Wireless data acquisition system for IoT applications

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***Abstract*— This paper presents an innovative implementation of a data acquisition, which is able to communicate with a chest belt in order to obtain the heart rate value and accelerometer data from a EZ Chronos watch. The main goal of the work presented is to implement an embedded system, which can be used in various life assisted or medical applications.**

Keywords—Arduino; Internet of things; body sensor; wireless sensors network

I. INTRODUCTION

The Internet of Things concept is more and more present in daily life and will take some time until it will be fully integrated, but this period is rapidly reduced thanks to new technological improvements. One of this is wireless networking technology which rich a high level of communications protocols standardization and it makes possible to acquire data from remote sensors from almost anywhere and no time restrictions. The new nano technologies applied in silicon chips manufacturing gave new capabilities, at lower costs. Also the new improvements in storage devices and increased computing power available via cloud computing, make possible a very large scale integration at declining cost.[19]

In health care domain, these sensors and high speed data links allow to monitor a patient behavior and disease symptoms in real time, allowing a better diagnose and an efficient treatment regimens. Patients suffering by chronic illnesses can be connected at different type of sensors, so that their health conditions can be monitored permanently without disturbing their daily activities. One most chronic illness is congestive heart failure. Patients suffering of this disease are typically monitored during a periodic for blood pressure, weight, and heart rate and rhythm. Sensors placed on these patients can now to supervise and send this data remotely and continuously, giving some vital information's and warnings of present health conditions that would otherwise could lead to heart failure or increased cost with treatment.[20]

II. PROJECT IMPLEMENTATION

The main goal was to design and implement a system capable to acquire different types of data, related to person monitoring process and as results of data processing to be able to extract a series of behavioral patterns. In order to achieve this, it was used, Arduino ChipKit MAX32, ChipKIT WiFi Shield, EZ Chronos development Kit produced by Texas Instruments and a chest belt produced by BM Innovation.

The chipKIT™ Max32 is based on Arduino™ open source hardware platform modified to Microchip PIC32MX795F512, a 32-bit microcontroller, compatible with the most Arduino™ microcontroller board shields.[21]

One of these shields, used on this project implementation is the WiFi shield, which allows to connect the platform to remote locations or to interface a webserver hosted in MAX32 board with client applications, via internet. This board is develop based on Microchip MRF24WB0MA WiFi module.[22]

The eZ430-Chronos is a wireless development kit which provides useful and complete hardware/software resources to implement wireless smart watch applications. Chronos is used in various applications: wireless watch, personal data processing system for personal area networks or as wireless sensor nodes in remote data acquisition systems.[23]

The BM-CS5R chest strap is used as heart rate sensor and a data transmitter using *BlueRobin*™ data transmission technology.

The schematic of experimental platform is presented in Fig.1

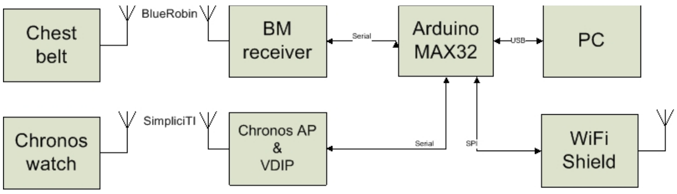

Fig. 1 Experimental platform schematics

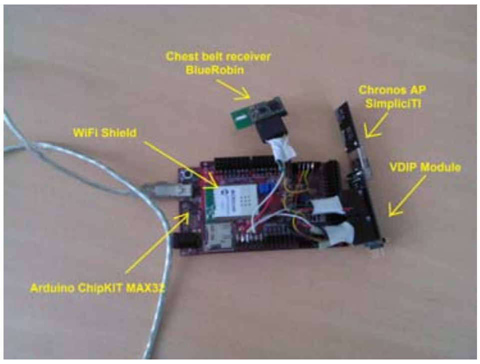

Fig. 4 Experimental platform

III. EXPERIMENTAL RESULTS

In first phase of project development, Arduino ChipKIT MAX32 it was used along with VDIP1 module and EZ Chronos Kit to acquire accelerometer data provided by Chronos watch. A schematic of this experimental setup is presented in Fig.2

Fig. 2 First experimental platform setup

Arduino MAX32 it was programmed by using MPIDE interface. The VDIP module and the Chronos AP interface require some command to start the communication. These commands are stored at the beginning of the program in VDIP_1, VDIP_2, data_rq, start_ap. Serial interfaces are initialized at 9600 baud. Serial interface is used in Arduino/PC communication and Serial1 interface is used to connect MAX32 board to Chronos watch trough VDIP and AP modules. AP module and watch use SimpliciTI protocol which is developed by Texas Instruments.

