On Location-Based Services for Patient Empowerment, Guidance and Safety

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Abstract. The importance of patients' active participation in healthcare delivery and disease management has been highlighted in various studies, especially for chronic patients. Overall, patient empowerment, guidance and safety constitute concrete goals in modern healthcare systems. To this end, mobile computing technologies can enable to realize such services in a pervasive manner, tailored to each patient's specific needs. The current work elaborates on the utilization of outdoor location information to deliver personalized services to patients, discriminating among reactive and proactive services according to their initiator and nature. In this regard, we present various use cases and relevant applications that have been developed by our group, exploiting this way the virtue and applicability introduced via the adoption of location-based services. The ultimate goal of this work is the development and establishment of an integrated framework for providing location-based healthcare information services targeting patient safety, empowerment and guidance.

Keywords: location-based services, mobile computing, patient safety, patient guidance, patient empowerment, personalization.

1 Introduction

Modern healthcare services delivery approaches emphasize on continuity and quality of care, personalization of services, and patients' active involvement in managing their health. Along these axes, patient empowerment, guidance and safety constitute concrete goals [1-2]. To this end, the utilization of mobile computing technologies, and the availability of location information in particular, lead to the development of healthcare services that are realized in a pervasive manner and meet the patients' specific needs and requirements in an "anytime-anywhere" fashion.

Location-based services in healthcare (both indoor and outdoor) have been recently explored in several works. For example, Kjeldskov et al. present a location-based service called 'GeoHealth' to support home healthcare workers, who attend patients at

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home within a large geographical area [3]. Boulos et al. elaborate on location-based services for patient independent living, that are provided via a light, wearable device [4], while Marco et al. target at the indoor localization of elder and disabled persons [5]. Location identification is crucial in health emergency scenarios where rapid response and action is needed. For example, in the work by Weixing et al. a mobile geospatial information system based on location-based services and wireless communications is presented aiming to enable rapid response to public health emergencies [6], while Vicente et al. investigate location-based access control policies in emergency situations [7]. Furthermore, location information is commonly employed and analyzed in conjunction with other attributes, e.g., various vital signs, such as the heart rate, and blood pressure, in order to monitor a subject's activity patterns [8]. Finally, mobile social networking systems have been presented [9], which employ location data for the delivery of various social networking services, mainly relying on the exchange of personal information.

In the current work, the primary focus lies on illustrating the use of outdoor location information as an important attribute in the design of pervasive health systems aiming to support the patients throughout their daily activities. Various use cases and applications that have been recently developed by our group are presented, aiming to illustrate the virtue and applicability of location-based healthcare services delivery.

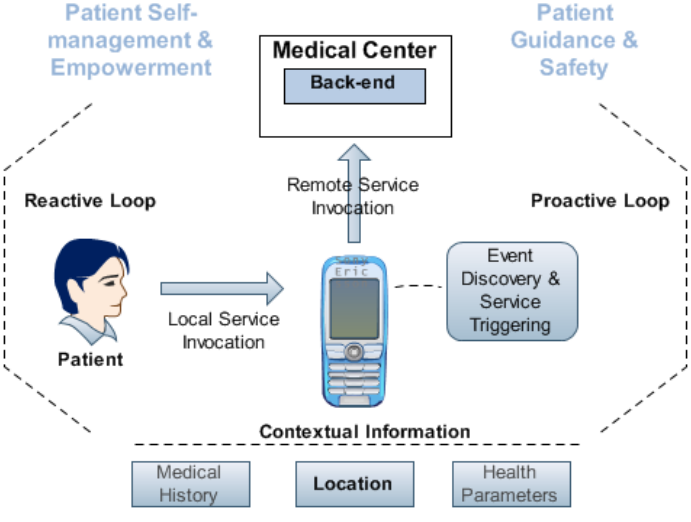


Fig. 1. The proposed conceptual framework for designing and providing location-based services for patient safety, guidance and empowerment

2 Methods

Figure 1 illustrates the overall conceptual framework of the current work. Using a mobile device, e.g., a smartphone or a Personal Digital Assistant (PDA), with outdoor

location detection, communication and computational capabilities, the patient is enabled to "consume" personalized services, which are either installed locally at his/her mobile terminal or remote ones that are available at the back-end infrastructure of the medical center. Among such services are self-reporting of symptoms coupled with the location of interest, information delivery on demand concerning community-based activities in terms of proximity, generation and communication of alerts to the caregivers when the location of the patient may indicate harm, etc.

