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WIRELESS DEVICE TO IMPROVE PERSON CARE

Abstract

Introduction and aim: The article presents the issues of system and prototype of the device to a wireless diagnostic health of elderly people. This system is able to control a pulse, temperature and ECG recording. There are also presented the main elements of hardware/software system that enables to communicate between the Smartphone and the device. Moreover, a biofeedback module is a kind of an innovation of the system.
Material and methods: The project has been designed and implemented based on software platform *Arduino*, mobile phone with *Android* system and sensors. In addition, have been presented the main elements of system enables communication between the *Android* system and *Arduino* platform.
Results: The result of work is fully functional prototype.
Conclusion: The method described is innovative with positive test and opinion of future users.

Keywords: Elderly people, mechatronics, *Android* system.
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BEZPRZEWODOWE URZĄDZENIE DO ANALIZY STANU ZDROWIA

Streszczenie

Wstęp i cel: *Celem realizowanego projektu jest opracowanie systemu wspomagającego analizę stanu zdrowia osoby starszej. Opracowany system zapewnia możliwość wykonywania badania tętna, temperatury i EKG. Urządzenie komunikuje się bezprzewodowo ze smartfonem, na którym wyświetlane są wyniki. Ponadto opisywany system posiada ćwiczenie związane z biofeedbackiem.*
Materiał i metody: *W pracy wykorzystano platformę programistyczną Arduino, telefon z systemem Android orz czujniki do pomiaru akcji serca, pulsu, temperatury. W artykule omówiono sposób działania systemu oraz oprogramowanie systemu Android i na płytkę Arduino. Dodatkowo przedstawione zostały najważniejsze elementy oprogramowania umożliwiające komunikacje pomiędzy telefonem na systemie Android a platformą Arduino.*
Wyniki: *Wynikiem pracy jest w pełni funkcjonalny prototyp.*
Wniosek: *Opisany system jest nowatorski z pozytywnymi opiniami przyszłych użytkowników.*

Słowa kluczowe: *Osoby starsze, mechatronika, system Android.*
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1. Introduction

Healthcare has emerged as one the biggest and fastest growing industry around the World. Demands on healthcare throughout the world are changing. Now we can see that, there is now huge demand for new mechatronic systems which improve efficiency healthcare. At the same time, theses systems cut costs. Moreover these solutions can support the shift of healthcare from hospital to the home. It is possible to provide the three most important reasons influencing the increasing popularity of wireless devices to improve people care:

- the global demographic trend towards ageing populations,
- less active lifestyles,
- fast-food diets.

It is leading to higher probability and earlier onset of chronic conditions such as Type 2 diabetes and cardiovascular diseases. Moreover it will cause a require for a long-term, continuous care and a growing burden on healthcare infrastructures. Today in most developing countries, 75-80 per cent of healthcare expenditure is spent on chronic diseases. The recent research shows that these wireless devices have enable more effective treatment of chronic disease, deliver improved patient outcomes and reduce the requirement for hospital visits [4], [5].

2. The aim of the project

The aim of the project was to develop and make a prototype of a small, portable device for testing (ECG, temperature, pulse), and generate reports for the elderly person and his doctor. In a dangerous situation (heart attack or stroke) this device will automatically send a message to medical service or user's family. Message informs about the dangerous situation and sends the location data (Fig. 1).

Fig. 1. Schema of the system
Source: Elaboration of the Authors

The article refers to design, hardware, software and prototype of this device and presents the first tests. This paper presents the description of the software and communication with the external measuring system was presented. The *Arduino* module was selected on the basis of the measurement system. Then, a program for this measurement system was written in the environment of *Arduino IDE*. *Arduino* is usually programmed in *C/C*$^{++}$.

The purpose of the program is to retrieve data from the sensors and send them to a Smartphone with *Android*. Furthermore, the application on the device with Android, which allows reading the data was described. There were used *Java* and *Android* environmental elements, such as SDK *(Standard Development Kit)*. This application has been enhanced with the function of biofeedback.

3. The measuring system

One of the most important parts of this wireless device to improve elderly person care is the measuring system. The construction of the measuring system consists of: a part placed on a finger (which includes temperature and pulse rate sensors), electrodes located on the chest and the computing system. Heart Rate Monitor is a system which allows users to measure heart rate.