In the next phase of project development, hearth rate data are received from a chest belt wich use BlueRobin protocol. Fig. 3 presents schematic implementation of the system.

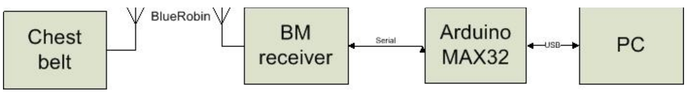

Fig. 3 Chest belt data read project implementation schematic

The BlueRobin protocol is able to offer low data rates communication support used in wireless body area sensor networks at low power consumption, with high reliability and low hardware implementation costs. Data rate is programmable from 8 bits up to 256 bits on each data packet and 500 ms up to 1 second interval between packet transmissions.

Additional control and configuration of sensor, it can be done from the receiver side by using an optional messaging system which allows data transmission to the sensor. This operation causes increased power consumption on the sensor side. This protocol permits also to switch sensors on or off in a very power efficient way, from the receiver side.

The next step in the system development was to combine all those data, accelerometer and hearth rate data, to see if a pattern of movement can be extracted. The experimental platform it is presented in Fig.4.

In the main loop of the program, data from the chest belt are requested and tested if they are valid, by testing the RSSI communication parameter. If they are valid, acceleration data from the Chronos watch are also requested and tested to be valid by testing the parameter contained in the header of data string. After validation of this parameter, all data (hearth rate, x acceleration, y acceleration, z acceleration) are sent to PC. All this process is presented in Fig. 5.

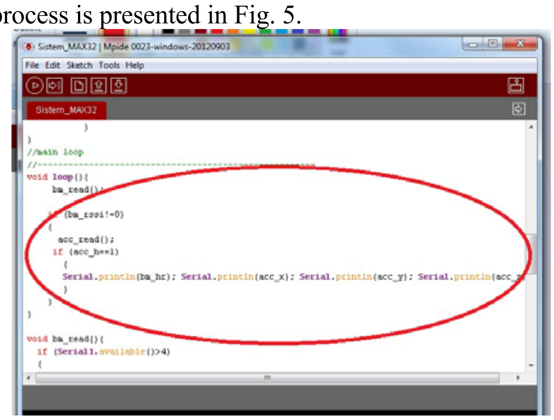

Fig. 5 Software main loop

It was also implemented a wireless data transmission by using WiFi shield. This functionality is very important for next project development stage. It can be used to send data to a remote PC, hosting a database, or a webpage to display charts or information based on this data.

The connection process starts with connection status check and a TCP connection to a web server. In this case connection is made to APRS server [1,4].

Connection to APRS server requires a specific IP address and port number and also a login process. After a successful login operation, data can be sent to the database for processing [3,8,9].

APRS system allows to display object parameters and to place them on map. Data for object placement on map it can be obtained from a GPS or they can be set manually. In this project these data are fixed because are used only for tests. An example of data transmitted, using this experimental platform, to APRS server is presented in Fig. 6.

Fig. 6 Data displayed on APRS system

The data received from the chest belt and Chronos watch was also stored on PC for advance processing in Matlab software. Based on these data some graphics and simulations were made. Some of the results are presented below.

As it can be seen on Fig. 7, a set of data representing ten static or dynamic positions was taken from the experimental platform. Data acquisition for each position was made during approximately ten seconds, at a rate of fifty sets of data per second.

