need a suitable information system architecture and environment to perform well. Smart glasses have already been used in educational domain and the learning performance was already investigated for special use cases for example in medical training/teaching domain as well as the industrial domain (production) (Rauh et al, 2015; Russell et al, 2014).

With all the new wearable devices, a new challenge rose: There is a technical solution (a new device), but we don't know what kind of (educational) problems could be solved and how the learning experience and performance can be improved with them.

This paper discusses already developed use cases and studies in which smart glasses were used to improve the learning experience for students and teachers.

The following research questions were defined:

RQ1: Benefits and drawbacks of smart glass user interaction techniques in learning situations?

RQ2: Are there already carried out smart glass field studies and which use cases were already examined?

RQ3: How could a sample educational use case be defined to be implemented by an adequate information system architecture?

After analysis of device features, use cases and already carried out field studies, a software framework concept is introduced to embed wearable devices in educational environments. The framework is explained based on the fine motor skills task: knitting. Additionally, a generic workflow is defined to implement fine motor skills use cases.

1 http://www.reconinstruments.com/, last accessed: 18.05.2016

Smart glasses in general

Smart glasses are derivatives of Head Worn Displays (HWD). Head Word Displays show visual information to the user directly in the user's line of sight. The user does not need to change the viewing direction to access visual information. (Rauh et al, 2015).
Based on the device Recon Jet, the main features of smart glasses will be described. This device was chosen because of the availability on the market. Table 1 shows the main features of the device. The device is a monocular optical see-through device with a display and the computational unit positioned at the lower right corner of the right eye's line of sight. The rechargeable battery is attached on the left hand side of the spectacle frame. Figure 1 shows the shape and the appearance of the Recon Jet smart glasses.

Figure 1: Recon Jet

CPU	1 GHz dual-core ARM Cortex-A9
Memory	1 GB SDRAM, 8 GB flash storage
Sensors	3D accelerometer, 3D gyroscope, 3D magnetometer, pressure sensor, Infrared sensor
Connectivity	GPS, Bluetooth 4.0, Ant+, Wi-Fi, Micro USB 2.0
Display	Widescreen 16:9 WQVGA display
Camera	Point-of-view photo and video camera
Controls	Optical touchpad, 2-button rocker
Battery life	4 hours typical use
Operating System	ReconOS – based on Android 4.4

Table 1: Recon Jet smart glasses - specification[2]

Analysis of the smart glass features for educational usage in educational environments

Based on the experience made with already implemented educational information systems (web services) with mobile device support, the smart glass features were analyzed for capability in usage in educational information systems environments. The recon jet supports Wi-Fi as well as Bluetooth connections therefore the data glasses can be easily connected to already available Wi-Fi networks. Bluetooth could be used as a backup connection to interact with other devices. Based on already gained experience made in schools and other educational institutions, the Wi-Fi network connections were not always stable and reachable hence the Bluetooth backup connection could be very useful. (Spitzer and Ebner, 2014)
An important impact factor of using wearable / mobile devices is the real world battery life. Students should be able to complete educational tasks without plugging the device to the power supply.

2 http://www.reconinstruments.com/products/jet/tech-specs, last accessed: 18.05.2016

Students will wear the smart glasses while performing an educational task hence the wearing comfort plays a significant role. In our previous studies in which the smart glasses Vuzix M100[3] were used, a lot of users of the subject group complained about the wearing comfort. One of the mentioned reason for this issue was that the Vuzix M100 computational unit, battery pack as well as the head worn display is mounted on the same side of the head or spectacle frame hence the device was imbalanced.
Another finding of the study was that most of the users rated the smart glass device (hardware, wearing comfort) and not the running software hence the appropriate wearable device (hardware) plays a significant role for the user acceptance (Stocker et al, 2016).
Smart glasses used while performing educational tasks must not impair the user's concentration hence the wearing comfort plays a significant role. The device's weight should be well balanced to prevent muscular imbalance of the neck muscles. Additionally, the smart glasses should be able to be worn in combination with ordinary glasses.
The efficient deployment of smart glasses in educational environment requires several possibilities of human-device-interaction techniques. The ideal user interaction technology depends on the usage scenario (learning task). Table 2 elaborates on the details of the available interaction technologies smart glasses in educational and industrial learning environments. Additionally the pros and cons of the interaction techniques in these domains will be shown.

