Cardiac Disorder Detection Application and ANT+ Technology

Ikram Nedjai Merrouche[1], Amina Makhlouf[1], Nadia Saadia[1] and Amar Ramdane-Cherif[2]
[1]*LRPE Laboratory, University of Science and Technology Houari Boumediene, Algiers, Algeria*
[2]*LISV Laboratory, University of Versailles-Saint-Quentin-en-Yvelines, Versailles, France*

Keywords: Heart Trouble Detection, Elderly People, Mobile Phones, ANT+ Technology, Android Application.

Abstract: The problems caused by the occurrence of a heart disorder are great threats to the elderly. With the evolution of new mobile technologies and data transmission, the smartphone has become an ideal platform for the development of applications that can monitoring the person in order to be able to provide assistance if necessary. In order to transmit the real-time data of a cardiac sensor placed on the person to a smartphone, a communication medium is required which consumes preferably the least battery possible. In this article we use a new technology called ANT + that promises a very good rate of wireless transmission with low power consumption. We present a system that offers the doctor or the person in charge of the security of the elderly the possibility of recording different data concerning the person monitored. This data is used in a cardiac disorder detection algorithm, and allow our system to match any type of profile. In addition, we are implementing an Android application, which monitors real-time heartbeat transmitted from a belt using ANT + technology, and detects any heart problems.

1 INTRODUCTION

The environment in which we live evolves rapidly. Several countries in the world are facing the same health problems due to various factors such as: aging of the population, rapid urbanization, etc. Currently a leading global causes of death is due to non-communicable diseases (cardiovascular diseases, diabetes, cancer, etc.) who have taken the magnitude of infectious diseases.

Cardiovascular diseases (CVD) include a number of disorders affecting the heart and blood vessels such as: coronary heart disease (heart attack); High blood pressure (increase in blood pressure); cerebrovascular diseases (stroke). Cardiovascular disease is the leading cause of death in the world: it dies every year more people because of cardiovascular disease than any other cause. The WHO (World Health Organization) estimates that 17.5 million deaths from cardiovascular disease are responsible for 31% of the world's total mortality. Among these deaths, she estimates that 7.4 million are due to coronary heart disease and 6.7 million to a stroke (WHO, 2016).

These dangerous cardiac disorders occur mostly suddenly, and early monitoring of people at risk, such as the elderly, reduces the dangers that these cardiovascular diseases can cause to their health.

A rapid aging of the population is observed around the world (World Health Organization, 2015), and the prevalence of cardiovascular disease increases with age. A cardiac disorder, for example, can cause falls which are also considered a major risk of trauma or death in the elderly.

Mobile technologies are becoming more and more popular on the market. The smartphone serves as a central device of informatics and communication in the lives of peoples. Such a trend is inevitable in the real world because of the phenomenal growth in recent years of new intelligent devices, which is expected to continue (GfK, 2015).

These phones integrate different sensors (Lane, et al., 2010) (Milette and Stroud, 2012), and can also communicate with other sensors that are external and that allow new applications in various fields such as health. The communication between the smartphones and the external sensors, is done through communication protocols generally wireless such as Bluetooth for example.

To provide monitoring services to seniors, there is a list of technical objectives and challenges (real-time monitoring, help service, etc.). In order to better meet the objectives, we encounter a list of theoretical and practical challenges, such as peripheral integration, data acquisition and real-time data exchange. All this

Merrouche, I., Makhlouf, A., Saadia, N. and Ramdane-Cherif, A.
Cardiac Disorder Detection Application and ANT+ Technology.
DOI: 10.5220/0006530202950300
In *Proceedings of the 10th International Conference on Agents and Artificial Intelligence (ICAART 2018) - Volume 2*, pages 295-300
ISBN: 978-989-758-275-2

with the least energy consumption possible.

A new 2.4GHz protocol called ANT + has recently become famous due to its low battery consumption (Thisisant, 2017). Its range is 30 meters (m) and the battery lasts up to 3 years compared to Bluetooth Low Energy (BLE) with 1 years (Khssibi, et al., 2013).

ANT + has a very good theoretical transmission rate which assists at 1 Mbps, making this protocol more appropriate for low bandwidth wireless personal area networks. The wireless device sensors are applied together in a group to provide general services.

Cardiac monitoring is the subject of several studies. Some only aimed at monitored heart rate (Agarwal, et al. 2016), and other monitored and also detected certain heart trouble. Knowing that cardiac arrest is one of the most dangerous cardiac disorders, several developed systems aim to detect them (Dicardiology, 2017) (Magar, M. U. S. M., and Shinde, U. B. 2016). Nevertheless, the detection of other disorders such as tachycardia, bradycardia or arrhythmia is just as important. Because it allows the doctor or supervisor to anticipate more important problems.

