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EKG Mobile

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Abstract. Diagnosis of latent cardiovascular disease may not always occur in the early stages of this disease, mainly due to the impossibility of patients and hospitals to have available all the medical resources necessary to meet current demand. In this paper, we propose a low-cost and lightweight mechanism aimed at detecting cardiovascular disease. The system allows the patient to have an easy way to monitor heart activity, as well as an online system to detect potential anomalies, which are automatically sent to the physician to certify or dismiss the problem detected.

Keywords: Cardiovascular disease; monitoring systems; mobile devices.

1 Introduction

Nowadays, mobile technology has experienced a breakthrough thanks to the miniaturization of components and to the increased processing capacities, favoring a reduction of manufacturing costs and making the smartphones more popular and attractive for the users. Because of this, more and more people uses the Smartphone to perform a multitude of tasks, for example those related to consultation of email or call management, and some of them allow to monitor physical activity there [6] [4] [7].

On the other hand, nowadays a set of "silent" type diseases [6] [2] are discovered. These diseases are characterized by no appreciable outward symptoms at their early stages. However, they usually evolve and manifest in advanced states in which it is very difficult to treat them and sometimes are impossible to remove. In this way it is important to detect some diseases such as diabetes or high blood pressure [4], which can be indicator to detect worse diseases such as myocardial infarction or stroke [9], major causes of high mortality among adults. These serious diseases, if treated in the early stages, can become treated and controlled using the media available today, thus preventing its spread and improving the health of patients, increasing the length and quality of life.

Thanks to Smartphones and to the development of numerous health monitoring applications, it is possible to monitor vital signs in a ubiquitous manner, which improves the autonomy and health control of the patients.

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The use of Smartphones, allows the design of non-invasive systems, characterized by a competitive cost, easy to use and continuously connected to the internet. Besides, the use of geo-location services, along with the use of complementary sensors (accelerometer, compass, temperature sensor... etc.), present in the vast majority of terminals, facilitates and automatic motion detection mechanism and a way to detect the situation and physical activities carried out by the patient [1]. The fusion of information from different sensors incorporates an added value to the system. In our case, the use of information fusion techniques provides a more accurate overview of the state of the patient.

Finally, the integration of the system within a multi-agent system allows data to be processed on remote computers with high computational performance, taking charge of the analysis of large volume of data that can be collected from a single patient and allowing the extraction of features so anomalous more efficiently and accurately. The use of a cloud architecture allows the implementation of algorithms that detect cardiac anomalies and can implement intelligent response actions so as to allow to act as quickly as possible. The use of a multi-agent based distributed architecture facilitates the adaptation to changes that occur in the environment and includes capacities for dynamic adaptation and learning.

2 Proposed system

The Holter [Fig. 1] are portable devices that measure and record heart activity (ECG) continuously in a continuous range of 24 to 48 hours. These devices are similar to a compact camera, and incorporate processing and data storage capacities, as well as a series of wired sensors that can be placed at different specific points of the patient's body using adhesive aid.

In this article, a system that allows monitoring of the vital signs of an individual with the help of a mobile phone is presented as an alternative to the Holter measurement systems.

This way, an architecture that allows an electrocardiogram using an Arduino hardware is proposed. The Arduino controller will communicate with a smartphone for the collection of measurements and immediate viewing them. An agent will run on the smartphone and will be integrated within a multi-agent system that makes use of cloud computing to collect and process the data. This distributed approach takes into account the processing constraints present in Smartphones and contribute to save battery. In addition, the multi-agent system will focus on performing data analysis and detecting potential problems using distributed computing and access to multiple databases with information about possible anomalies associated diseases.

As hardware support, we used an Arduino Bluetooth device in conjunction with the EKG-EMG shield, Olimex brand. The device has an approximate cost of 20 euros, and the electrodes with 3-lead, which represent an increase of about 10 euros connect.

We opted for the use of Arduino boards because they are under the license-free software and hardware, as well as being very economical and have a wide range of components for use. The receiving device consists of an Arduino board with a separate processor and is responsible for interpreting and processing the information

received from the shield, and later transmitted to the mobile device via its built-in Bluetooth module.

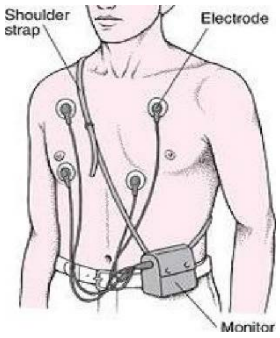

Fig. 1. Holter monitor

The shield Olimex board and model SHIELD-EKG-EMG [Fig. 2], is a board responsible for receiving the information provided by the electrodes. It also has a number of electronic components that allow us to adjust the input and filter any noise that might occur, so that the signal can be clean quickly, eliminating the processing load on the plate board. The electrodes used for readings consist of 3-lead should be placed on the wrists and right ankle of the patient.

