Service Platform for Personal Medical Training Roadmaps

Analyze and tune rehabilitation of cardiologic dominated diseases

Ralf Seepold
Ubiquitous Computing Laboratory
HTWG Konstanz
Konstanz, Germany
ralf.seepold@htwg-konstanz.de

Patrick Datko
Ubiquitous Computing Laboratory
HTWG Konstanz
Konstanz, Germany
padatko@htwg-konstanz.de

***Abstract*—Rehabilitation from cardiologic dominated diseases include physical training supervised by professional medical personal. This work will provide a platform to interchange vital data (e.g. heart rate), gathered during physical exercises, between a patient and medical personal without further interaction by the patient. Based on the analysis of data by medical professionals, the personal health plan (roadmap) can be tuned to the needs. The patient has access to his data, he can compare exercises over the time and he can recognize general tendencies. The patient can actively plan new activities without running the risk to pass critical thresholds because relevant vital parameters are monitored.**

Medical roadmap training; cardilogic sensors; sensor integration; personal health profiling

I. Introduction

As a consequence of a continuous increase in the average age of people in European society and the need to reduce health service costs, efficient rehabilitation activities are of raising importance. The teamwork between professional (medical) personal and patient is key for a successful treatment. Most often, rehabilitation requires a longer period of monitoring and customizing of parameters according to a patient's needs and evolution. As an example, the heart rate can indicate the intensity of an exercise over time that should be limited and must not pass a threshold fixed by medical personal. However, the threshold may be different after a longer training period. Since long-term hospitalization is not a feasible solution, rehabilitation at home (but outside of the house) is common. However, the treatment cannot be done completely offline, since control and adjustment of the training parameters (e.g. duration and stress of exercises), is a duty of the medical personal. In many cases, rehabilitation from cardiologic dominated disease domains (CDDD) can be treated with exercises like bicycle driving. Therefore, this use-case will be in the focus of the work. However, conditions of routes, personal limitations and monitored parameters have to be taken into account when executing the training. Controlled support from an electronic bike when driving uphill and thus not passing the heart rate threshold can be one way to support the driver. It is clear that this help cannot be made available after but during the ride. In other words, a system is required that uploads data, processes data and pushes feedback to the driver. The 'feedback' can be the start of the electronic motor supporting the uphill drive or to stop the driver from proceeding in the exercise. The following work uses smartphones: to communicate to a platform, receive feedback from the platform, gather data from internal sensors (like GPS data) or external sensors (like a heart rate sensor) and push it to the platform. Furthermore, the development of a useful platform to provide services to the driver (e.g. heart rate logging, route tracking etc.), and services to the medical personal (e.g. long-term training analysis). And finally, a smartphone application capable to provide a GUI and needed features to communicate to services hosted be the platform.

II. Supporting Technologies

In comparison to the situation some years ago, the market of smartphones raised very much [Gar11a]. As a result, many people own a smartphone that can be used as a client connecting to a server that is hosting a platform providing services tuned to the discussed CDDD. Besides the communication feature, smartphones offer several possibilities to connect to internal sensors and external sensors. With internal sensor we are referring mainly to sensors provided by the smartphone (e.g., GPS or movement). External sensors are completing missing functionalities needed for our application area. Several proprietary sensors are on the market; for example sensors like a Shoe Pod Datasheet [Car12], or a more sophisticated solution integrated into textile [Var12].

Currently, the market share is mainly divided between Android (25%) and iOS (16%) operating systems (OS), while Microsoft (2%) presented the first OS considered competitive in this mobile phone market [Gar11b].

III. System Architecture

The system is composed of three parts: the client (smartphone), the sensors (internal and external) and the server (main service platform). The client is responsible to establish the communication to the server (upload data), to access to different sensors and to receive the data pushed back from the server; computation capacity is regarded as limited. The sensors are internal sensors like GPS sensors provided by the smartphone or external sensors connected to the smartphone. Internal sensors have few or no integration effort but CDDD tuning is low. Therefore, more specific sensors have to be integrated. A sensor that is measuring the heart rate can serve as an example, since typically it is not part of a smartphone's internal sensor set but required to measure relevant vital data of the bike's driver.

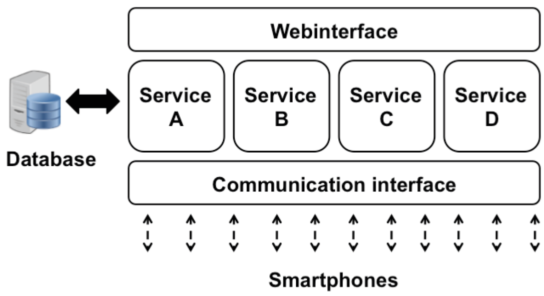

Figure 1. Principal system architecture

Figure 1 shows the principal architecture of the system (without mentioning sensors explicitly). The smartphone is connecting to the main service platform via a communication interface. Services a clearly defined and separated one from each other. The top layer is a Webinterface supporting different applications to access, e.g. a medical application running on a desktop PC. It is assumed that the amount of data generated is big, and therefore, it should be stored in a database for efficient access and processing by the services. A service can be a tagging of a route driving by bike or a planning service to propose new routes according to the personal profile and training plan.

A. First prototype

A first prototype has been implemented with the support of an existing real-time platform [Ber12]. The tracking of positions has been made with a simple position algorithm. However, the tagging selected was not very accurate; fast movements like biking could result in missing points not tagged due to high speed driving and low tagging frequency. As a result some positions are not documented. This is no major issue, since the first implementation should show the general feasibility of the model. A good overview for suited tracking and tagging can be found in [SP08].