Such services are deployed using the patient's location as a primary attribute. However, location can be considered as only one dimension of the contextual information related to the patient, which can be used in conjunction with others that include his/her medical history and/or user profile, various health parameters that can be monitored via available sensing devices, such as the heart rate and the blood pressure, the time of the day, etc.

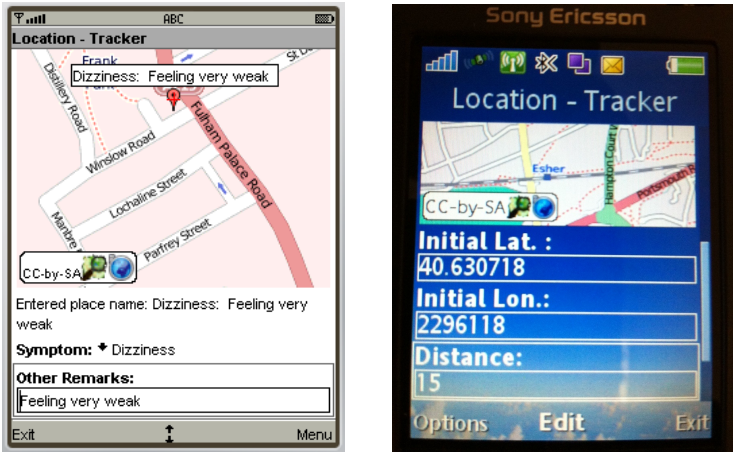
In the current work, location-based services are discriminated into two categories [10]: a) *Reactive services*, which are usually initiated by the users and require their constant interaction and attention being suitable for patient self-management and empowerment [11], and b) *Proactive services*, which are initiated either by the system or by the patient's family or caregivers and are typically executed in an event-driven manner, being particularly appropriate for patient guidance and safety. The services of the former type (employed in the *Reactive Loop* depicted in Fig. 1) are specifically targeted at chronic patients who are highly aware of their disease and wish to play a more active role in their disease management, gaining potential positive outcomes in their quality of life and well-being [12]. The services of the latter type (employed in the *Proactive Loop* depicted in Fig. 1) are adequate for emergency cases, where rapid response is required after the identification of a possibly hazardous situation within the *Event Discovery and Service Triggering* module.

In the following, we present various use cases and relevant applications that we recently developed corresponding to both reactive and proactive location-based services following the conceptual framework depicted in Fig. 1.

2.1 Reactive Location-Based Services

A characteristic reactive location-based service involves logging on a mobile phone various subjective elements concerning the patient's health status during his/her daily activities. This is particularly important for helping patients to understand their disease, providing them potentially with better insights into their self-management and treatment. Specifically, the patients are able to record various symptoms (e.g. dizziness, chest pain, shortness of breath, etc.), and associate their health status with their current location as illustrated in Fig. 2(a). Healthcare professionals may in turn receive this information via appropriate reports that are generated by the back-end framework, in order to identify and assess the potential health problems and hazards that patients may face and proceed with fine-tuning of their treatment and exercise plans.

Besides self-reporting, another reactive location-based service that we developed involves conveying information to the patients, which is generated by the members of relevant communities (e.g. young obese patients). Thus, the users can create events (e.g. walking, cycling, etc.) through their interaction with a map-based application, enabling them to share the relevant information with other members of the community. The aim of this service is to provide emotional support to the patients and/or increase their self-confidence towards achieving their personal health goals (e.g. losing weight). This information is provided by applying a filtering mechanism according to user-defined spatial criteria (e.g. physical distance from the events defined in the social networking platform).



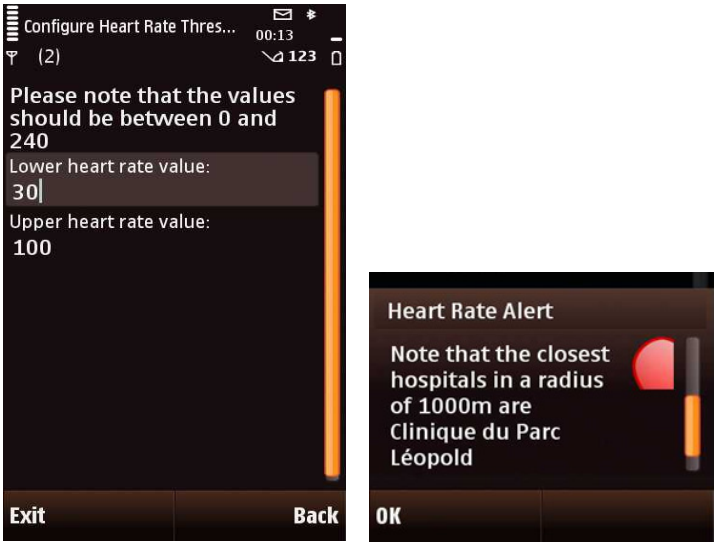
(a) (b)

