Sensor Based Interaction Mechanisms in Mobile Learning

Kai-Uwe Martin[1], Madlen Wuttke[2], and Wolfram Hardt[1]

[1] Computer Engineering, Chemnitz University of Technology, Chemnitz, Germany
{kai-uwe.martin,wolfram.hardt}@informatik.tu-chemnitz.de
[2] Institute for Media Research, Chemnitz University of Technology, Chemnitz, Germany
madlen.wuttke@phil.tu-chemnitz.de

Abstract. This contribution discusses the possibilities for mobile interaction and learning, facilitated by the increasing use of sensors in mobile devices. Each sensor provides information which is useful in certain learning contexts and allows for distinct interaction mechanisms. However a model is required how to collect the sensor data and connect it to the learning environment and content. A suitable architecture is described and the steps of the information flow are explained. Future prospects to enhance mobile interaction with more natural ways of communication supported by sensors are given.

Keywords: Collaboration technology and informal learning, Mobile and/or ubiquitous learning, Personalization, user modeling and adaptation in learning technologies, Technology enhanced learning, sensors, context information, architecture, m-learning.

1 Introduction

Over the last years smart mobile devices reached a significant market share [1]. They are characterized by having advanced calculating powers, high resolution displays, permanent internet access, an app store and social network integration as well as a full scale operating system like Android or iOS. They have essentially reached the technical level of former desktop environments while usability characteristics like display size, resolution and operating systems were standardized and gained a broad acceptance [15].

These devices use special interaction mechanisms like touchscreens and accelerometers which offer a broader and more natural human to computer interaction than previous desktop computers [2]. With increasing success they are used as e-learning devices, which is the focus of the research field mobile learning that can be defined as a special area of technology enhanced learning, where either a mobile device is used or the user himself is mobile and communicates with devices in his environment [3].

However almost all e-learning contents and interaction mechanisms are aimed at desktop devices. For this reason an adaptation to the special characteristics of mobile devices is required to better support mobile learning processes and to fully use their potential [4]. Especially for interaction purposes mobile devices offer more

P. Zaphiris and A. Ioannou (Eds.): LCT 2014, Part II, LNCS 8524, pp. 165–172, 2014.

possibilities and channels than most desktop e-learning environments. Several sensors, primarily used in the mobile interaction and communication processes, have a high potential for mobile learning. In addition, the interaction with the environment, personalization and continuous reachability in social networks can be used to promote learning purposes.

2 Sensors in Mobile Devices

Sensors are converters that measure physical quantities and convert them to signals or data which can be interpreted by users, electronic instruments or applications [16]. Most sensors need to be calibrated which in the case of mobile devices is usually part of the manufacturing process.

Examples for sensors used in current devices are the camera, microphone, accelerometer, gyroscope, GPS, temperature, light, humidity and pressure sensors, orientation sensor, magnetic sensor and the clock as a time measuring instrument. Related are scanners for mobile networks or Bluetooth devices.

2.1 Typical Sensors and Interaction Mechanisms for m-Learning

One important sensor of mobile devices which is usually not present in desktop environments is the accelerometer. It is used to calculate the orientation of the device in space and to measure any motion of the device. Furthermore, it's movement can serve as an indicator of the distraction level the user is experiencing during the mobile learning process. Shaking the device can trigger actions like activating learning content or switching to the next chapter while acceleration can be used to showcase physical processes within learning content.

Most devices, except special ones used for secure business areas, include cameras. With this sensor, it is possible to determine whether the learner is facing the device, if he is focused on the content or elsewhere and to provide augmented reality support [5]. A small variety of facial expressions is also detectable by several phones. A camera can be used to recognize an individual learner, which is useful to offer content according to one's personal learning history and offer other personalization and context features [6]. The camera is also useful to attach pictures or videos of real life situations to learning content and to or to collect further data by scanning codes like QR tags, which provide additional information.

With the microphone it is possible to record annotations of the learner to the learning content, to give commands to the application and to communicate with other learners [7]. The microphone can be used to collect all environmental audio data and connect it to the current learning process, e.g. the audio is repeated when the user repeats the learning process which supports a better knowledge representation. The audio information can also be used to change device parameters like the volume or to request a repetition of the learning content due to a sensed disturbance. In connection with the internet cloud based speech recognition programs can be used to search for answers to questions.

The light sensor measures the ambient light level or illumination in lux. It can give information whether the mobile device is covered or worn in a pocket and when used outdoors of sun position and day or night time. The light sensor is able to adapt the mobile device parameters to the learning environment as it provides the ability to adjust the brightness of the mobile display to the environmental factors. A valuable information for learning is whether the device is covered which means a learning process should be put on hold if it does not solely rely on audio content.