In this article we propose a monitoring system for the elderly. The system is based on the new ANT + technology, to monitor continuously and in real time the state of the person. The monitoring allows to detect the eventual cases of cardiac disorder (Tachycardia, Bradycardia and Cardiac arrest). The use of ANT + technology makes it possible to have a system with a long autonomy of energy and therefore a long period of monitoring without interruption.

In Chapter II, we discuss ANT + technology, followed by technological implementation in Chapter III. Chapter IV deals with experimental results, and future work can be found in Chapter V.

2 ANT+ TECHNOLOGY

ANT + is a wireless sensor network technology, designed to enable communication between self-powered devices in an expandable network environment, to facilitate the collection, automatic transfer and tracking of sensor data to monitor all personal information on the well-being. This ability to transfer data between sensors is a feature based on the ANT (Advanced and adaptive Network Technology) protocol.

ANT is a wireless protocol at ultra-low power (ULP) felt that is responsible for sending information wirelessly from one device to another device, in robust and flexible way (Thisisant, 2017). With millions of nodes deployed, ANT is ideally suited to all network topologies of low data rate sensors in Personal Area Networks (PANs) well suited to sports, fitness, wellness applications and home health care. In addition, ANT is a convenient solution for local area networks (LAN) in homes and industrial automation applications. A convenient wireless protocol 2.4GHz and embedded system solution, ANT still has the opportunity to break into complex network topologies and communication methods, thereby reducing costs and power. It is capable of being powered by a coin pile, working for several years.

ANT + is said to be compact, with a small stack size; Extensible, supporting complex network topologies; Flexible, supporting ad hoc network reconfiguration; Concentrated, not being a standard development organization; And proved, because of the millions of knots delivered worldwide.

ANT + is a set of mutually agreed definitions for what the information sent on ANT represents. These definitions are called device profiles and are usually linked to a specific use case.

ANT + files are currently available for different devices: Heart Rate Monitor, Fitness equipment device, Bicycle power, Multi sport speed &Distance, Weight scale, Blood pressure, geocache, etc.

This is a fairly recent technology and most of the products available on the market focus on sport and efficiency, instead of health and wellness. This has resulted in more research (Mehmood and Culmone, 2015) (Belchior, et al., 2012) being done on this technology and on the benefits it offers. In our research we take advantage of this technology and its application to health services.

3 BACKGROUND

As part of a study of the literature on the subject, we have found some systems that use ANT + technology for the purpose of providing assistance to people.

The system developed by (Priyadharshni, et al.,2016) aims to monitor real-time and remote heart rate, temperature and position of a patient. Its main design is the follow-up of the heart attack during the duct. In order to send help and stopped the car through a controller.

The system uses ANT + and Bluetooth technology for data transmission. Nevertheless, the ECG for a normal state is set between 70bpm (beat per minute) and 80bpm. Knowing that heart rate standards differ

from one person to another, the interval set in this study may not match all of the targeted user profiles.

Another study has also focused on the use of ANT + technology for data transmission. Legido created a system that interacts with the patient (Lagido, 2013). The patient uses devices such as a blood pressure monitor and a scale to measure certain values (blood pressure, heart rate, weight, etc.) when he wants it during the day. These values are then sent to the Smartphone and to a medical entity via the internet. This system allows to provide assistance to the elderly if the measures sent are not good. However, surveillance is not real-time and non-stop, it depends on the patient and when he decides to use the devices.

Our system not only provides continuous, real-time heart rate monitoring. But also the advantage of being intended for any type of profile. And this, avoiding to use fixed thresholds. Rather, by offering the medical entity in charge of the care, the possibility of recording the exact cardiac standards that correspond to the patient monitored.

4 TECHNOLOGICAL IMPEMENTATION

4.1 Hardware

The prototype application uses the heart rate monitor (Geonaute Digital Coded), a small, lightweight sensor with built-in power supply to the chest. It utilizes the conductive strap to calculate heart rate. The monitor is powered by a coin battery that provides a usage time of several years. It uses ANT + technology to transmit the strap signal to the application. Once a connection is established with an Android device, the monitor will broadcast the data continuously, which will be displayed in BTM (Beat per Minute).

4.2 Software

This application is designed on the Android software stack produced by Google. Android is an open source framework designed for mobile devices such as smart phones and tablet computers. It packages an operating system, middleware, and key programs (Android developers. 2017). The Android service development kit provides libraries needed to interface with the hardware at a high level and make/deploy Android applications (Hoog, 2011).

