Platform for Ambulatory Assessment of Psycho-Physiological Signals and Online Data Capture

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ABSTRACT
Over the last years there has been an increasing interest in finding new methods for capturing psychological, behavioral and physiological data in real-time using infield data acquisition systems. Within our research group a system for ambulatory assessment of psycho-physiological signals for real-time data capture has been developed. The system is based on Smartphones which are equipped with software to record contextual and subjective data from participants and have that information transmitted wirelessly to a central online database. An online database offers the possibility of collecting, storing and analyzing all study related data in a central point. This paper provides an overview of this system.

Author Keywords
Platform, Ambulatory Assessment, Smartphones, Self-report method, Field Studies, online database

ACM Classification Keywords
J.4 Social and Behavioral Sciences: Psychology

INTRODUCTION
Self-report methods for understanding everyday human behavior in form of diaries or questionnaires are a very common procedure in the field of medicine, psychology and sociology. In the past, studies that include self-report have mainly been done via paper and pencil; participants were given questionnaires after the study and were asked to fill them with their thoughts or feelings. Such procedures have the disadvantage that the participants can only estimate the events in the past and thereby make false statements. Paper diaries try to solve this problem by letting the participant track the events during the study [1]. But the participants often fill out the diary at the end of the day which also leads to false estimation. An electronic diary can exactly track the times when an entry was made which makes it possible to better characterize the statement of the participant.

In the last years, a wide range of hardware and software solutions, focusing on multichannel systems for physiological data acquisition and hand-held computer based experience sampling systems has been developed [2]. However, the systems that have been developed up to now do not provide one solution that combines all the key features and that would set a standard platform for studies in different research fields.

The main goal of this paper is to present all components of a mobile system that collects physiological, psychological and contextual data (e.g. the geographical position) and stores them in a central online server. The mobile data collecting software is designed to run on Smartphones. These devices are not only a very good platform for mobile data acquisition they also provide multimedia features such as digital photo or video capture. Once the data is recorded, using the Smartphones connectivity to the internet, the data can be transmitted to a central online database. This feature provides the researchers with the ability of having real-time information regarding the ongoing study.

SYSTEM OVERVIEW

Mobile Sensors
Smart mobile sensors are recording physiological signals like the electrocardiogram, the activity or the galvanic skin response. From these physiological signals, important features are extracted. These features are transmitted to the

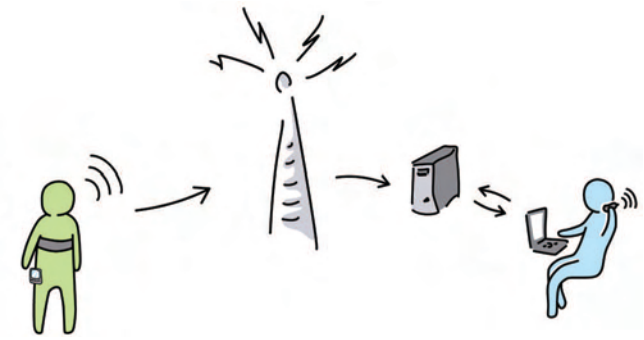

Figure 1. Schematic overview of the system.

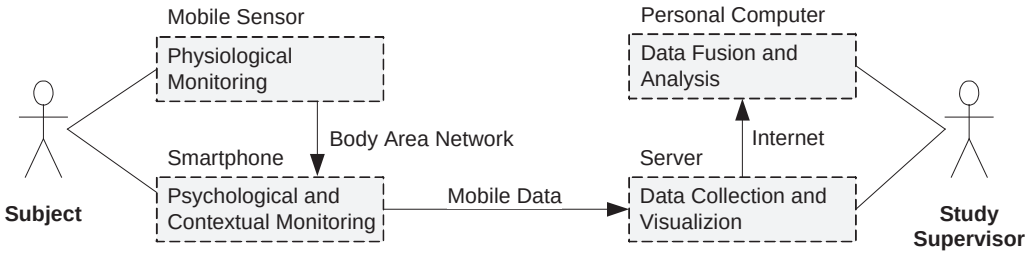

Figure 2. Components of the data collecting platform.

