MOBILE SYSTEM FOR MONITORING SPORTS ACTIVITY

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Abstract

This paper presents a possible technical solution for monitoring sports activity. An important parameter of workout monitoring is a heart rate usually measured via a chest strap. Electric signals of heart activity are transmitted into an open-source Arduino platform and results are presented to the user in a clear and structured way through a mobile application. The suggested system shows the possibilities of using available SW and HW technologies and their implementation in the design of an integrated tool for monitoring sports activity with the iOS operating system. The Project is a part of my Master's thesis and this paper presents its current version. The aim of this project is to design a tool that supports the user by monitoring his or her heart activity and unlike other available solutions also show the user's respiratory rate.

Keywords

Sports activity, POLAR, Arduino, iOS, heart rate, respiratory rate

Introduction

Monitoring biological parameters during a sports activity is one of the fastest growing segments on a field of "The internet of things". An important part of these systems are mobile applications that provide the user with clear results and offers possibilities to share these with the networking community. Getting the user's real-time heart rate (HR) is a common method of workout monitoring. The measured HR is also an important parameter for assessing an anaerobic threshold and thus deriving individual sports load thresholds. These thresholds represent "sport zones" based on the percentages of the users individual maximal heart rate. A further essential parameter for measuring a workout that reflects an individual load is also the respiratory rate (RR). The measurement of HR and RR improves the accuracy of a load level assessment and also the affectivity of a workout evaluation.

Furthermore a distance and speed measurement during a workout is easily integratable when using a mobile phone equipped with a GPS function.

Evaluation and presentation of the workout data is done via a native iOS mobile application on an iPhone device. SW and HW connected with this operating system must meet the strict conditions of Apple company. This paper also presents the possibilities of available SW and HW solutions while designing and connecting an external accessory with the iOS.

In the first part of this paper I will be evaluating available HW tools for monitoring heart activity with an open-source Arduino platform and their possible interconnection. The components used while designing a full-integrated system for monitoring sports activity and the method of calculating HR will be also described. Lastly I will present my suggestion for a mobile application for evaluating the measured data and presenting it to a user.

The suggested system is a part of a Master's thesis project. Some parts of a system, like measurement of RR, are currently not in a state of final realization.

Monitoring heart activity with Arduino

Electric heart activity is used as a primary biological parameter for calculating heart rate and later also respiratory rate. In the following chapter two available technical solutions of monitoring heart with Arduino platform will be presented.

AD 8232 Single Lead Heart Rate Monitor

The AD 8232 (Fig. 1) is a little chip distributed by Sparkfun used to measure electric activity of the heart. This electric activity can be charted as an Electrocardiogram (ECG). Electric signals of the heart are measured with 3 sensor pads. The chip is designed to be easily connected with any Arduino development board. In this project the chip was tested with Arduino-UNO board [1].

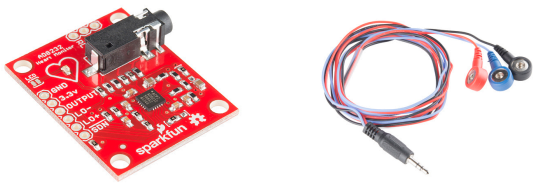

Fig. 1: Chip AD 8232 [1].

The running ECG signal shown in Fig. 2 suggests that the AD 8232 chip is not a suitable device for measuring sports activity. The sensor works correctly when a user is not moving at all. With movement, as seen in the second half of the chart, the measurement picks up too much noise to realize feasible RR interval measurements based on the ECG and thus it is also not possible to count HR and RR.

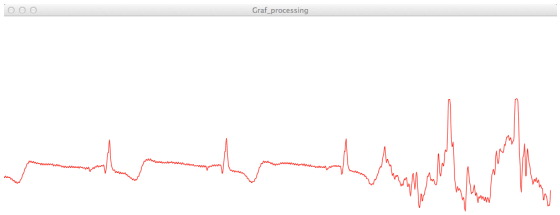

Fig. 2: Electric aktivity of heart (ECG) measured according to [1] at a rest and while moving.

POLAR T61 chest strap, RMCM-01

Chest straps for monitoring workout developed by POLAR are one of the most accurate. Monitoring is realized by two electrodes placed on the sides of a belt. The Central block of the belt is used for preprocessing and signal transmission into the processing part of a system. Presented system uses the sensor T61 (Fig. 3). This sensor electrically detects a heartbeat and transmits the pulse corresponding to each heartbeat for further evaluation and HR calculation. Transmission frequency is 5 kHz [7].

Fig. 3: Sensor POLAR T61[3].