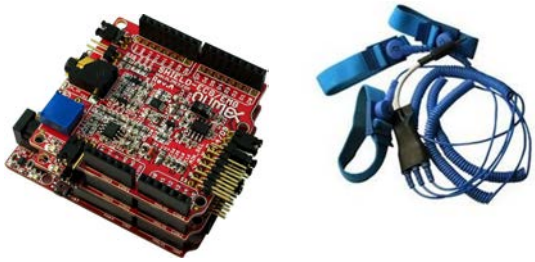

Fig. 2. Arduino Shield EKG-EMG and electrodes

Once obtained the sensor signal, encoded and sent to the Arduino board, it transmits the information to the Smartphone via Bluetooth. The agent installed in the smartphone executes an information fusion algorithm to merge the received values with the values obtained by means of its own sensors such as GPS, accelerometers ... and associating a timestamp to all of them. Once tagged the measurements obtained, the agent connects to the multi-agent system, via Wi-Fi or 3G, and transmits the results of the fusion process. More specifically the system uses the IRC protocol. The advantages of this protocol over other methods, such as HTTP or MQTT [2], focus on its strength, ideal for a mobile connection that can be constantly changing, and battery

saving. It also allows options broadcast, multicast and sending private information [Fig. 3].

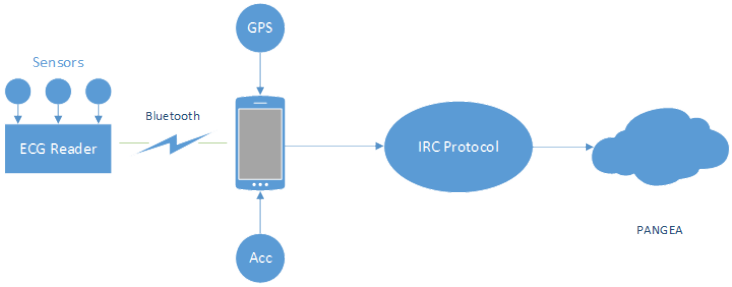

Fig. 3. General architecture

As in the case of Holter monitors, the use of the proposed device requires to continuously wear a mobile phone but this results almost natural for the patient the patient and less invasive. In the cloud, a multiagent system will be responsible for storing the values collected from each patient individually, using the timestamps obtained from the Smartphone to relate the readings. To do this, we used the PANGEA platform [3][6][2], developed by the research group BISITE University of Salamanca.

PANGEA is composed of a number of agents that are present for any interaction with the platform are given [Fig. 4], the most important being the following:

For this particular case we define specific agent types to interact with the EKG Mobile agents are available in their own sub-organization "ECG" the following agents:

- ECGComm: This agent will liaise between the platform and Smartphone PANGEA, both for receiving data and for sending notifications.
- ECGRegister: An agent who will be responsible for maintaining the records in database and get the values that are required.
- ECGAnomalyDetector: One of the most important agents for the treatment will be the signal for potential anomalies, to launch ads for the patient and the doctor if necessary.
- ECGPatternSeeker It is responsible to detect any known disease patterns. Thus, a dedicated system and accessible from the cloud crowd can process information simultaneously, releasing the mobile device for carrying out this task, the battery consumption would mean.

Although there are many algorithms for the detection of cardiac disorders, the recognition rate achieved by them is not sufficient, in large part due to unreliable extraction characteristics in the signal analysis. However, it is possible to find more advanced works, in which an SVM model is applied to the characteristics of the extracted signal to make predictions.

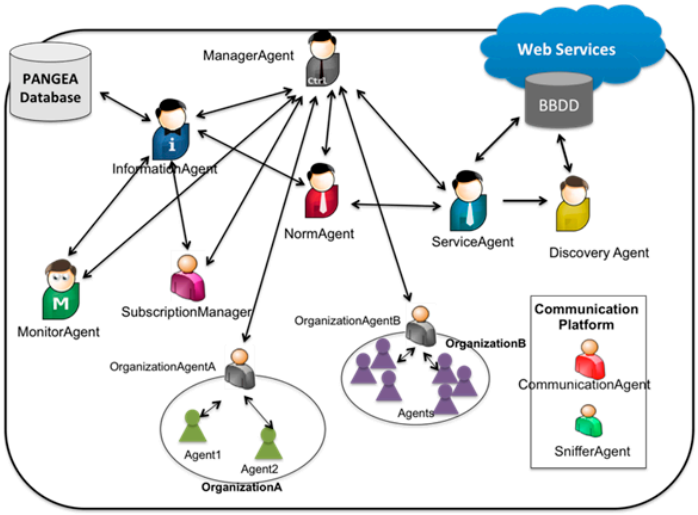

Fig. 4. Schematic of the organization of PANGEA

For the EKG Mobile, the values obtained by the Arduino, despite the filtering system built in, introduce more noise in the signal in the case of a professional Holter, so the calculation of P waves, Q, R, S and T is affected. That is why it was decided to calculate the point corresponding to the maximum in the range corresponding to the QRS complex, rather than attempting to measure wavelengths.