Application are written in Java and data concerning localizations and configuration of the client is synchronized with a server application. The server is written in PHP, run on Apache server and uses a MySQL database to store persistent data. The GSM or WIFI connection is used following their availability. We choose this platform as it is the most widespread (Statista, 2016), and is supported by a large community of developers and also to its compatibility with other Android devices.

4.3 Heart Disorder Detection

Pulse measurement can be used to assess heart rate regulation in a simple manner, ie heart rate (beats of the heart per minute) and pulsation amplitude. Assessment of the general condition of a person is used to monitor the course of a cardiac disease, to prevent and / or detect a complication (rhythm disorder). Without proven heart disease can still remove some anomalies in the frequency outside the norms. (Bauer et al. 2008)

- Bradycardia: Decreased heart rate.
- Tachycardia: Acceleration of the heart rate.
- Cardiac arrest: no pulse.

There are heart rate standards for a person in good health. Nevertheless these standards can not be used in the development of an algorithm that aims to monitor and detect cardiac disorders. Especially as these generally occur in people with some health problem or older people. After various research and the opinion of several cardiologist doctors, one came to the conclusion that for these types of person there were no fixed standards and the thresholds can vary from one individual to another. And so tried to set them by ourselves in our algorithm was an error that will generate several false positives, and that will cause our application can not be used by any type of user profile.

The solution offered by our system is to allow the doctor or the person in charge of patient safety to enter the standards, and thus the minimum and maximum heart rate (Hmin and Hmax) specific to the patient. These two thresholds will be stored in a database with the rest of the patient profile information. And used later in the detection of possible cardiac disorders (Tachycardia, Bradycardia, and cardiac arrest). For tachycardia, for example if BPM (i) <Hmax and BPM (i + 1)> Hmax the system starts a small timer, if a T = t the beats are always greater than Hmax then a cardiac disorder (tachycardia) is detected.

The detection of recurrent tachycardia and bradycardia allows the overseer to anticipate other more important health problems.

4.4 Data Base

A database is a device for storing a set of information in a structured manner. The databases for Android are provided using SQLite (Owens and Allen, 2010). The advantage of SQLite is that it is a very compact DBMS and therefore very efficient for embedded applications.

SQLite does not require a server to run, which means that it runs in the same process as the application. Therefore, a massive operation launched in the database will have visible consequences on the performance of your application. Thus, we had to know how to master its implementation so as not to penalize the rest of our execution.

For our application we have created a database to record user profiles with several information (Name, date of birth, max and min heart rate, etc.) (Figure1).

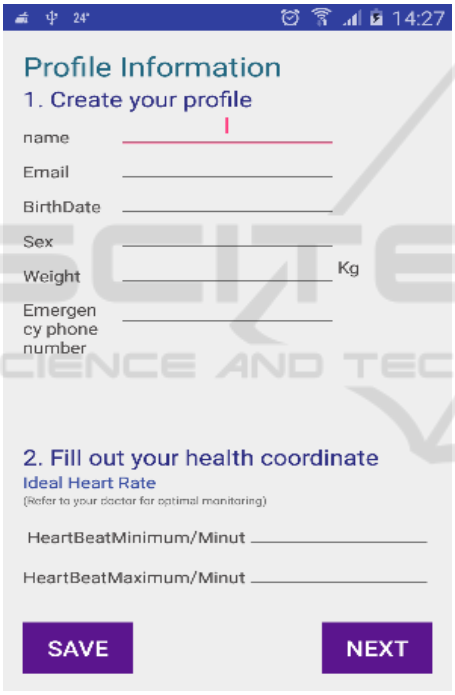

Figure 1: Screenshot profile information.

Some of these data such as minimum heart rate and maximum heart rate are used in algorithms for the detection of various disorders such as tachycardia or bradycardia.

5 EVALUATION AND EXPERIMENTAL RESULT

5.1 Experimental Setup

For reasons of safety, this study was carried out on two persons of different sex and an average age of 29 years in good physical condition. And the max and min thresholds used comply with safety standards. During the tests the cardiac belt was placed on the chest of the subject. Once the Android app is running and the profile data for the user counting the min and max thresholds recorded.

The application checks to see if the belt is positioned on the person. If yes, a connection is established and an interface opens automatically displaying the change of the BPM (Figure 2). The algorithm for detection of cardiac disorder is then launched. If a heart trouble is detected, a toast is displayed for a moment on the application interface.