The GPS sensor determines the current location of the mobile device with the help of satellite position information and is able to provide hints about the movement speed of the user and the altitude. Especially the location is an important context information which is especially true for learning purposes as it is one main factor that determines whether the environment is suitable for learning. The location is essential for learning recommendations based on objects or people nearby and a lot of additional information is attainable by combining the location information with content from the internet [12]. It shows whether the user is learning at home, in the library or at the university, where he has learned before. Another example would be whether or not he is moving in a car or public transport, where learning might be possible but only with specific content which has been adapted to a short travel time. With the positional information, situation based mobile learning approaches become feasible.

A clock is able to measure the learning time and to keep track of the learning history. The local time, especially in combination with a calendar, schedule or reminder is able to trigger learning events, request users to learn after intervals and arrange meetings with other learners. In assessments the time is usually a measurement for success. Sessions for learning and other activities can be defined and frequent situations of mobile spare time e. g. while travelling can be identified.

The temperature sensor measures the temperature of the device or the ambient environment. It indicates weather conditions and detects temperature changes, which are further indicators about indoor or outdoor learning situations. Moreover it is more difficult to learn in an unusually hot or cold environment which might be an indicator for adjustment of the learning content.

A proximity sensor measures the position of an object relative to the surface of a device. Usually the sensor is typically used to determine whether a handset is being held up to a person's ear [18] or, within a learning context, it can be used for gesture based control of the content or for an intuitive interaction with a virtual teacher.

2.2 Other Sensors

Other available sensors include the barometer which supports the GPS location service in cloudy weather conditions, the compass or magnetic field sensor, which is also mainly useful for navigation purposes, and the humidity sensor.

In addition to these commonly built in sensors additional wearable sensor systems are available which typically connect to the mobile device via Bluetooth. Especially the biophysiological values of a human body can be measured in this way, often a special watch or wristband is used to collect pulse data, body temperature and motion.

These can also be an indicator for the stress level or exhaustion which is useful in a learning context.

With Bluetooth it is possible to scan for other users in the area using a learning tool or to exchange data between users. Data sent from local objects can be received and some objects can be manipulated and controlled, which offers a wide variety of real world interaction suitable for learning.

Another channel, which has not been previously mentioned in detail is the multi-touch screen, which allows for several ways of interaction usable for mobile learning, but is mainly seen as an input device and not as a mobile specific sensor.

Most of these sensors can also be plugged into a desktop computer, but when designing an e-learning environment these cannot be assumed in the same way it is possible for an average mobile device, which is a special characteristic and advantage of a mobile learning environment.

3 Combining Sensor Data to Identify Learning Situations

A combination of collected sensor data can be seen as typical for a special situation the user is experiencing [17]. By defining a range of conditions to match certain situations it is possible to categorize, save and later to recognize them. Some of these situations are more suitable for mobile learning purposes and some need an adaption of the content or the device parameters to maximize the learning support.

Examples are quiet and noisy surroundings, spaces where there is typically less time for learning than elsewhere and times and dates when a learning routine took place in the past and is likely to be repeated in the future. This information could be obtained by recording sensor parameters of such a situation [14]. The captured dimensions of the sensors need to be in a certain range to be classified as a known learning situation.

Based on a recognized learning situation a content proposal mechanism [13], interaction mechanisms or device parameter adjustments to support the learning process can be activated. Examples would be complex content in quiet situations without much distraction, like being in the library or at home, and short learning nuggets in busy situations, like travelling in a public transport.

4 A sensor Based Interaction Architecture

4.1 Technical Collection of Sensor Data

To make the sensor data usable for learning purposes, a service has to collect the data and provide ways for an e-learning application or learning management system to obtain this data. The service collects the data of the selected sensors continuously and, after a filtering process to reduce the complexity, streams it to the applications. A suitable transfer format for the multi-dimensional information is necessary to extract the relevant data and to convey it to the learning application.

4.2 Interaction Architecture

A suggested architecture to work with sensor data to support the interactions in mobile learning is described in the following paragraph. Using a client-server architecture multiple mobile devices can be supported by a server, which hosts the learning content, and a certain mapping logic for sensor data. This data is collected through a context service [8] which aggregates the raw data of all hardware sensors and then filters it to reduce the amount of data to relevant parts needed in the current context.

This data is sent to a server, where a decision making engine maps it to different categories and determines the degree of fulfillment of a certain action or decision. Based on this, a learning situation may be recognized and suitable learning objects can be chosen and sent back to the mobile device [comp. 9].