Interaction technology / technique	(+)	(-)
Voice recognition	Hands-free, possible usage for language stimulating educational tasks.	Not suitable in environments with high ambient noise. This could be the case in big student groups as well as in industrial environments.
Touch interaction (Spectacle frame)	No functional disturbance by high ambient noise. Many users within one room could control their own devices without disturbing each other.	The big advantage of hands-free devices is lost. The user needs a free hand to interact with the device. This could have a deep impact on the learning experience. Additionally, the necessity of moving the hand towards the head could cause signs of fatigue, this could be a big issue in industrial learning domain. Furthermore, this interaction method is not suitable for dirty environments where usage of touch interaction could lead to damage of the device.
Interaction with gestures without touching the device (Hand-wave)	No functional disturbance by high ambient noise. The device will not be damaged in dirty environments because no direct, physical (hand) contact will be performed.	This could be very exhausting, especially if the hand wave recognition fails. In this case the user has to repeat the gesture until the recognition succeeds. Additionally, the learning experience could be interrupted by hand wave gestures especially while performing fine motor skills learning tasks.

Table 2: Smart glasses - interaction technologies

3 https://www.vuzix.com/consumer/products_m100, accessed: 18.05.2016

Use cases in education

Due to the fact that smart glasses are highly mobile devices, they will be able to assist all those well-known learning theories. Especially, those scenarios, which can be placed in real life situations (context based learning) according to Schön et al. (2011) or where the location plays important role (Kukulska-Hulme and Traxler, 2005).
Smart glasses could be used from two different user perspectives in educational domain.
Teachers can use data glasses to record practice videos (tutorial videos) from the user's point of view. This could be very effective for practicing fine motor skills learning tasks. Another use case is, that researchers/teachers in dangerous or difficult accessible environments could perform experiments where students are able to attend remotely by observing the experiments from a safe location (Lamoreaux, 2014).
This approach is very effective in medical domain because medical students can watch difficult operations remotely (Paddock, 2013).
Ebner et al investigated how smart glasses (Google Glass) could be used within an Audience Response System (ARS) and if the device could provide feedback to the lecturer without disturbing the lecture. They identified requirements, build a working prototype and carried out a field study, followed by a revision. The field study indicates, that lecturers are able to get instant feedback without any interruption. Google Glass has benefits in face-to face teaching situations. Additionally, the interaction between the lecturer and the audience was raised. Users should be aware of the limitations of smart glasses (Google Glass), such as limited size of the display and unconventional ways of user interaction techniques (Ebner et al, 2015).
From the student's perspective, a lot of use cases could be defined as well. Students could perform a task while wearing data glasses and the teacher is able to watch the process from the student's point of view and could give advices and feedback immediately. The teacher does not have to be on site but is able to monitor the student remotely. This could improve the learning situation for the student because the student might not have the feeling that he or she is being monitored. This use case will be evaluated during a field study.
Russel et al already evaluated such a use case. They used the device Google Glass to tele-mentor cardiac ultrasonography. Three student groups were formed: one group received tele-mentored education through Google Glass remotely from an expert, the second group received bed side education from the same expert, the third group (control group) did not receive any additional instructions. After analysis of the results there was no statistically significant difference in the performance of the tele-mentored group and the bed-side mentored group. (Russel et al, 2015)

Information system requirements to support wearables in educational environments

From the technical point of view the described device class could be seen as an android smart phone with additional sensors and device interaction features. The following system architecture is based on already gathered experience in implementing an IT infrastructure for multiple mobile devices (iPads) in school environment. An Android device was chosen because data glasses with other operating systems where not available during the concept phase (Spitzer and Ebner, 2013).
To maintain multiple devices, a server (web services) will be implemented which is responsible for managing the inter device communication and forwarding content to the data glasses. The web service will also be used to interconnect other wearables (smart watches, other sensors and additional smart devices) with the data glasses (Labus et al, 2015).
Figure 1 shows the basic architectural concept of the information system.

