A MOBILE SENSOR DEVICE FOR LEARNING SUPPORT: DESIGN CONSIDERATIONS

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LISA – Learning Analytics for Sensor-Based Adaptive Learning - is a research project[1] including 3 scientific partners (Hochschule für Technik und Wirtschaft, Berlin, Humboldt-Universität zu Berlin, Leibniz Institut für Wissensmedien, Tübingen) and 3 companies (NEOCOSMO, Saarbrücken, Serious Games Solutions, Tübingen, SGM Educational Solutions, Berlin). The principal goal of the LISA project is to provide support to a learner, analyzing learning activities from different learning environments together with a learner's vital data obtained from sensors. There are 3 principal working packages in LISA: the development of a mobile sensor device (SmartMonitor), which acts as a learning companion, a learning analytics engine (backend) to provide learning analytics methods as a service, and the adaptation of learning applications to support sensor-based adaptive learning. In the following, we will present 3 design aspects for SmartMonitor development, which have been realized in a prototypical state.

Keywords: learning support, analyzing learning activities, mobile sensor device.

Sensor Data for Learning Support: A mobile device which accesses sensor data has the potential to detect areas of learning such as cognition, emotion, behavior and context. For instance, attention level can be detected using a camera (Sharma et al., 2016) and both heart rate sensors and galvanic skin conductance sensors can monitor motivation (Mandryk and Atkins, 2007). A learner's movements can be measured using accelerometer, gyroscope, GPS and barometer. Furthermore, information related to a specific learning space can be obtained using location detection sensors, camera and microphone (Schmidt, 1999), or environmental sensors like an air quality sensor. Nethertheless, relating a specific learning state with actual sensor data needs in-depth research.

Fig. 2: Sensor prototype

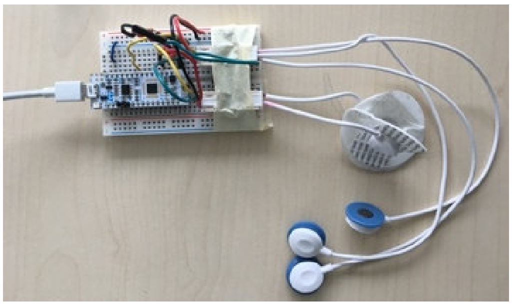

Fig. 3: Emergency training

Interpretation of Sensor Data in a Learning Environment: In the LISA project, a prototype of a wearable sensor device was developed, which contains EDA- and ECG-sensors as well as a Nucleo microprocessor. Actually, it is used to carry out experiments in different learning scenarios, to provide valid data sets for further investigation. The "multimodal" data sets comprise sensor data (EDA – electro-dermal activity, ECG – electrocardigraphy), data derived from sensor data (HRV – heart rate variability, derived from ECG), and educational data, i.e. learning activities w.r.t. the specified learning scenarios. The first scenario is a cognition-oriented experiment, recording sensor data while conducting a mathematical task (bisection task). The second one is emotion-oriented, watching and rating IAPS pictures (International Affective Picture System). The third scenario records sensor data in a serious game for emergency training.

Awareness of a Learning Context: The definition of learning context can vary from its literal meaning which is limited to spatial information to a broader understanding of interactions between learner and learning environment. Properties of a physical learning space are important for effective learning as they affect learning progress and outcomes (Heschong, 2002). Learning space criteria for effective learning are fresh air supply, comfortable temperature as well as good lighting and sound conditions (BRANZ, 2007). Within the LISA project, a prototype aimed at increasing awareness about the physical learning environment was developed, showing actual state and progression of CO_2, humidity, temperature, light and sound conditions. Additionally, studies on learning context consider both learners' cultural, virtual, knowledge-related and social aspects and conditions, and the effects a learning environment imposes on learners. Within the LISA project, internal learning contexts, comprising cognition, emotion, and behavior, will be investigated via the physiological sensors described above.

Fig. 3: prototype with environmental sensors

Fig. 4: Design study (1)

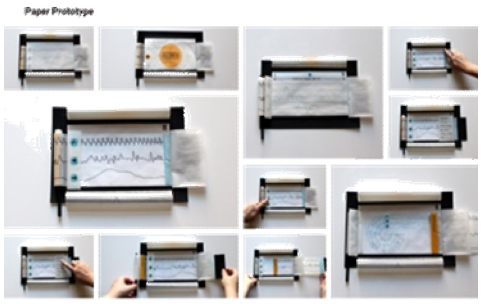

Fig. 5: Design study (2)

HCI Considerations for Learner Interaction: To provide awareness of learning contexts back to learners, the LISA SmartMonitor was designed a learning companion (c.f. Yun et al, 2017), based information related to a learner's physiological state, as well as information about the physical learning space. To further develop the idea of a learning companion supporting adaptive learning, we used a user-centric design approach including a design study, focus group discussion, development of prototypes and a HCI workshop. The discussion within the focus group revealed basic requirements regarding usage scenarios, functions, visualizations, mobility, dialogue-types and privacy. Based on these requirements design variations were developed in a design study, focusing on interaction flow, visualization of sensor data and enclosure of the SmartMonitor device. Building upon the design study, a group of computer science students built a digital prototype of the SmartMonitor, implementing the core visual und interaction concepts. First informal evaluations of the digital prototype revealed difficulties regarding visualization of graphs and verbal feedback, and raised questions whether it is needed to show raw sensor data. An HCI workshop was conducted to refine the dialogue and visualization principles under the perspectives usability, user experience, and ethics and privacy. Key findings of the workshop can be summarized as: providing options to customize visualization of sensor data, visualizing the learning progress, providing a back channel from the LISA analytics application, and giving the learner full control recording, storing and processing sensor data. Additionally, learners could take notes via the SmartMonitor device. Based on these findings, we will conduct further studies on interaction between the SmartMonitor as a learning companion and the learner, as well as studies on hardware design of the SmartMonitor device.

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Мобильное сенсорное устройство для поддержки обучения: Особенности проектирования

LISA - учебная аналитика для адаптивного обучения на основе сенсоров - исследовательский проект, выполняемый тремя научными партнерами (Hochschule für Technik und Wirtschaft, Berlin, Humboldt-Universität zu Berlin, Leibniz Institut für Wissensmedien, Tübingen) и 3 компаниями (NEOCOSMO, Saarbrücken, Serious Games Solutions, Тюбинген, SGM Educational Solutions, Берлин). Главная цель проекта LISA - обеспечить поддержку учащегося, анализируя учебные мероприятия в различных учебных средах вместе с жизненно важными данными учащегося, полученными от датчиков. В LISA есть 3 основных рабочих пакета: разработка мобильного сенсорного устройства (SmartMonitor), которое действует как обучающий компаньон, учебный движок аналитики (backend), чтобы обеспечить методы обучения аналитике как услугу, и обучающих приложение для адаптивного обучения на базе датчиков. Далее мы представим три аспекта проектирования для разработки SmartMonitor, которые были реализованы в прототипе.

Ключевые слова: поддержка обучения, анализ обучающих действий, мобильное сенсорное устройство.