Fig. 2. (a) Sample reactive, location-based service: reporting a health symptom on a map, and (b) sample proactive location-based service: tracking the location of a person with Alzheimer's disease

2.2 Proactive Location-Based Services

As a typical proactive location-based service, we developed a tracking tool focusing on safety aspects (Fig. 2(b)), which relies on a GPS (Global Positioning System) enabled mobile phone. The tool is particularly useful for easily tracking patients suffering from diseases such as Alzheimer's disease. In a first step, a geographic area is specified (e.g. by the health professional or the patient's family), denoting the patient tracking boundaries. This area is determined by defining a point of interest (POI) with a certain longitude and latitude and specifying a radius, formulating this way a virtual circle (the Region of Interest - ROI). If the patient enters or leaves the specified ROI, he/she is provided with relevant recommendations or guidance information, while the caregivers are informed with appropriate alerts encapsulated in SMS (Short Message Service) messages, denoting the patient's current location.

In the case where the constant monitoring of the patient's health condition is required, various sensor-enhanced devices may be utilized in combination with location data, as additional information sources for defining the patient's context [13]. In the current work, we elaborated on continuous monitoring of the patients' health condition by employing a wearable multi-sensing device that incorporates sensors for monitoring the heart rate, the respiratory rate, the skin temperature and the activity. By analysing the acquired data, event-driven patterns in the form of personalized ECA (Event-Condition-Action) rules may be defined by the healthcare professional in order to identify an emergency situation (e.g. a high heart rate) (Fig. 3(a)). Thus, in the case of an emergency, a service can be triggered aimed at the detection of the user's location and the discovery of the nearest hospitals or pharmacies (Fig. 3(b)), notifying also the healthcare professionals for the occurred event.



(a) (b)

Fig. 3. (a) Definition of emergency situations related to heart rate, according to configured thresholds, and (b) the message obtained by triggering a proximity service for the discovery of the nearest hospitals to the patient's location

3 Implementation

Prototypes of the presented use cases and services have been implemented and tested in JavaME platform (Nokia N86 and Sony Ericsson C905 devices) as well as on Android-based smartphones (Motorola Milestone), in order to illustrate their technical feasibility and realization. JavaME provides Application Programming Interfaces (APIs) that are appropriate for dealing with the small memory footprint and the limited processing capabilities that are typically met in mobile phones. On the other

hand, Android offers a Java-enabled platform that is particularly suitable for high-end smartphone devices.

As regards the location-based software modules developed, the Java Specification Request (JSR) 179 location API was used [14], in order to develop the required functionality, according to the user's geographic location. The Nutiteq's Mobile Maps API (http://www.nutiteq.com/mobile-map-api-sdk-guides/) together with the OpenStreetMap (http://www.openstreetmap.org/) were also employed for the provision of the necessary mapping capabilities, e.g. definition of POIs/ROIs and route handling. The SMS implementation relied on the Wireless Messaging API (WMA 2.0) JSR-205 [15].

Zephyr BioHarness (http://www.zephyr-technology.com/bioharness-bt) was employed as the multi-sensing device, while the communication between the mobile device and BioHarness was achieved by adopting the JSR 082 API for Bluetooth [16], which provides all the necessary methods for device discovery and the appropriate Bluetooth stream handling.

The communication between the back-end platform and the mobile terminal was realized by deploying a Service-Oriented Architecture (SOA) [17] based on Web services. For this reason, the JSR 172 API was employed [18], in order to provide the required Web service functionality based on the Simple Object Access Protocol (SOAP) and the Web Service Definition Language (WSDL). Moreover, aiming to flexibly implement and handle the required back-end operations, the Medical Center utilizes the Drupal platform (http://drupal.org/), which constitutes an open source Content Management System (CMS) based on the PHP server-side scripting language and offering various add-ons for robust service management.

