Journal of Advanced Sport Technology 3(2):42- 49 Received: December. 8, 2019; Accepted: February. 15, 2020

Original Research

Designing the Prototype of Smart Athletes Recording Equipment Based on Internet of Things Using the Arduino Board

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ABSTRACT

Nowadays recording the performances and body activities of the athletes during the exercises and the matches have noticeable importance which is the reason for growth of the sports wearable's technology, for the past few years. Accordingly, we designed new wearable equipment on the basis of internet of things, using Arduino Boards and different kind of sensors for recording the performance and physical activities of the athletes. The process data of the sensors are available in real time and could be displayed in the PC through the internet connection which makes the coach capable of analyzing the performance of the athlete during or after the activity. The weight of this equipment is less than 100 gr and works with a frequency of 5 Hz (the data will be updated every 200 ms). The advantages of the designed equipment comparing to similar imported ones are the smaller size and the less ultimate cost.

Keywords: *Wearable Technology, Sport, GPS, Wi-Fi.*

Introduction

Global Positioning System (GPS) is a navigation and positioning system based on the information of orbiting satellites. The system serves both military and civilian users. Initially, the Standard Positioning System (SPS) with an accuracy of 100 meters was usable to private users, which provided military users with an accuracy of 20 meters for the Precise Positioning System. Both of these services did not require local references throughout the land, but in Differential GPS accuracy of 2 to 10 meters, it was available within 1000 kilometers of a fixed GPS reference receiver. New GPS systems provide centimeter accuracy of 10 kilometers and potentially 100 kilometers around a stationary GPS reference receiver [1]. The first suggestion to use GPS in assessing physical activity goes back about 40 years. Validation studies and steady-state motion measurement studies have brought this technology fast into the sports world [2].

Nowadays, the wearable technologies in sports, which consist of the sensors for recoding the physical activities and heart rate, have 14 billion dollars and the growth rate of 12-25 percent from 2012 to 2017 [3].

Wearable sensors are an essential tool in sports. They can provide individual feedback to athletes during training and improving their health. Physiological and biomechanical movement data typically measured in all applications [4-6]. Most athlete physiological tests performed in well-controlled laboratory conditions. Numerous factors make it difficult to control the use of field-specific exercise tests. Recently, the GPS technique has proposed as a way to monitor the position and speed of athletes while performing outdoor activities. These two performance factors are critical during the training of athletes [7, 8]. The GPS technique can provide probably other bioassays, such as heart rate, that may be combined, and may allow other

physiological studies of exercise in this area. Otherwise, it is limited to the lab [7]. Also, this technology can describe the covered distance and the number of acceleration and intensity of training and average speed per game [9-11]. There are a lot of patents on wearable technologies that can be cited as some of these:
Wearable human physiological data sensors and reporting system therefore (John StivoricFrancine, GemperleChristopher, Kasabach). Exercise Monitoring system and methods (Jack B.stubbs, Waynesville, and Kevin L.Schwieger). Wearable Electronic Device (Jonathan C. Burrell, David F.Lammers-meis, Prairie Village). Methods and apparatus for recording and synthesizing position data (Brig Barnum Elliott).
The designed equipment by our team is a smart recorder of performances of the athletes with a monitoring system using the Arduino Boards based on the internet of things. The mentioned system is a cutting-edge technology that monitors the physiologic and physical variations of athletes' bodies (e.g., measurement and assessment of the heart rate, instantaneous acceleration, and speed in addition to the covered distance) and make it available for the coach to observe. This equipment is in the field of sport-medical engineering and electronics-information technology engineering. The mentioned equipment using a microcontroller and proper sensors are capable of measuring the heart rate and the other parameters and sending them to a PC to analyze the performance of the athlete. The transferred data and analysis will help the athletes to increase their physical status and become Well-adjusted with the exercises.