To measure temperature was used DS18B20 1-Wire digital temperature sensor from Maxim IC. Reports degrees C with 9 to 12-bit precision, −55C to 125C (+/−0.5C). Each sensor has a unique 64-Bit. Electrocardiography (ECG or EKG) is the process of recording the electrical activity of the heart over a period of time using electrodes placed on the skin. For this measurement was used the AD8232 SparkFun *(Heart Rate Monitor).* It is a cost-effective board used to measure the electrical activity of the heart. This electrical activity can be charted as an ECG and output as an analog reading.

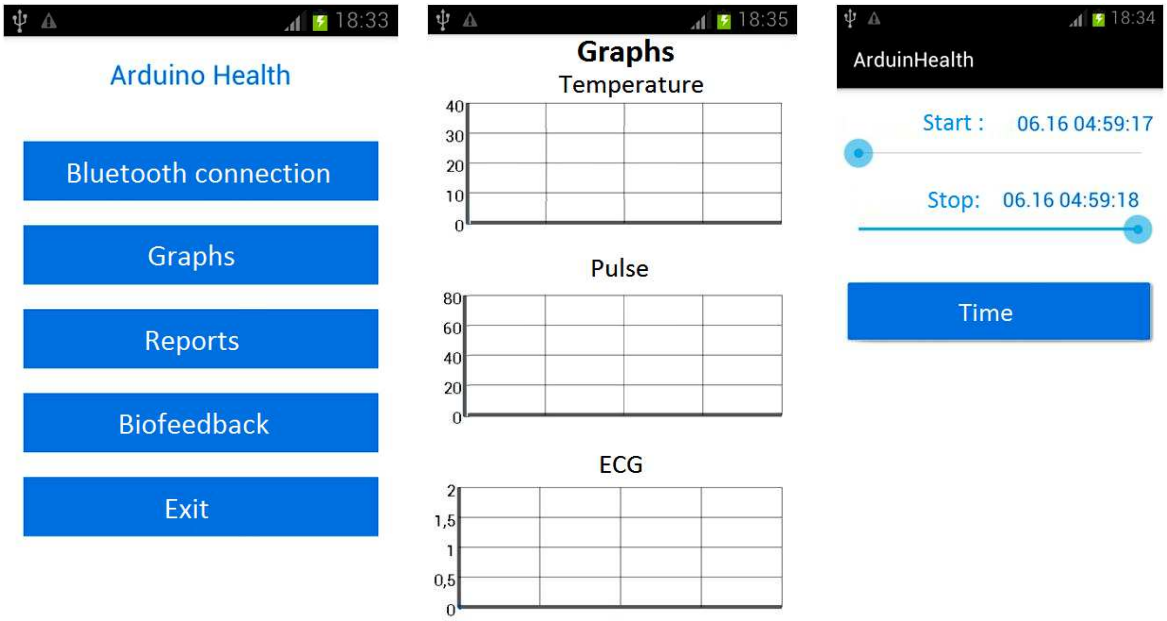
This project was based on *Arduino Mega 2560*. It is a microcontroller board based on the *ATmega 2560*. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection. In this project it was used HC-05 module. It is an easy in use *Bluetooth SPP (Serial Port Protocol)* module, designed for transparent wireless serial connection setup. Serial port *Bluetooth* module is fully qualified *Bluetooth V2.0+EDR (Enhanced Data Rate)* 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It uses CSR Bluecore 04-External single chip Bluetooth system with CMOS technology and with AFH *(Adaptive Frequency Hopping Feature).* In this project it was used 9V battery. All of these data are displayed on LCD screen or on Smartphone [3].

The software and communication with the external measuring system were written in the environment *Arduino IDE*. *Arduino* is usually programmed in *C/C*$^{++}$. The purpose of the program is to retrieve data from the sensors and send them to a Smartphone with *Android*. At the beginning, the program initiates the used libraries. Then, the OneWire object was created to communicate with a temperature sensor. The pin number was given in the function argument. This object is given as an argument to the class object named DS18B20 sensor. The table "address" specifies the address of the temperature sensor. Then, global variables are defined, and finally found the initialization of the display with the specified pins numbers. Pulse rate measurement is performed by using two functions: warp () and pulse (). The warp () is designed to set a threshold value above which the measurement is started. The pulse () during the first minutes does a preliminary measurement of count heartbeats. Then, continuous pulse measurement is performed.