Smartphone over a wireless body area network. For this wireless technology, Bluetooth has been the best solution due to its technical benefits and also because many vital sensors are already outfitted with the necessary radio hardware. Depending on the study either a continuous stream of extracted features is transmitted to the Smartphone or, if this consumes too much power, events can be transmitted as soon as features reach a defined threshold.

Smartphone

On the Smartphone we use the open-source software MyExperience that runs on Windows Mobile devices. Besides the synchronous recording of the features received from the mobile sensors MyExperience also collects self-reports of the participant to gather quantitative and qualitative data on human behaviors in the field [3]. MyExperience is based on a three tier architecture of sensors, triggers and actions. Triggers use sensor event data to conditionally launch actions. E.g. Self-reports can be questionnaires which are triggered by features from mobile sensors [4].

We extended MyExperience to transmit the collected physiological, psychological and contextual data to an online server.

Server

In order to achieve a modular, flexible and reusable online platform for study-relevant data collection and visualization, there are several things to focus on. First of all it must be a system capable of handling any kind of content. It also needs to be expandable and configurable to meet the special needs of each study. Another important thing is that it is expandable and not be limited to solve a specific problem.

A Content Management System (CMS) is an application to collaboratively create, edit, and review various kinds of digital media. We analyzed the possibilities of storing study relevant content such as questionnaires, cognition tests, location tracks or physiological data in Content Management Systems. For this task we compared different open-source CMS which accomplishes this task best.

Because of its modular and extendable architecture the CMS “Drupal”, which is also called a Content Management Framework [5], fits the requirement of handling different data and different studies.

Drupal accomplishes this task by abstraction. It provides systems and tools that allow assembling of different modules that can be combined to achieve a completely new functionality. The content managed by Drupal is stored in so called nodes. To achieve an abstraction the main content types are a variation of a “node”-Object. Nodes hold structured data (such as Title, Content, Author and Date). It is possible to create custom content types that extend a node by additional fields (e.g. the content type “personal data” could have the fields: name, gender and age).

A module extends Drupal features. It is possible to write custom modules by using the programming language PHP and interact with Drupal via an Application Programming Interface (API).

With this flexible architecture it is possible to use modules to build a server specific for a study that collects, processes, stores and visualizes relevant data. The modules can be shared with the community so that other researchers can use them in their studies. There are already lots of contributed modules developed and shared by the Drupal community. For example there are several modules available that can be used to visualize results of a study in a graph.

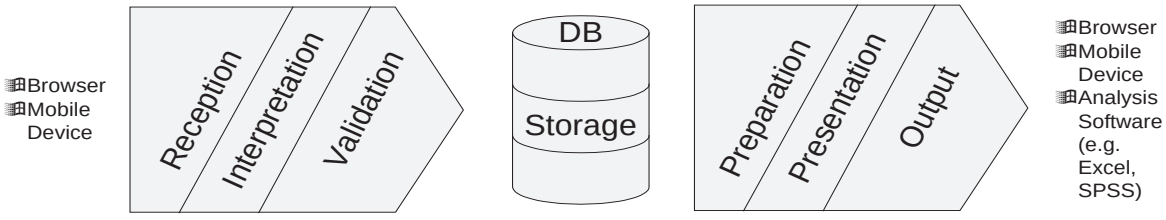

Figure 3. Modular Architecture of Drupal-Server.

Personal Computer

The study supervisor can monitor the study over a browser on his personal computer and view data collected in real-time. Additionally, he or she can download the collected data for further data fusion and analysis.

STUDIES

Although the system is still being developed, it has already been applied to a number of studies. The participants were all students of the Karlsruhe Institute of Technology (KIT) and the following studies have been carried out in the year 2009:

- Mobile acquisition of vital parameters and geographic position [6].
- A study investigating the mental state of 100 students during lectures.
- A study carried out in cooperation with the Department of Sociology where the student's campus life was investigated.
- An investigation into the cognitive ability of students during lectures.

CONCLUSION

In conclusion, within this article all components of a mobile online monitoring system have been described. The advantages of this system are that no more data allocation or conditioning is necessary because all the data is stored in a central point. Further studies will be carried out in order to generalize the system and to establish an integrated solution that can be used in a wide range of research studies. This research establishes a basis for further developments in the field of real-time psycho-physiological monitoring.

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