Material and Methods

The general block diagram of the equipment has shown in figure 1

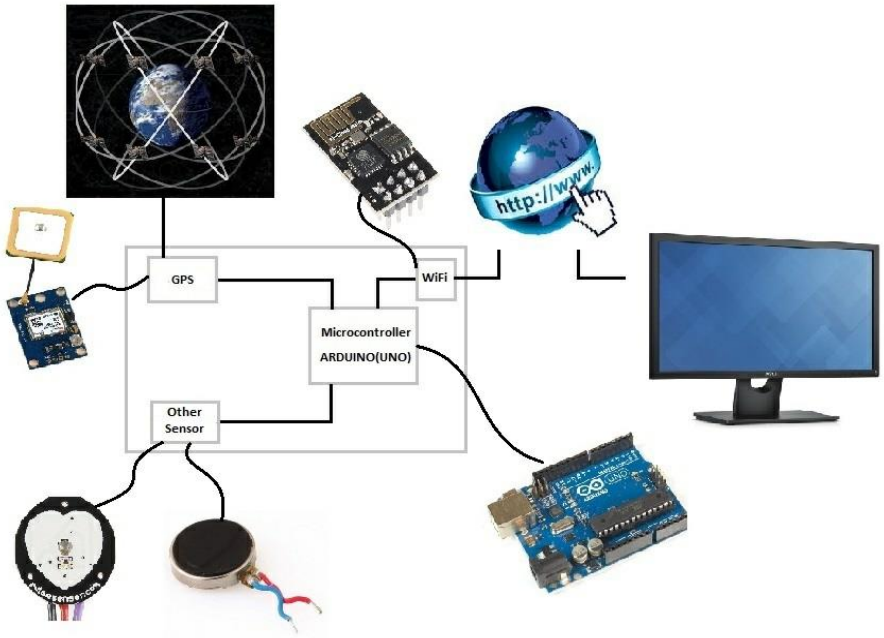

Figure 1. Block Diagram of the Equipment.

The designed equipment uses four following sensors: 1) GPS, for measuring the velocity, acceleration, and the taken distance of the athlete. 2) Pulse sensor, for the measure of heart rate. 3) Wi-Fi module, as the wireless connection to communicate the data to display on the PC. 4) The vibration module used to warn in case that the athletes' health is in danger. The main core of the equipment is an Arduino board (equipment) consist of a microcontroller (Atmega328, Atmel, USA) with 32 KB of flash memory and the processing speed (frequency) of 16 MHz. The supply of the board could be in the range of 7-12 volts while the operational voltage is 5. This board includes 14 digital input-output pins and six analog inputs for receiving the signals and the data of the sensors and modules.
Integrated Development Environment (IDE) has been used as the programming software with the advantage of being open source. The desired program will be written in the environment of the mentioned software, and

it will be programmed on the board. During the working mode of the board, the microcontroller will receive and process the raw data of the sensors and modules which are coming through the digital and analog input ports. Meanwhile, the processed data will be sent to the PC to be displayed using the Wi-Fi module. This equipment has been designed based on the internet of things.
Regarding the use of the GPS module (which records the data of position, speed, etc.), the equipment should be attached to the athlete's body. Also, because of the pulse sensor, which uses the infrared waves, the equipment should always be close to the skin to have the least error. Due to the mentioned reasons, it is advised to implement and use this equipment in the form of a sports vest, wrist, or bracelet.

Modules and the measuring sensors

Measuring the heart rate

The Pulse Sensor Amped is used in order to extract the heart rate parameter. This sensor is capable of measuring the invisible variations of the blood vessels during the blood pumping and indicate a heartbeat in the form of an electrical pulse. By recording these pulses with a microcontroller, it's easily possible to calculate the heart rate [12]. Figure 2 shows a Pulse Sensor Amped.

Figure 2. Pulse Sensor.

This sensor has been set up in analog form with a voltage of 3-5 volts.

Measuring the acceleration, velocity, and distance

NEO-6M module could display the position, geographic latitude, and longitude, velocity, height over the sea level, angular velocity, exact acceleration timing, etc. while we use only the athlete's performance-related parameters, which are acceleration, velocity, and distance. This module is set up with a voltage of 3.3 v, and the communication protocol is serial using the digital pins. The receiving data from the module will be updated with a frequency of 5 Hz. The external antenna of the module will influence the accuracy of the positioning, and considering that the positioning data will be received by Global Positioning System satellites, this equipment should be used in outdoor environments. Figure 3 shows a sample one with the external antenna.

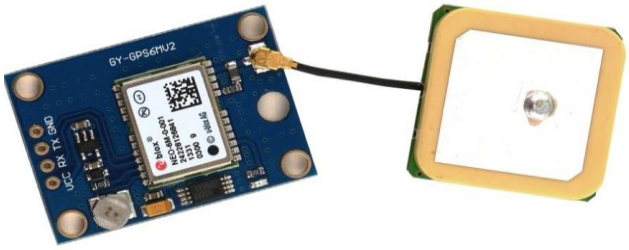

Figure 3. GPS Module.

Sensor for the internet of things

We used the ESP8266 module for accessing the internet, which makes us able to send and receive data to the equipment through the internet. The mentioned module is one of the best Wifi modules, which is capable of programming and using the Arduino environment. Figure 4 shows the view and specifications of the module.