4 Conclusion

Location-based services constitute a significant mean for healthcare service delivery particularly targeting patient empowerment, guidance and safety. Especially considering outdoor activities, modern mobile phone platforms may support efficiently the deployment of advanced location-based services through their (constantly advancing) sensing, communication and computational capabilities. This work discriminated location-based services into reactive and proactive ones, according to their initiator and nature. Reactive services are typically initiated by the users requiring their constant interaction and attention and being suitable for patient self-management and empowerment, while proactive services are initiated either by the system or by the patient's family or caregivers being particularly appropriate for patient guidance and safety scenarios. The presented use cases and applications for each service category highlighted their virtue and applicability in various scenarios of healthcare service delivery. The ultimate goal of this research is the development and establishment of an integrated framework for providing location-based services targeting patient safety, empowerment and guidance, through the incorporation of various personalized services such as the presented ones.

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References

1. Lang, A., Edwards, N., Fleiszer, A.: Safety in home care: A broadened perspective of patient safety. Int. J. Quality Health Care 20(2), 130–135 (2008)
2. Koutkias, V.G., Chouvarda, I., Triantafyllidis, A., Malousi, A., Giaglis, G.D., Maglaveras, N.: A personalized framework for medication treatment management in chronic care. IEEE Transactions on Information Technology in Biomedicine 14(2), 464–472 (2010)
3. Kjeldskov, J., Christensen, C.M., Rasmussen, K.K.: GeoHealth: a location-based service for home healthcare workers. J. Locat. Based Serv. 4(1), 3–27 (2010)
4. Boulos, M.N., Rocha, A., Martins, A., Vicente, M.E., Bolz, A., Feld, R.: CAALYX: a new generation of location-based services in healthcare. Int. J. Health Geogr. 6(9) (2007)
5. Marco, A., Casas, R., Falco, J., Gracia, H., Artigas, J., Roy, A.: Location-based services for elderly and disabled people. Computer Communications 31, 1055–1066 (2008)
6. Weixing, W., Jianhua, G., Lihui, Z., Jinjin, Z., Fang, L., Cao, W.: Design and Implementation of Mobile GeoSpatial Information System for Public Health Emergency. In: 5th International Conference on Wireless Communications, Networking and Mobile Computing, September 24-26, pp. 1–4 (2009)
7. Vicente, C.R., Kirkpatrick, M., Ghinita, G., Bertino, E., Jensen, C.S.: Towards location-based access control in healthcare emergency response. In: 2nd International Workshop on Security and Privacy in GIS and LBS, pp. 22–26 (2009)
8. Duncan, J.S., Badland, H.M., Schofield, G.: Combining GPS with heart rate monitoring to measure physical activity in children: A feasibility study. Journal of Science and Medicine in Sport 12(5), 583–585 (2009)
9. Cheng, R., Zhuo, Y., Feng, X.: iZone: A Location-Based Mobile Social Networking System, Parallel Architectures. In: 3rd International Symposium on Parallel Architectures, Algorithms and Programming, pp. 33–38 (2010)
10. Bellavista, P., Kupper, A., Helal, S.: Location-Based Services: Back to the Future. IEEE Pervasive Computing 7, 85–89 (2008)
11. Warsi, A., Wang, P., LaValley, M., Avorn, J., Solomon, D.H.: Self-management education programs in chronic disease: a systematic review and methodological critique of the literature. Arch. Intern. Med. 164(15), 1641–1649 (2004)
12. Mosen, D.M., Schmittdiel, J., Hibbard, J., Sobel, D., Rem-mers, C., Bellows, J.: Is patient activation associated with out-comes of care for adults with chronic conditions? J. Ambul. Care Manage. 30(1), 21–29 (2007)
13. Konstantas, D.: An overview of wearable and implantable medical sensors. IMIA Yearbook 2(1), 66–69 (2007)
14. Java Community Process: JSR-000179 Location API for J2ME™, Final Release (2003)
15. Java Community Process: JSR-000205 Wireless Messaging API 2.0, Final Release (2004)
16. Java Community Process: JSR-000082 Java™ APIs for Bluetooth, Final Release (2002)
17. Singh, M.P., Huhns, M.N.: Service-oriented computing: Semantics, processes, agents. J. Wiley and Sons (2005)
18. Java Community Process: JSR-00172 J2ME™ Web Services Specification, Final Release (2004)