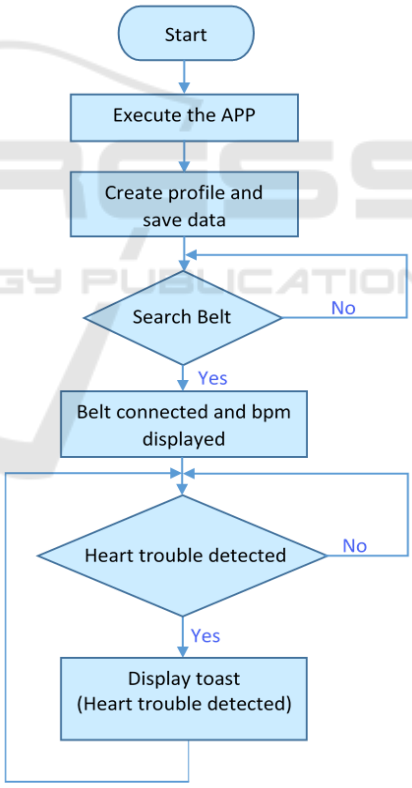

Figure 2: Flow chart of the execution steps.

5.2 Experimental Result

For the evaluation of our application, we first set the max and min thresholds and verify the correct

functioning of the database. Once the data is recorded they are used in our algorithm of detection of cardiac disorder.

The Figure 3 shows a screenshot of the cardiac monitoring interface, where we can see the thresholds previously recorded in the profile as well as the BTMs can be seen.

Knowing that a tachycardia is by definition an acceleration of the heart rhythm, in our case study we asked the subjects to make a physical effort

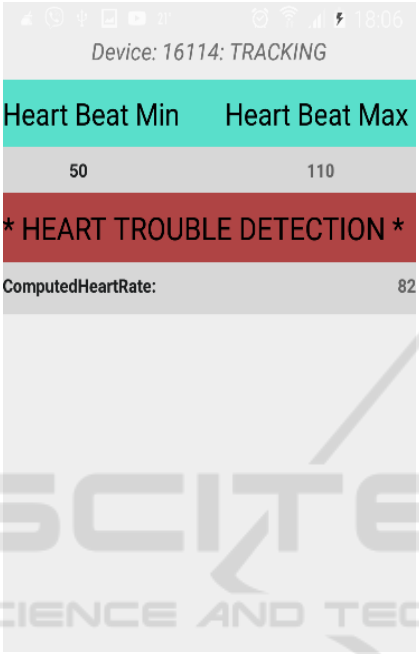

Figure 3: Screenshot of cardiac monitoring interface.

As a result, the observed increase in beats was observed and once the maximum threshold was exceeded, the Toast appears showing the detection of a tachycardia (Figure 4).

The tests were performed several times with different thresholds and the result was that, whenever the beats are lower or above the set threshold a trouble is detected after a short time t.

The results obtained during our tests show that the system instantly detects some cardiac disorders mainly Tachycardias and Bradycardias.

The detection of cardiac arrest has been included in the algorithm of our system but the verification of this part in a real and secure case study is almost impossible. For now, the detection of the cardiac disorder is displayed by a Toast (Figure 4), but this validation is temporary. Services such as alarm triggering and message sending, for example, will be added to the application (see the next section for details).

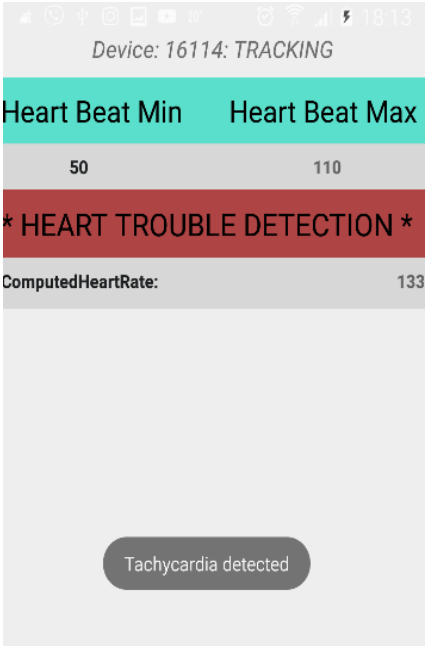

Figure 4: Screenshot of cardiac monitoring interface at moment of tachycardia detection.

When the minimum threshold is set at 60 bpm for example, and the patient beats below this threshold, a disorder (Bradycardia) is detected. And that either beats are slightly lower (example 55bpm) or really lower (example 35bpm). This difference plays a very important role in the consequence of the disorder on the health of the patient. For this reason assistance services will have to be adjusted to the application. In order to interact with the user and checked his / her state before sending the emergency services.

