A Dynamic Approach to Medical Data Visualization and Interaction

Vitoantonio Bevilacqua[1], Fabio Cassano[2], Giovanni Dimauro[2],
Francesco Girardi[3], and Antonio Piccinno[2]

[1] Dipartimento di Ingegneria Elettrica e dell'Informazione
Politecnico di Bari, via Orabona 4, 70125 Bari, Italy
[2] Dipartimento di Informatica,
Università degli Studi di Bari Aldo Moro, Piazza Umberto I 1, 70121 Bari, Italy
[3] ASL Bari,
Lungomare Starita 6, 70123 Bari, Italy

Abstract. Modern web applications lack in flexibility when multiple medical data are shown at the same time. This could bring users to not consider important aspects of their health status and physicians to lose critical patients situations. The "Registro Elettronico Sanitario Personale" (RESP, in English "Personal Sanitary Electronic Registry") is a prototype of a web portal allowing patients and physicians to share health problems, diagnosis, prognosis, pharmaceutical therapies etc. Currently, it presents to patients a static web page. This paper proposes a prototype of a dynamic and fully customizable Graphical User Interface (GUI) for the RESP, in order to provide patients with current and historical medical data, and allow them to analyze their lifestyle. This real-time health monitoring give patients a better awareness on their overall status.

1 Introduction

Since the last decade, the Italian Government is tempting the Public Administration (PA) through a dematerializing process to lower its cost. This involves even the Health-care System by the adoption of: Electronic Medical Record (EMR), Patient Health Record (PHR) and Electronic Health Record (EHR) [1][2][3]. An example of EHR is the "Registro Elettronico Sanitario Personale" (RESP, in English "Personal Sanitary Electronic Registry"), an on-line available prototype of electronic medical record that stores and shows patient's data [4]. As the most patient-centered electronic medical record, it not only allows patients to search and keep in touch with their preferred care-provider physician, but also to report them any occurring issue. However this approach results static and may bring patients to access the RESP only though assistance is needed. On care-giving side, there is no real-time knowledge though any patient's health parameter is becoming critical. This situation may lead to late assistance. To improve both patient and care-provider awareness of the overall patient's health status, we have studied a dynamic and customizable approach to the personal medical data. This involves the usage of many real-time sensors to catch data and

allow users to customize the way those are shown. In this way, while patients can monitor medical data and visualize their history to analyze the lifestyle, care-provider can promptly spot any issue and give a fast assistance. Furthermore, showing those kind of information in every user's home page can lead to a deeper parameter monitoring for every user.

The adoption of the electronic medical record rather than the classical one, is a way to revolutionize people's approach to health [5]. Thanks to modern pervasive systems of sensors (e.g. Internet of Things (IoT) devices) and the advantage of the modern smart-phone applications, people get involved in a more healthy lifestyle [6]. Despite many studies, currently there are no unified platforms where all those data are conveyed and where users can easily get an overview [7][8]. In fact each i-health sensor or application has its own proprietary (sometimes commercial) web portal where only specified data are shown.

The RESP is an electronic medical record web portal which allows patient and care-provider from Italy (but in the future maybe all over the world) to meet and share their information or medical problems. It works similarly to a social network where both patient and care-provider can send and receive messages, ask and get diagnosis, and so on. However, differently from the most known social networks, it lacks in customization on both sides. In this work we underline the importance of a dynamic approach to medical data visualization for the patient.

The current RESP patient's home page shows, on the center, a human image. It shows areas where the patient reported pain in a previous session. An example is shown in Figure 1. On the left side of the screen there is a bar where the patient can find a fixed menu with useful medical utilities (such as patient's diary, diagnoses, personal files, medical therapy etc.). On the top center side of the screen there is a button that allows patient to communicate an issue to his/her care-provider. Finally on the right side are summarized all patient health parameters. The just described view is static and each patient should navigate through the left menu to reach the desired piece of information. Moreover, it is pointless to provide an "always static" image of the patient at the center of the screen.