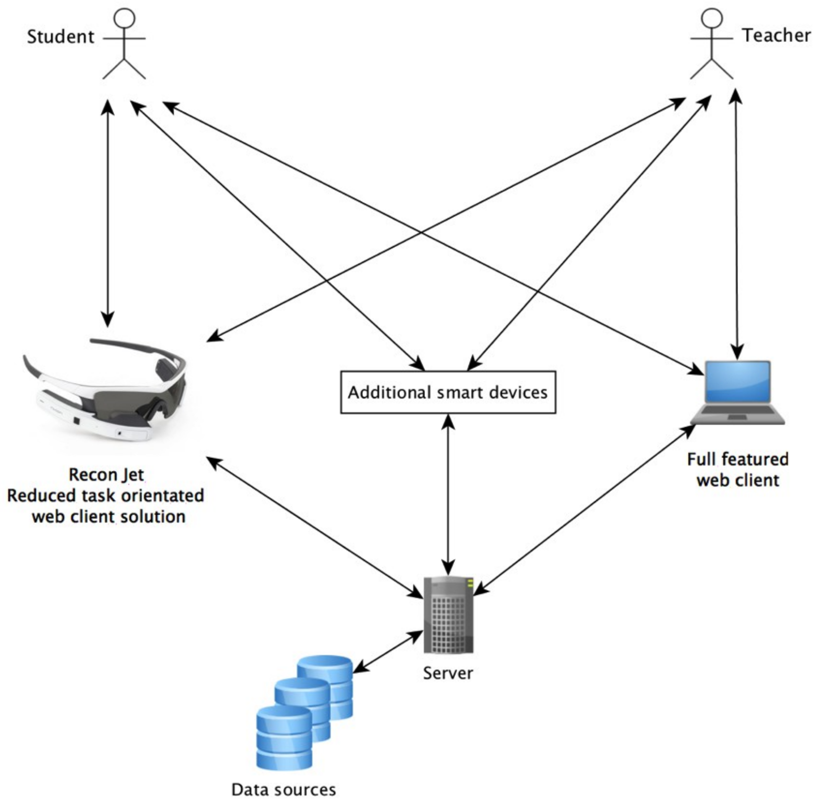

Figure 2: IT System architecture

The information System will be implemented as a framework for multiple applications to provide a common platform for different kinds of learning tools. The teacher or the students will use the full-featured web client to select the apps and browse detail information about the learning applications and tasks. As they select an application, the task will be transferred to the smart glasses or other wearables. The teacher is able to transfer tasks to all registered data glasses and is able to observe the learning progression and give feedback remotely.
During the iPad field study the observing feature and functionality appeared very expressive to evaluate student performance and to give qualified feedback (Spitzer and Ebner, 2013).

Sample use case for the suggested IT infrastructure

The teacher decides to show the students how to knit. At first a small verbal introduction will be given. Then all the students get the material as well as the knitting needles. The teacher selects the knitting tutorial on his full-featured Web interface on his or her tablet/PC and transfers the video tutorial to the smart glasses. The students are able to learn knitting while watching the video and can control the tutorial (start, stop, slow motion, rewind). An adequate user interaction technique should be chosen to not interfere the learning experience. One big advantage of using smart glasses for this kind of task (fine motor skills task) is that the students could work hands-free while getting instructions through the smart glasses. Students are learning by watching the tutorial video, which was created from the user's perspective, and simultaneously performing the task with their hands. Therefore the learning experience will be improved, the students are learning with multiple senses (hear, see and touch (haptic experience)) (Shams and Seitz, 2008).
Figure 3 shows a picture taken with the Recon Jet smart glasses from the teacher's point of view. The small picture on the upper left shows the teacher while recording the knit tutorial video with the Recon Jet glasses.