Electrocardiogram measurement is realized by reading of the analogue port. This measurement is performed when the slider is activated and the ECG electrodes are placed on the user's body. The function print () is designed to send data to the application. The data is formatted as JSON. It is a data exchange format for easy communication. The function display () generates a text. Then the current data are shown the on the LCD, depending on the condition of changed keys [2], [8].

4. Android application

A Smartphone with *Android* is used to retrieve data from sensors. An app for this device was written in *Java* and activated by *Dalvik Virtual Machine*. The *Android* application is using the *Android Studio* development environment [1], [3], [7]. Application is characterized by ease of use and clarity. The application consists of four basic windows: main window, graphs, reports and biofeedback. A main window is also the startup screen. It has the buttons that allow to control of this application (Fig. 2a). Graphs allow to display the data from measuring system or display data from the reports (Fig. 2b). Reports allow presenting the results in the selected time period. Biofeedback was created based on open source of tetris game. Biofeedback provides information about changes of physical condition and user's reaction during selected exercises. This module is described in detail later in this article (Fig. 2c).



(a) (b) (c)

Fig. 2. *Android* application: (a) Main Window, (b) Graphs and (c) Biofeedback
Source: Elaboration of the Authors

Source code contains several important classes (e.g. MainActivity, WykresyActivity, HistoryActivity, ChooseDataActivity, BluetoothConnection, HealthDBHelper, HealthDBManager, ArduinoService).

5. Biofeedback module

Biofeedback module is an innovation of this kind of system. Biofeedback is a method of treatment that our device uses to measure and display on smartphone screen patients physiologic information of which they are normally unaware [9]. By monitoring the smartphone screen, patients can learn by trial and error how to control "involuntary" bodily processes such as blood pressure and temperature. This module enables biofeedback training with the use of changes in heart rate and temperature. This module based on game of Tetris using code to Open Source License. It allowed us to prepare this game with specific modification for biofeedback. In our version of this game, user can change the speed of the falling blocks depending on changes in heart rate and temperature.

The game is designed to help user to control sudden nervousness which is a result of changes in the speed of action of the game. If blocks in game are changing the speed of falling down, user should not be nervous but he should concentrate on the game and his emotions. The purpose of this training is to improve the bioelectrical activity of the brain, what causes improving the patient's condition.

6. Tests

The software was prepared and tested on Smartphone Samsung Galaxy. During the first tests we wanted to check the behavior of the application user body in stressful situation. This stressful situation was generated when the user played the game Tetris with our with specific modification for biofeedback. In our version of this game, the speed of the falling blocks can be change. In our version of this game, the speed of the falling blocks can be changed suddenly in strange of situation. The average speed of the falling blocks is 0,5 one block of the tetris game per second. The playing field in tetris game is 34×21 blocks. It causes a stress in user body which can be detected by changing of pulse, temperature and ECG or a frequent errors in the game. It is possible to observe this phenomenon (stressful situation) in the ECG chart (Fig. 3) and temperature chart (Fig. 4). In our case a low-cost temperature sensor, it cannot observe this phenomenon. The game is designed to help user to control sudden nervousness and learning to control own body.