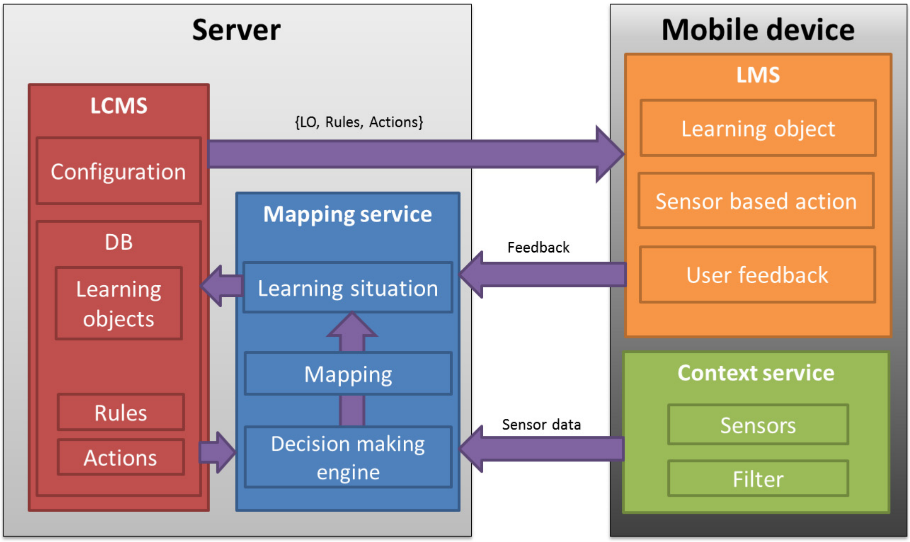

Fig. 1. Sensor based interaction architecture

The learning management system on the client's mobile device delivers the learning object sent by the server to the user. The learner benefits from learning content that is appropriate to the actual context he is currently in. In addition, an assisting mechanism to better support the mobile learning in the recognized situation can be started. An example would be the rise of the volume level or the adjustment of the device's brightness level.

To adjust the decision making process on the server, user feedback data is collected about whether the learning object and assisting mechanisms were appropriate for the learner.

5 Connecting Sensors and Learning Content

To connect the sensors with the learning environment a model which supports sensor data acquisition and the inclusion of the sensor data within the learning content is necessary. Furthermore, if the sensor information is supposed to trigger actions to support the mobile learning process, an event based interaction model specified for the learning content is required.

A set of rules determine the way the sensor is used and how it affects each learning content.

The following figure [Fig. 2] shows mobile learning content which is connected with sensor data. The sensors can be clipped to the learning objects and are indicated by icons. During the learning process the sensors are used to display information in the content or to change device parameters.

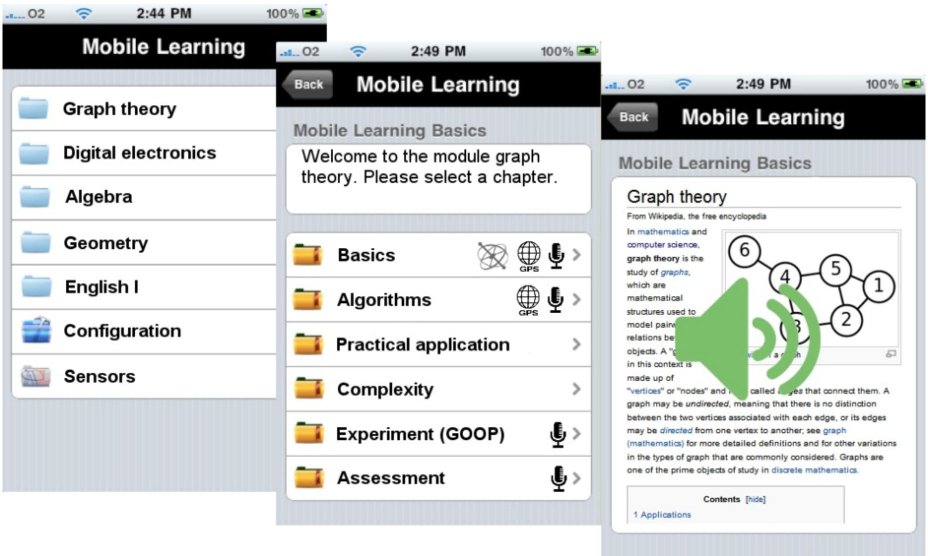

Fig. 2. LMS with Learning Objects connected to sensors

6 Towards a Mobile Pedagogical Agent

A natural form of tutoring and interaction in e-learning is the communication with or through a virtual pedagogical agent. In this context the collected sensor data can serve as a basis for a mobile pedagogical agent to allow a human-like form of interaction with the mobile device. The advantage of such a system would be to have a mobile learning system which is visualized by a face, following the theoretical implications of the persona effect [10]. The sensors would serve as senses and interaction channels for an agent. Furthermore, the sensory equipment could not only be used as a passive source of surrounding environmental information, but result in a pro-actively assessing agent-infrastructure [11]. By implementing aforementioned senses to the pedagogical agent, the transfer of knowledge would be greatly enhanced, since learning software usually does not observe the user's visual attention to the learning material nor does it check for disturbing noises in the learning environment. By opening up these additional channels of non-verbal communication, any e-learning software would be able to adjust its material presentation and enables it to react pro- and retroactively to disruptive occurences.