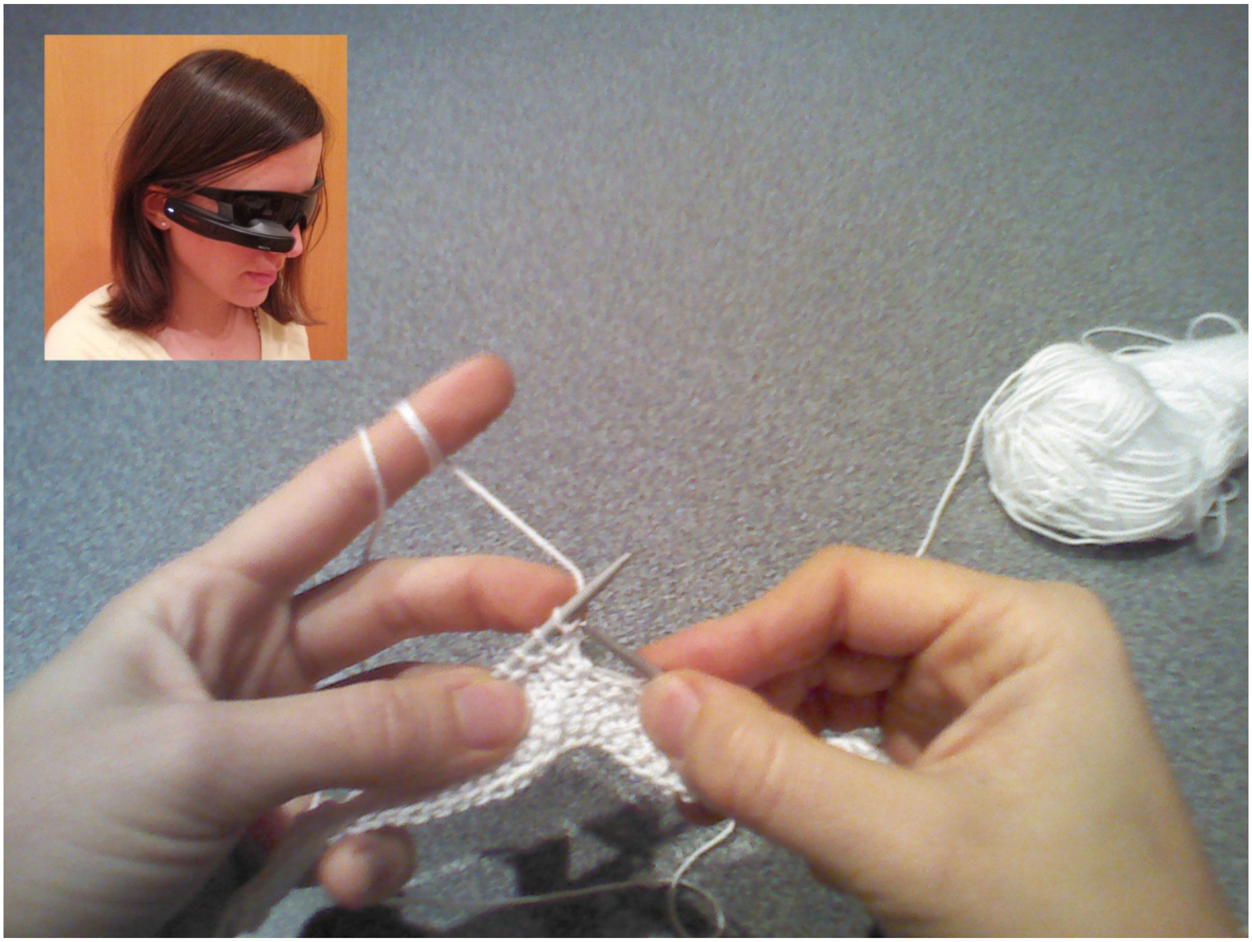

Figure 3: The teacher is recording a knit tutorial video (image captured with Recon Jet)

After the teacher has finished creating the tutorial, the video will be uploaded to the information system. The teacher can manage the recorded media (audio / video) with the full-featured web client. Then the tutorial can be sent to the student's smart glasses and they can start to view the tutorial.