Figure 2. Routing tags visualized

The route has been documented in Google Maps™ and the person could analyze the route later on the screen. In principle it is possible to track the route only via the server since tagging points are transmitted and uploaded in real-tine. An example is presented in Figure 2; it shows the results of a tagged route. Due to limitations in the interface when passing a high number of tagged points, the resulting track visualization may vary: the red line shows the exact visited positions (driving from A to B), while the blue line is created by Google Maps™ only allowing a limited set of data uploaded.

The navigation on the smartphone is looking like in Figure 3. In this first approach, you can see the direction to the next checkpoint (when again driving on a previously tagged route), the number of checkpoints missing to complete the track, the distance and the remaining total distance for the run. This has been taken from the uploaded tagged track, in order to re-run it, for training purposes.

B. Extended model

Until now, the relevant data for cardiologic dominated disease domain (CDDD) has not been measured. This is planned as the next step: Firstly, we need to select the sensor, and secondly, we need to push this data to the backend server. This data need to be accompanied with additional information, like e.g. the speed, direction or the inclination. In a second step, we need to derive the personal profile from the user. This means, since every person will have different capabilities and training roadmaps, the plan and the future evolution must be tuned to a person's profile. The profile to be developed will be a mixture from past (experiences), current "fresh" data and general limitations (e.g. max. heart rate). A deep investigation on capturing profiles has been made in [FASM12]. This work will serve as a basis to extend or re-design the algorithm, and finally, to match the domain specific needs (to be defined). The result is the design of a *person profile derivation algorithm*.

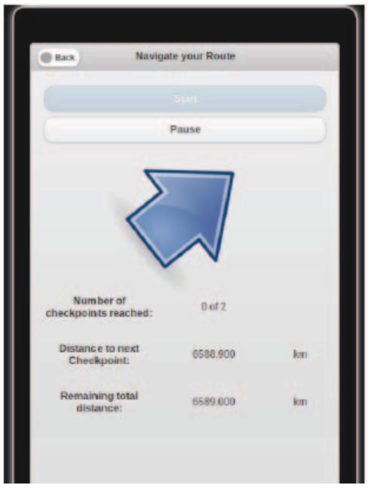

Figure 3. Routing tags visulized

C. Enhanced prototype

After showing the principal feasibility of the approach and after designing the enhanced model, it is planned to setup the backbone server as an open-source solution with the following capabilities: Implement the architecture shown in Figure 1. We propose to use the play framework [PLA12] that comes with routing, a template engine and supporting web services. The database interface supports PostgreSQL and MySQL out of the box. Then, design a service integration architecture with open interfaces: ANT [ANT12] may serve as a communication standard to integrate external sensors, since there are several devices on the market and many smartphone already support ANT or ANT+ for communication. And finally, integrate the person profile derivation algorithm into the enhanced prototype architecture.

IV. Results and Future Work

Cardiologic dominated disease has been identified as a major economic problem. Individual training incorporation medical personal and providing a personalized roadmap for rehabilitation could lower long-term investment of the public sector. In a first approach a feasibility study has been made to integrate route tagging and analysis into a smartphone application. A server platform has been used to analyze the tracks later and thus provide input when repeating tracks. The prototype is working and enhanced to cover more accurate navigation/tracking data. The next step is the design and integration of three main elements: the extension to integrate typical sensors used to capture relevant data, to develop an algorithm to profile a user and to design and implement the overall system architecture. Later, the profiling will be used to adapt and tune the medical roadmap to personal needs, also showing a long-term behavior. Together with a novel algorithm (personal health profiling) the system will support to reach the overall goal: individual training support with medical supervision and guided rehabilitation.

References

[ANT12] ANT Network, Wireless sensor network technology, Wikipedia, 2012, http://en.wikipedia.org/wiki/ANT_network

[Ber12] Bernot IT, M3 Platform, BERNOT Information Technology, 2011 www.bernot.net/eng/pages/start

[Car12] Cardiosport, Shoe Pod Datasheet, Healthcare Technology Limited, 2012. www.cardiosport.com

[FASM12] J. M. Fernández, J.C. Augusto, R. Seepold, N. Martínez Madrid, "Why Traders Need Ambient Intelligence," in Advances in Intelligent and Soft Computing series, Springer-Verlag Berlin Heidelberg, vol. 72, pp. 229-236, 2012 [accepted for publishing]

[Gar11a] Gartner. "Gartner says sales of mobile devices in second quarter of 2011 grew 16.5 percent year-on-year; smartphone sales grew 74 percent. Website, August 2011". http://www.gartner.com/it/

[Gar11b] Android Market Share Doubles, iOS Drops In Q3, http://www.gartner.com/it/page.jsp?id=1848514".

[PLA12] Playframework, Build web applications with Java & Scala, www.playframework.org, 2012

[SP08] Maj. R. Sabatini and Prof. G.B. Palmerini. Di erential Global Positioning System (DGPS) for Flight Testing. In SCI-135, the Flight Test Technology Task Group of the Systems Concepts and Integration Panel (SCI) of NATO Research and Technology Organisation, October 2008. http://www.rta.nato.int/Pubs/rdp.asp?RDP=RTO-AG-160-V21

[Var12] Vijay Varadan et al., e-Nanoflex Sensor System: Smartphone-Based Roaming Health Monitor, Journal of Nanotechnology in Engineering and Medicine, Vol. 2, ISSN: 1949-2944, 2011.