2   The Proposed Approach

Modern smart-houses have been designed to assist people during their daily life through many IoT sensors and actuators. Those can be Internet-driven via smart-phones, Personal Computers or tablets. Nowadays there are plenty of Zig-Bee based devices or other commercial solutions such as the Nest [9] [10]. In a context where the patient owns a smart house and constantly use health applications on the smart-phone, RESP can become the main landmark for the collection and visualization of all those information. In this work we propose to change the patient's home page by showing:

1. Different and customizable views allowing users to rearrange them;
2. Hourly/daily graphs for each desired sensor;
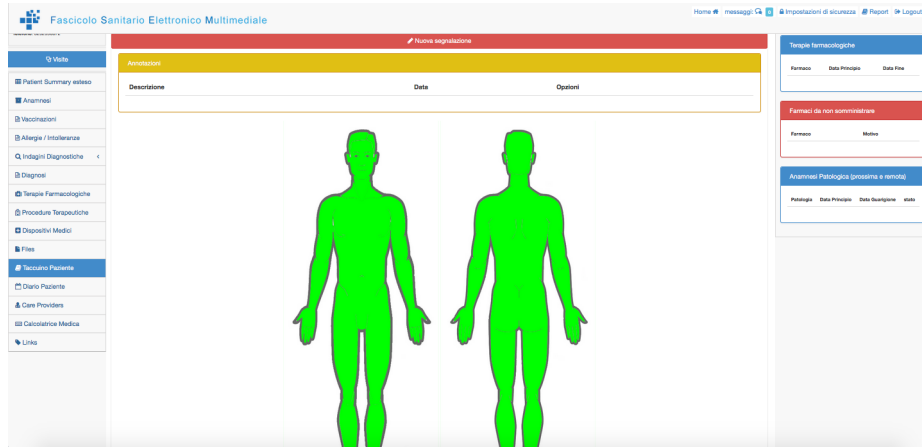
Fig. 1: The current patient RESP home page

3. Historical graphs for those parameters that cannot be daily or hourly monitored.

Each active graph may show a critical section that could warn the patient though a parameter is becoming critical and needs to get lowered.

An example of how the home page gets modified is shown in Figure 2. Rather than show the human image, a dynamic interface with multiple graphs can be shown (Figure 2 (a)). Users can add the desired graph by clicking on the "Add new graph" box at the bottom of the page. To delete an undesired graph it could right click on it and choose the delete option on the contextual menu. All available graphs could pop-up to the user once the "Add new graph" box is clicked (Figure 2 (b)). With this approach, each patient can customize its own home page by adding or deleting custom types of view, showing collected data from all sensors and devices he/she has. This kind of customization takes inspiration from the way modern smart-phone Operating Systems allow users to customize and rearrange icons on the different screens. Moreover, with this interactive approach, every RESP patient can constantly take under control its health status every time he/she login into the web portal. Unlike the actual services developed by some major technology companies, such as Microsoft with HealthVault and Apple with iOS Health, RESP purpose is different. While commercial solutions concentrate on data collection and visualization asking for a medical support when needed, RESP allows patients and physicians to meet and share medical records, pharmacological therapies etc. Our approach wants allow care-providers to keep track in real time the desired patient's health parameter (or parameters). On patient's side, the visualization of health information may lead to a self awareness of the lifestyle and the overall health status.

9

(a)   **(b)**
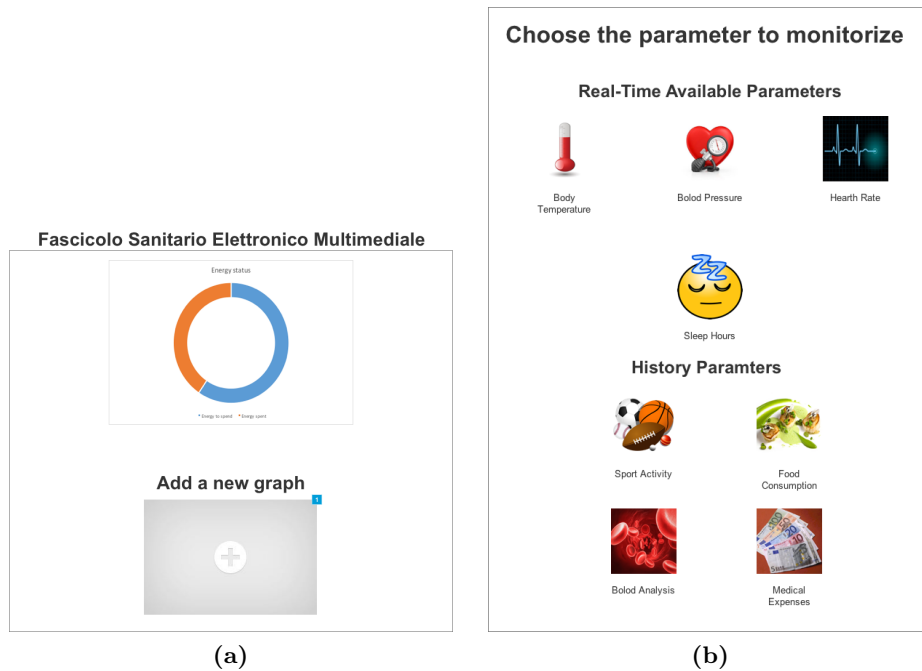
Fig. 2: The proposed RESP main Graphical User Interface: the patient home page (a); the available graphs accessible to the patient from its home page (b).