Concurrently while the students are learning the knitting techniques, the built-in camera of the smart glasses will record the student's performance and will reveal difficulties. By observing the students, the teacher is able to identify issues and can give additional support.

This teaching technique can also be used to teach students remotely. In this case students could receive additional support via audio.

This kind of learning task could be adapted for various use cases. Figure 4 suggests a workflow for learning situations and tasks in which smart glasses are involved.

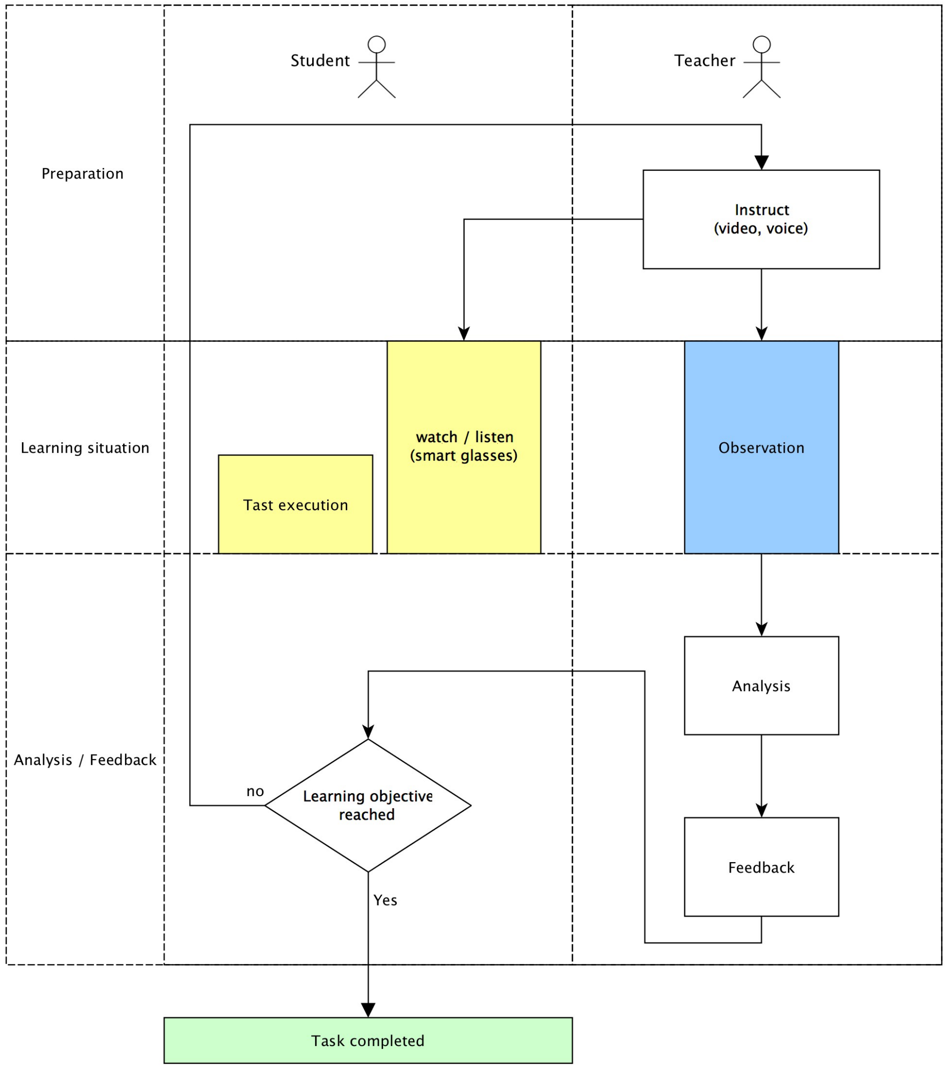

Figure 4: Generic workflow of a fine motor skills learning task for smart glasses

Conclusion

As more and more wearable devices become easily available on the market, new use cases were examined and defined. One field of application is the usage in educational environments to improve the learning experience.
Suitable user interaction techniques depend on the learning environment Voice recognition should only be used in quiet environment and in a way that no others will be disturbed. Hand-wave gestures can be used in dirty and loud environments (industrial domain). Touch interaction can be used in environments with high ambient noise. Drawbacks of the touch and gesture interaction techniques are that the hands-free feature of smart glasses is affected and could interfere the learning experience, especially in fine motor skills tasks (RQ1). Various use cases were identified and analyzed, which shows the potential of smart glasses to enhance the learning experience (RQ2). Additionally, a concept of information system architecture was introduced to provide a framework for learning applications. One sample use case was taken to show the potential of the suggested information system architecture (RQ3). A generic learning workflow was introduced to assist teachers and students while using smart glasses for (fine motor skills) learning tasks.