7 Conclusion

This paper discussed the different sensors available in mobile devices with the focus on enhancing the mobile learning experience. Several techniques to use sensory information for mobile learning purposes were presented and scenarios for practical application, methods for implementation and evaluation are suggested. Using a sensor based interaction architecture, matching rules and the concept of defining specific learning situations from data aquired by sensors is a feasible way to utilize this context information in learning content.

Following this evolution an efficient use of sensor data leads to more natural ways of human computer interaction and thus can be used to further enrich e-learning scenarios and support mobile aspects of learning.

References

1. Franklin, T.: Mobile Learning: At The Tipping Point. The Turkish Online Journal of Educational Technology 10(4) (2011)
2. Roschelle, J.: Keynote paper: Unlocking the learning value of wireless mobile devices. Journal of Computer Assisted Learning 19(3), 260–272 (2003)
3. Rensing, C.: Szenarien und Erfahrungen mobilen situierten Lernens an Hochschulen. DeLFI (2012)
4. Sharples, M., Taylor, J., Vavoula, G.: Towards a theory of mobile learning. In: Proceedings of mLearn 2005, vol. 1(1), pp. 1–9 (2005)
5. Gellersen, H.W., Schmidt, A., Beigl, M.: Multi-sensor context-awareness in mobile devices and smart artifacts. Mobile Networks and Applications 7(5), 341–351 (2002)
6. Taylor, J.: A theory of learning for the mobile age. In: Medienbildung in Neuen Kulturräumen, pp. 87–99. VS Verlag für Sozialwissenschaften (2010)
7. Sarker, S., Wells, J.D.: Understanding mobile handheld device use and adoption. Communications of the ACM 46(12), 35–40 (2003)
8. Chia, Y., et al.: Context-aware mobile learning with a semantic service-oriented infrastructure. In: 2011 IEEE Workshops of International Conference on Advanced Information Networking and Applications (WAINA), pp. S.896–S.901. IEEE (2011)
9. da Silva, L.C.N., Neto, F.M.M., Júnior, L.J., de Carvalho Muniz, R.: Recommendation of Learning Objects in an Ubiquitous Learning Environment through an Agent-Based Approach. In: Putnik, G.D., Cruz-Cunha, M.M. (eds.) ViNOrg 2011. CCIS, vol. 248, pp. 101–110. Springer, Heidelberg (2012)

10. Lester, J.C., Converse, S.A., Kahler, S.E., Barlow, S.T., Stone, B.A., Bhogal, R.S.: The persona effect: affective impact of animated pedagogical agents. In: Pemberton, S. (ed.) Human Factors in Computing Systems: CHI 1997 Conference Proceedings, pp. 359–366. ACM Press, New York (1997)
11. Wuttke, M.: Pro-Active Pedagogical Agents. In: Fakultät für Informatik (ed.) Proceedings of International Summer Workshop Computer Science, pp. 59–62 (July 2013)
12. Wang, S.-L., Wu, C.-Y.: Application of context-aware and personalized recommendation to implement an adaptive ubiquitous learning system. Expert Systems with Applications 38(9), S.10831–S.10838 (2011)
13. Hong, J., et al.: Context-aware system for proactive personalized service based on context history. Expert Systems with Applications 36(4), S.7448–S.7457 (2009)
14. Martin, K.-U.: Delivering complex learning content on mobile devices. In: World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education, pp. S.161–S.166 (2013)
15. Ally, M. (Hg.): Mobile learning: Transforming the delivery of education and training. Athabasca University Press (2009)
16. Eckardt, D., Hettich, G., Schmid, H.-D.: Sensor for measuring physical dimensions and process for balancing the sensor. U.S. Patent Nr. 4,845,649 (1989)
17. Martin, K.-U., Hardt, W.: Adaptive agent supported mobile learning. In: International Summer Workshop Computer Science 2013, vol. 17, p. S.28 (2013)
18. Hinckley, K., et al.: Sensing techniques for mobile interaction. In: Proceedings of the 13th Annual ACM Symposium on User Interface Software and Technology, pp. S.91–S.100. ACM (2000)