Recognizing each wave begins with the detection of R. To do this, it is necessary to look for a sequence of values up to the TR threshold and the maximum value is selected. Once obtained, the same procedure is repeated to obtain the minimum value of the P wave, with the difference that the sequence sought to lower threshold values TP and obtain the minimum interval before the wave period TR. Proceeds similarly for P, S and T. The shape and distribution of these waves can be seen waves in Fig. 5.

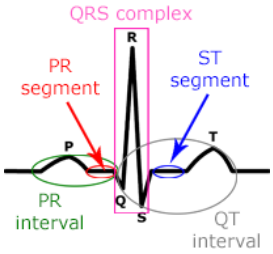

Fig. 5. Waveforms P, Q, R, S y T from ECG

Once the ECG measurements are analyzed, we have extracted a set of features that another agent has to interpret taking into account external factors collected by sensors and Smartphone included in the message sent. With the whole set, the agent can detect anomalies and relate to external conditions at that time or any anomalies that the patient is suffering at that given moment. If a fault occurs, the platform can send a message to the user asking him to indicate his subjective physical state, and at the same time the physician is notified as well to perform a visual inspection of the data

and possible abnormality detected. In case of a false alarm the system uses the experience to improve recognition and discrimination of false positive values.

3 Conclusions

After testing the system, it has been found that we have obtained a distributed platform that collects the ECG readings of a patient with sufficient reliability to be treated. The Arduino device allows a ECG low cost solution accessible to anyone who may need it as well as being very light and require very low consumption of battery, so the battery does not involve incorporation of excessive weight to be carried throughout the day.

Thanks to the Smartphone the patient can be monitored in in real-time. Besides, the system is able to obtain contextual information, thanks to the GPS and accelerometer readings.

Moreover, the use of a multi-agent platform facilitates capacities for distributed task performing and signal analysis, with the consequent saving on battery consumption and increasing the processing speed of the signal.

References

1. Smith, T.F., Waterman, M.S.: Identification of Common Molecular Subsequences. J. Mol. Biol. 147, 195--197 (1981)
2. Barata, D., Louzada, G., Carreiro, A., & Damasceno, A. (2013). System of acquisition, transmission, storage and visualization of Pulse Oximeter and ECG data using Android and MQTT. Procedia Technology, 9, 1265-1272.
3. Kennedy, H. L. (2013). The Evolution of Ambulatory ECG Monitoring. Progress in cardiovascular diseases, 56(2), 127-132.
4. Zato, C., Villarrubia, G., Sánchez, A., Bajo, J., & Corchado, J. M. (2013). PANGEA: A New Platform for Developing Virtual Organizations of Agents. International Journal of Artificial Intelligence™, 11(A13), 93-102.
5. Sánchez, A., Villarrubia, G., Zato, C., Rodríguez, S., & Chamoso, P. (2013). A gateway protocol based on FIPA-ACL for the new agent platform PANGEA. In Trends in Practical Applications of Agents and Multiagent Systems (pp. 41-51). Springer International Publishing.
6. Carolina, Z. A. T. O., VILLARRUBIA, G., Javier, B. A. J. O., & CORCHADO, J. M. (2013). An Integrated System for Disabled People Developed with the Agent Platform PANGEA. ADCAIJ: Advances in Distributed Computing and Artificial Intelligence Journual, 1(6), 65-77.
7. Barata, D., Louzada, G., Carreiro, A., & Damasceno, A. (2013). System of acquisition, transmission, storage and visualization of Pulse Oximeter and ECG data using Android and MQTT. Procedia Technology, 9, 1265-1272.
8. Eysenbach, G. (2001). What is e-health?. J Med Internet Res, 3(2), e20.
9. Andreassen, H. K., Bujnowska-Fedak, M. M., Chronaki, C. E., Dumitru, R. C., Pudule, I., Santana, S., ... & Wynn, R. (2007). European citizens' use of E-health services: a study of seven countries. BMC public health, 7(1), 53.