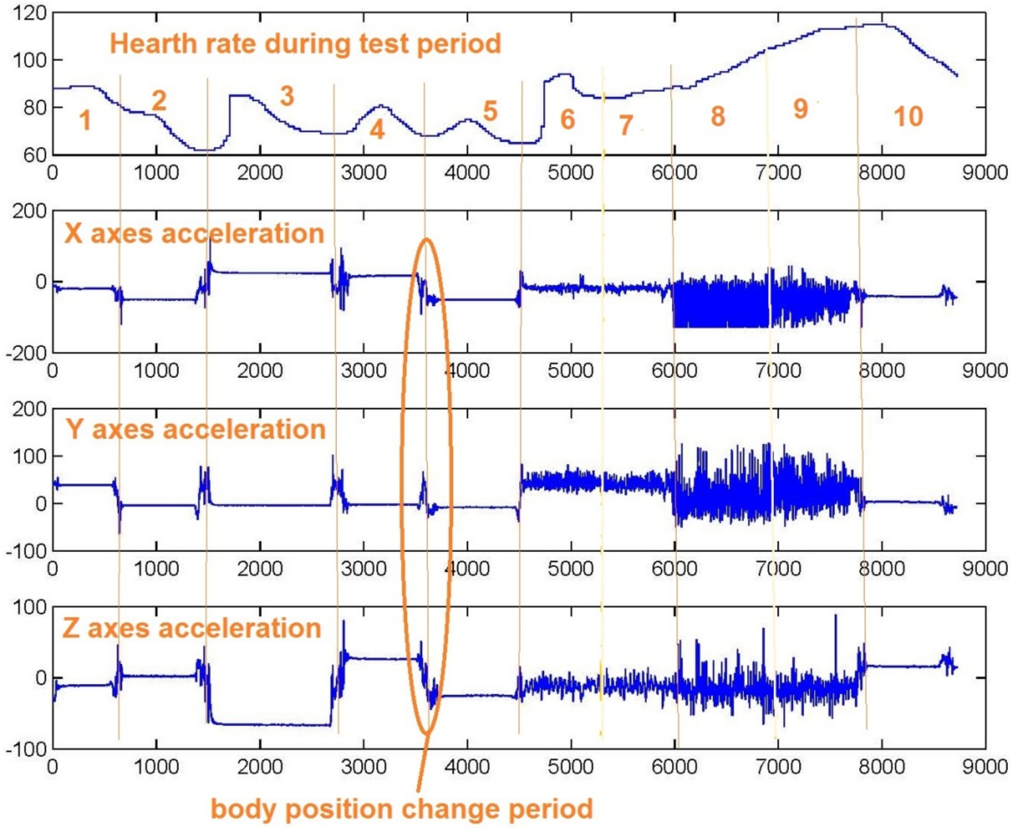

Fig. 7 Experimental test results processed in Matlab

It can be observed the rising value of heart rate during the period of dynamical gesture such as slow forward walk (position 6),slow backward walk (position 7), slow forward running (position 8), slow backward running (position 9) and falling value on resting period (position 10).

Changes of body position and statically/dynamical gestures can be also observed by analyzing the accelerometer data. There are represented six static positions: stand-up (1), lying on back (2), lying on one side (3,5), lying on belly (4) and rest position (10). The body position changing, determines a "spiky" data as it can see on Fig. 7.

IV. CONCLUSIONS

Wireless sensors network technology it is one of the most important technologies of 21st century [5]. Smart electronically devices, a large variety of sensors type at affordable price, connected through wireless or internet connections placed in very large numbers, offer the opportunities for monitoring and management applications. All of these networks of micro sensors provide new solutions to many vital areas such as health or industry, offering new options in monitoring actions or other industrial, automotive applications. Sensors can be installed on the ground, in the air, underwater, on the body of persons, in auto vehicles or inside of buildings. All these sensors connected together on a network can be used to process a lot of events, to monitor vehicles, persons or to identify biological or chemical agents [14-19]. Each intelligent sensor from the local network is based on an embedded system which is capable to process data from one or more sensors implemented with less processing capabilities. These sensors may be thermal, infrared, gravitational, magnetic or ultrasonic.

The project is fully functionally and it can be used on real situation of person's assistance and monitoring activities [9, 14-18]. It was implemented various configuration in order to be able to receive data from an accelerometer and from a chest belt. These data, acceleration and hearth rate, are used for extracting behavioral patterns relating to persons assistance process.

The application presented in this paper, is a part of a wider project which aims to create and develop a smart sensor wireless network implemented in microcontroller or FPGA circuits, using mono or multiprocessor technology according to Internet of Things concept [1,4,8].

ACKNOWLEDGMENT

The presentation was supported by the TÁMOP- 4.2.2.C-11/1/KONV-2012-0001 project. The project has been supported by the European Union, co-financed by the European Social Fund.

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