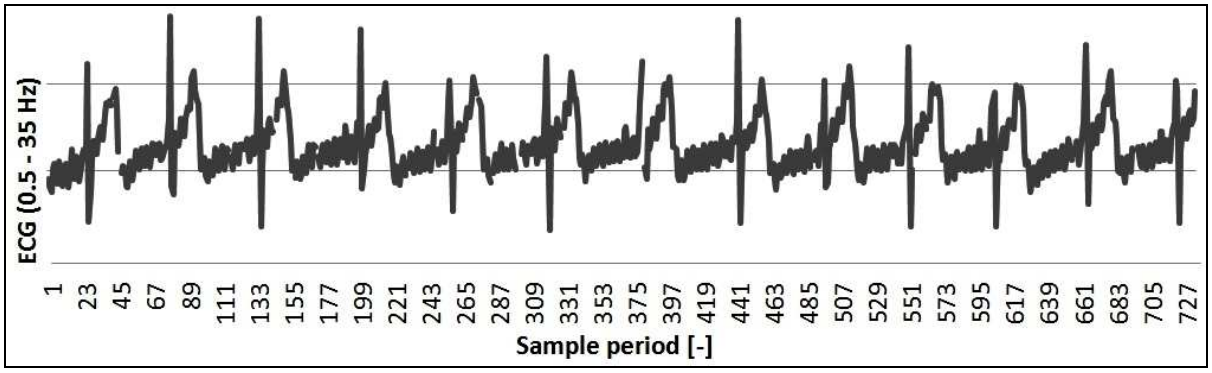


Fig. 3. ECG chart
Source: Elaboration of the Authors

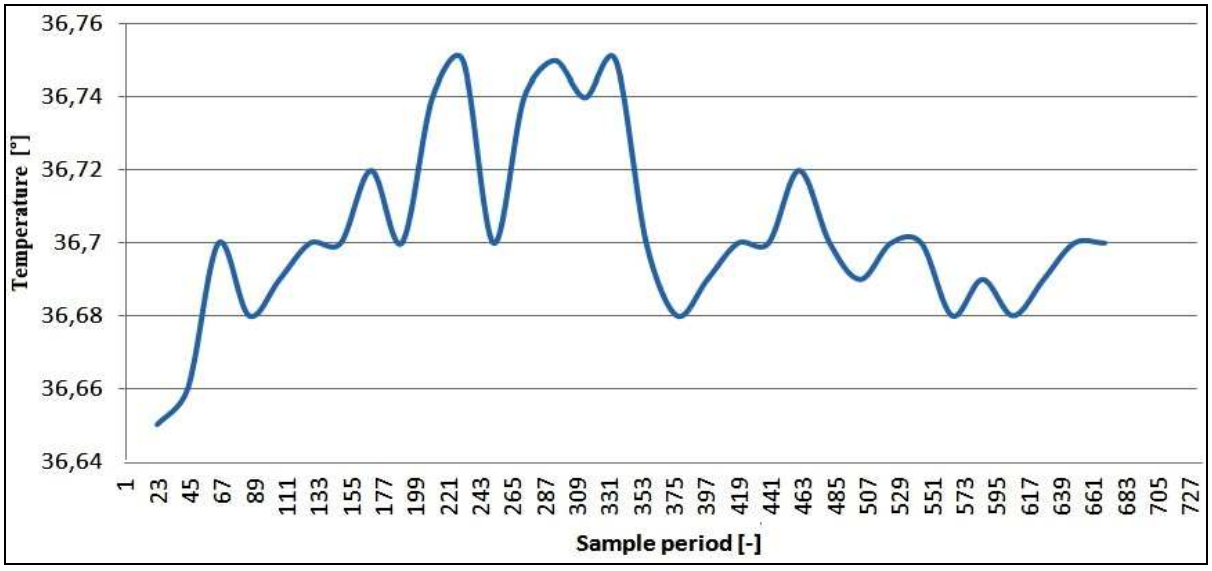


Fig. 4. Temperature chart
Source: Elaboration of the Authors

7. Conclusion

Taking everything into account, our measuring device consists of two parts: measuring system and application. The system is able to control a pulse, temperature and ECG recording. This innovative application was prepared in *Android studio*, this app collects data from the measuring system and contains a biofeedback module to help user to learn self-control and self-discipline.

This biofeedback module is based on the game Tetris using code to Open Source License. In our version of this game, user can change the speed of the falling blocks depending on changes of basic vital signs measurements. The speed of the falling blocks depends on changes in heart rate and temperature. During the game, user should not be nervous but should concentrate on the tasks. However, working on someone's concentration can be carried out not only on the basis of the proposed game.

The most helpful function during the rehabilitation is the ability to generate graphs and possibility to further analysis. Thanks to the modular design, it is possible to expand the system with additional sensors and new function of app.

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