Real-time monitoring is very important because if a disorder is not detected over time more serious problems can arise. Our system not only aims, monitored the condition of a person. But also to provide him help if necessary. In the next section we can see the main objectives of our system in order to offer assistance to individuals.

6 FUTURE WORK

Our system provides a solution that can detect certain cardiac disorders (tachycardia, bradycardia, and cardiac arrest). Knowing that a severe disorder is followed in most cases by a fall, we work on a solution based on the accelerometer of the smartphone which aims to detect the moments of fall (Merrouche, et al., 2016)(Makhlouf, et al.,2017). The fusion of the two algorithms will allow us to create a

table that classifies the various disorder and their severity. This table will then be used in emergency services.

The flexibility of the platform as well as the applications of the hardware capacity of the phone allows this system to be extended in many ways. Several features such as emergency call, emergency message, alarm and localization are under development to be integrated into our application.

7 CONCLUSIONS

In conclusion, we presented an approach to the detection of certain cardiac disorders using a smartphone and a cardiac belt based on the ANT + technology. For detection, we have modeled a system that provides the ability to capture and record the maximum and minimum heartbeat thresholds for a patient who monitors his BTM in real time and detects different disorders such as tachycardia, Bradycardia or cardiac arrest.

The modeled system is implemented on an Android platform, and uses the new ANT + technology to transmit the heart rate data to our application installed on the smartphone. The application we have developed aims to monitor in real time an elderly person, detected any problems and provided help if necessary. Overall, the work in this article provides an example of the great potential for application of detection technology using mobile phones for health care.

REFERENCES

Agarwal, R., & Parmar, M. (2016). Android Based Electrocardiogram Monitoring System. *International Journal of Engineering Science*, *3683*.

Android developers. 2017. Google Inc, Android developers. developer.android.com.

Bauer, A., Malik, M., Schmidt, G,. Barthel, P., Bonnemeier, H. et al. (2008) Heart rate turbulence: standards of measurement, physiological interpretation, and clinical use: International Society for Holter and Noninvasive Electrophysiology Consensus. Journal of the American College of Cardiology, 52(17), 1353-1365.

Belchior, R., Júnior, D., & Monteiro, A. 2012. ANT+ medical health kit for older adults. In *International Conference on Wireless Mobile Communication and Healthcare* (pp. 20-29). Springer Berlin Heidelberg.

Dicardiology, 2017. https://www.dicardiology.com/content/new-smartphone-app-detects-heart-attacks.

GfK, 2015. Smartphones www.gfk.com.

Hoog, A. (2011). *Android forensics: investigation, analysis and mobile security for Google Android*. Elsevier.

Khssibi, S., Idoudi, H., Van Den Bossche, A., Val, T., & Saidane, L. A. (2013). Presentation and analysis of a new technology for low-power wireless sensor network. *International Journal of Digital Information and Wireless Communications*, *3*(1), pp-75.

Lagido, R.B. T. (2013). Ant + medical health kit for older adults.

Lane, N. D., Miluzzo, E., Lu, H., Peebles, D., Choudhury, T., & Campbell, A. T. (2010). A survey of mobile phone sensing. *IEEE Communications magazine*, *48*(9).

Magar, M. U. S. M., & Shinde, U. B. (2016). Wireless Patient Healthcare Monitoring System For Cardiac Patient (Wireless Heart Attack Predetecion System). *Imperial Journal of Interdisciplinary Research*, *2*(5).

Makhlouf, A., Nedjai, I., Saadia, N., & Ramdane-Cherif, A. (2017). Multimodal System for Fall Detection and Location of person in an Intelligent Habitat. *Procedia Computer Science*, *109*, 969-974.

Mehmood, N. Q., & Culmone, R. (2015, March). An ANT+ protocol based health care system. In *Advanced Information Networking and Applications Workshops (WAINA), 2015 IEEE 29th International Conference on* (pp. 193-198). IEEE.

Merrouche, I. N., Makhlouf, A., Saadia, N., & Ramdane-Cherif, A. (2016, December). Overview and systems of assistance to older people. In *Control Engineering & Information Technology (CEIT), 2016 4th International Conference on* (pp. 1-6). IEEE.

Milette, G., & Stroud, A. (2012). *Professional Android sensor programming*. John Wiley & Sons.

Owens, M., & Allen, G. (2010). *SQLite*. Apress LP.

Priyadharshni, P. Vishnu Priya, A. Swarnambiga, A. (2016, April). Design of android application using.

Statista, 2016; http://www.statista.com/

Thisisant, 2017. http://www.thisisant.com.

Who. 2016. Heart disease. http://www.who.int/en/ (consulted April 2017).

World Health Organization. 2015. World report on ageing and health. World Health Organization.