3   Conclusions and Future Works

In this work we have proposed a dynamic approach for medical data visualization and interaction. We have focused the attention on the way multiple data are stored in the RESP and how they can be visualized by the patients. The User Interface on both care-provider and patient side can be improved, applying End-User Development (EUD) techniques [11]. This study, is going to be tested and validated by different users according to the EUD theory and will evolve in many future works:

– The proposed patient customization will be ported to the care-providers (physicians, nurses, pharmacists etc.) home page showing all patient's critical situations. In this way, if necessary, care-providers can promptly give assistance or suggest them a medical examination. This support can be extended by creating, on care-providers side, an Expert System that, for example, may study patient's walk and warn for an Alzheimer disease start. This could lead to critical situation like patient's fall and can be detected by using a system like described in [12].
– The actual care-provider's GUI allows users to get a fast (but static) overview of a single patient's health status (shown in Fig 3). This GUI will be improved (e.g. including dynamic menu) to better keep in touch with the patients

(a)

(b)

Fig. 3: The actual RESP care-provider GUI: the patient's list (a); once the care-provider clicks on the patient's detail, a view with the patient's last visit is shown (b).

health. Every care-provider will be able to customize the view of his/her patients by the specific pathology they are affected.
– A mobile application will be developed in order to keep all users closer to their health status and lifestyle. Push notifications can warn care-providers and patients if many sensor are recording some critical value or may suggest patient to improve the lifestyle.

References

1. Wang, S.J., Middleton, B., Prosser, L.A., Bardon, C.G., Spurr, C.D., Carchidi, P.J., Kittler, A.F., Goldszer, R.C., Fairchild, D.G., Sussman, A.J., et al.: A cost-benefit analysis of electronic medical records in primary care. The American journal of medicine **114**(5), 397–403 (2003)
2. Margalit, R.S., Roter, D., Dunevant, M.A., Larson, S., Reis, S.: Electronic medical record use and physician–patient communication: an observational study of israeli primary care encounters. Patient education and counseling **61**(1), 134–141 (2006)
3. Mantas, J.: Electronic health record. Studies in health technology and informatics **65**, 250–257 (2001)

4. Dimauro, G., Caivano, D., Girardi, F., Ciccone, M.M.: The patient centered electronic multimedia health fascicle-emhf. In: Biometric Measurements and Systems for Security and Medical Applications (BIOMS) Proceedings, 2014 IEEE Workshop on. pp. 61–66. IEEE (2014)

5. Hillestad, R., Bigelow, J., Bower, A., Girosi, F., Meili, R., Scoville, R., Taylor, R.: Can electronic medical record systems transform health care? potential health benefits, savings, and costs. Health Affairs **24**(5), 1103–1117 (2005)

6. Istepanian, R., Hu, S., Philip, N., Sungoor, A.: The potential of internet of m-health things m-iot for non-invasive glucose level sensing. In: Engineering in Medicine and Biology Society, EMBC, 2011 Annual International Conference of the IEEE. pp. 5264–5266. IEEE (2011)

7. Rector, A., Nowlan, W., Kay, S., Goble, C., Howkins, T.: A framework for modelling the electronic medical record. Methods of information in medicine **32**(2), 109–119 (1993)

8. Fraser, H., Biondich, P., Moodley, D., Choi, S., Mamlin, B., Szolovits, P.: Implementing electronic medical record systems in developing countries. Journal of Innovation in Health Informatics **13**(2), 83–95 (2005)

9. Han, D.M., Lim, J.H.: Smart home energy management system using ieee 802.15. 4 and zigbee. Consumer Electronics, IEEE Transactions on **56**(3), 1403–1410 (2010)

10. Yang, R., Newman, M.W.: Learning from a learning thermostat: lessons for intelligent systems for the home. In: Proceedings of the 2013 ACM international joint conference on Pervasive and ubiquitous computing. pp. 93–102. ACM (2013)

11. Cabitza, F., Fogli, D., Piccinno, A.: Fostering participation and co-evolution in sentient multimedia systems. Journal of Visual Languages & Computing **25**, 684–694 (Dec 2014)

12. Bevilacqua, V., Nuzzolese, N., Barone, D., Pantaleo, M., Suma, M., D'Ambruoso, D., Volpe, A., Loconsole, C., Stroppa, F.: Fall detection in indoor environment with kinect sensor. In: Innovations in Intelligent Systems and Applications (INISTA) Proceedings, 2014 IEEE International Symposium on. pp. 319–324. IEEE (2014)