The next step is to specify and implement a prototype of such a framework and provide sample applications, which implement the suggested use cases. Then the learning performance of these applications will be evaluated in several field studies.

References

Ebner, M., Mühlburger, H., Ebner, M. (2015). Google Glass in face-to-face lectures - Prototype and first experiences. In: International Journal of Interactive Mobile Technologies, (accepted, in print).

Kukulska-Hulme, A. and Traxler, J, (2005). Mobile Learning: A handbook for educators and trainers. In: The International Review Of Research In Open And Distributed Learning, 8(2), p. 108, New York: Psychology Press.

Labus, A., Miltutinovic, M., Stepanic, D., Stevanovic, M. and Milinovic, S. (2015). "Wearable Computing in E-Education." In: Journal of Universal Excellence, 2015, pp A39-A51, ISSN: 2232-5204.

Lamoreaux, J., (2014). "Could Wearable Tech Like Google Glass Play a Role in Connected Education?" http://www.online-phd-programs.org/google-glass, accessed: 30.11.2015.

Paddock, C., (2013). "Surgeon Live-Streams Procedure Using Google Glass And iPad." In: Medical News Today, http://www.medicalnewstoday.com/articles/262540.php, accessed: 20.11.2015.

Rathore, K., Patel, R. and Painkra, A. K. (2014). "Google Glass and its Role in Modern Education." In: International Journal of Engineering Sciences & Research Technology, pp. 154-162, ISSN: 2277-9655.

Rauh, S., Zsebedits, D., Tamplon, E., Bloch, S. and Meixner, G. (2015). "Using Google Glass for mobile maintenance and calibration tasks in the AUDI A8 production line." In: Emerging Technologies & Factory Automation (ETFA), 2015 IEEE 20th Conference, pp.1-4, doi: 10.1109/ETFA.2015.7301618.

Russell, P. M., Mallin, M., Youngquist, S. T., Cotton, J., Aboul-Hosn, N. and Dawson, M. (2014). "First 'Glass' Education: Telemetored Cardiac Ultrasonography Using Google Glass- A Pilot Study." In: Official Journal of the Society for Academic Emergency Medicine, pp. 1297-1299, ISSN: 1069-6563.

Schön, S., Wieden-Bischof, D.; Schneider, C. and Schumann, M. (2011). "Mobile Gemeinschaften. Erfolgreiche Beispiele aus den Bereichen Spielen, Lernen und Gesundheit". In: Social Media, volume 5, Salzburg: Salzburg Research, ISBN 978-3-902448-25-5
http://de.slideshare.net/snml/mobile-gemeinschaften-erfolgreiche-beispiele-aus-den-bereichen-spielen-lernen-und-gesundheit-6165650

Shams, L. and Seitz, A. R. (2008). "Benefits of multisensory learning." In: Trends in Cognitive Sciences, Volume 12, Issue 11, pp 411 – 417, doi: 10.1016/j.tics.2008.07.006.

Spitzer, M. and Ebner, M. (2015). "Collaborative Learning Through Drawing on iPads." In: Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2015, pp. 633-642 Chesapeake, VA: AACE.

Stocker A., Spitzer, M., Kaiser, Ch., Rosenberger, M. and Fellmann, M. (2016). "Datenbrillengestützte Checklisten in der Fahrzeugmontage." In: Informatik-Spektrum 2016, pp. 1-9, Springer Berlin Heidelberg, ISSN: 1432-122X, doi: 10.1007/s00287-016-0965-6.