Chip RMCM-01 is used to wirelessly receive heart rate signal from a Polar chest belt. This chip can be integrated into the Arduino platform where it generates a corresponding digital pulse. The output is fixed at 1ms 3V positive pulse. The time between two incoming pulses corresponds to the RR interval. It is possible to obtain this interval by subtracting the time of the last R wave from the previous. RR interval represents the primary parameter in heart rate variability (HRV) evaluation. From the knowledge of RR intervals the HR can be calculated as shown [8].

$$\mathrm{HR} = \frac{60}{\text{RR interval}} \ [\text{beat/min}]$$

The Value of the actual RR interval is derived as an average of the last eight detected pulses. The Chip was connected and tested as documented in [5] with the Arduino-UNO development board. Results of the calculation are values of an actual heart rate (Fig. 4).

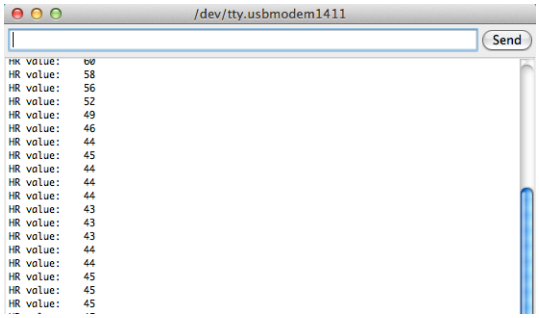

Fig. 4: HR values measured with T61 chest strap and calculated in Arduino-UNO development board according to [5].

This method of detecting and calculating HR provides valid data independent of the user's movement.

Connecting Arduino to iPhone

Connection between Arduino and iPhone is possible from version 3 of the iOS operating system. Also the current version iOS 8 supports this connection via the "External Accessory Framework". However strict Apple regulations to SW and HW developers means that there are just few possibilities of a legal connection.

One possible way of connecting iOS to Arduino is the development of a brand new HW. This process not only involves designing a new device, but also participation in Apple's MFi (Made For iPod) programme. Becoming a member of this programme is not easy and the entailed process of approvement by Apple takes very long time. In this paper two possible solutions, already approved and licensed by Apple, will be used [2].

The Redpark Serial Cable

Serial cable from Redpark (Fig. 5) is an easy solution for connecting external HW with iOS. Serial communication is established between Arduino and 30-pin iPhone adapter using developer library. This library is written by Redpark to make the connection possible [2].

Fig. 5: 30-pin Redpark TTL Serial Cable [4].

Blend Micro

Blend Micro from RedBearLab (Fig. 6) is an integrated development board that combines Arduino compatible microprocessor and Bluetooth 4.0 Low Energy module. This special board is certified to connect with iOS compatible devices via supported library of functions. Any sensor can be than easily implemented to this board. This will create an easy solution for preprocessing incoming signals. Signals can be then send to compatible iOS device for further calculations and analysis [6].

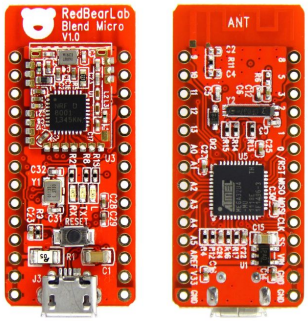

Fig. 6: RedBearLab Blend Micro integrated developement board [6].

Suggested system

The aim of this project is to design a tool that supports the user during his workout through a mobile application. This is done by implementation available SW and HW technologies when designing full-integrated monitoring tool. Suggested system consists of three main components. The detector of a biological signals, receiver implemented with Arduino board for preprocessing and end user equipment - a mobile application for data processing and analysis.

Detector (sensor)

Based on the testing of the two mentioned approaches of electric heart activity measurement the chest belt T61 proved to be the better system to be used for the final realization of a system. Electric signals detected on the skin by two electrodes are filtered and the R wave of the ECG is amplified in a chest central unit. Then this signal is wirelessly sent to the processing unit.

Processing unit

RMCM-01 chip (Fig. 7) connected to RedBearLab development board is used to wirelessly receive a heart signal from a Polar chest belt and for the generation of the corresponding digital pulses. Based on RR interval measurement it is then possible to calculate HR and later also RR. This solution allows to make processing unit small and connect it with iOS application via Bluetooth 4.0.

Fig. 7: Chip RMCM-01 [7].

Mobile application

Data detected by a chest belt and preprocessed by Arduino platform microprocessor are transmitted to a native mobile application via Bluetooth. In this application the data is processed and HR calculated. Later also the RR will be calculated. Using iPhone sensors like GPS or gyroscope is also possible to display actual and average speed or total distance during sports activity. Graphical user interface of the application (Fig. 8) corresponds to Apple's regulations for iOS 8.

Fig. 8: Suggested mobile application

Conclusion

The suggested system presents the possibilities of using available SW and HW technologies and their implementation when designing a full-integrated monitoring tool.

The System is being designed as a part of a Master's thesis and in its current development state can calculate HR from electrical pulses of a Polar chest belt connected to Arduino board. Data is then transferred to iOS mobile application where actual value of HR and other information about the respective sports activity are displayed. The aim of this project is unlike other technical solutions also to calculate values of RR from distances between incoming RR intervals of ECG, which ultimately represents the goal of further development.

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