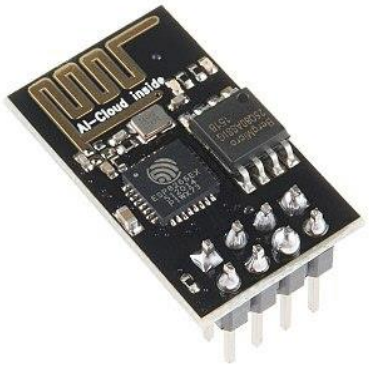

Figure 4. ESP8266 Module and specifications of the module.

#	Property	Description
1	Voltage	3.3 V (3.0 – 3.6 V tolerated)
2	Flow	10 uA – 500 mA (64 mA average)
3	Microcontroller	Tensilica L106 32 bit
4	Clock	80-160MHz
5	RAM	32K + 80K (explained below)
6	Memory	Flash memory, 16MB max (512 K – 4 MB often provided)
7	GPIOs	(multiplexed with other functions)
8	ADC	1 (10 bit)
9	WiFi	802.11 support b/g/n/d/e/i/k/r

Figure 5. Specifications of ESP8266 Module.

Results

The weight of this equipment is less than 100 gr and works with a frequency of 5 Hz (the data will be updated every 200 ms). The advantages of the designed equipment comparing to similar imported ones are the smaller size and the less ultimate cost.

Before the final test of the equipment, the accuracy of each sensor (pulse sensor and GPS module) have been checked individually. For measuring the accuracy of the pulse sensor, we used the serial connection to the Arduino software and obtained the heart rate using the serial plotter tool of the software (figure 5).

According to the plotted waveform and dividing the measured distance between two consecutive peaks over 60, we found the heart rate, which shows an error of less than 3 percent.

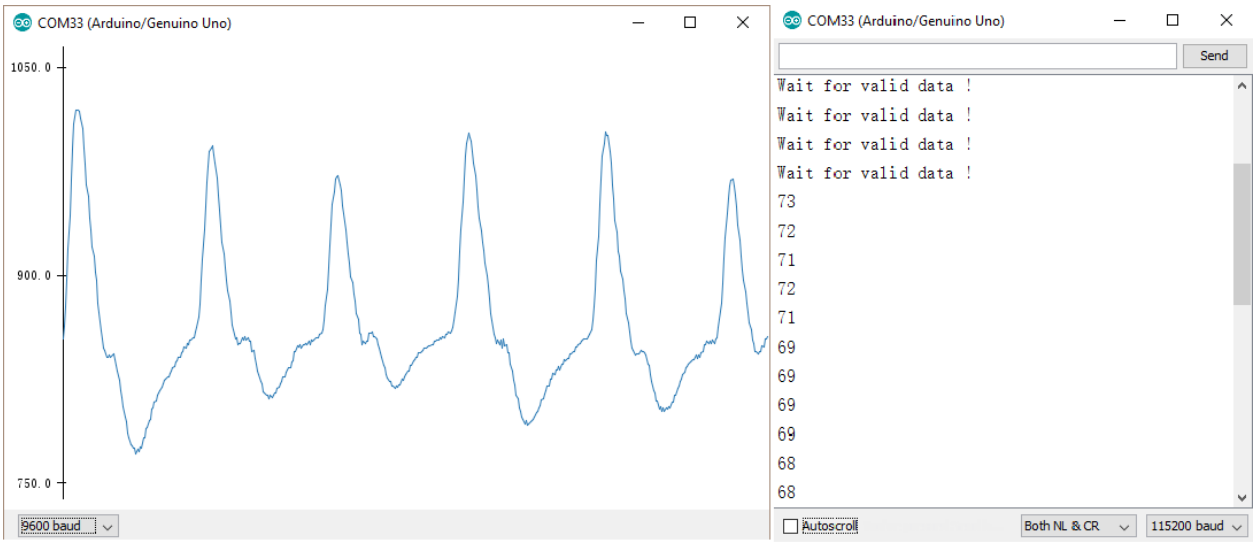

Figure 6. Serial Plotter Output.

Also, for measuring the error of the GPS module, we separately connected to PC using the PL2303 chip (USB-TTL adaptor) and receive the data through the U-center 19.03 software. Figure 6 shows the output of this module, and considering the obtained numbers in this software, the accuracy of this module had been evaluated in the acceptable range. Nevertheless, the NEO-6m is capable of updating the positioning data with the frequency of 5 Hz while it could reach 10 Hz by upgrading it to higher versions.

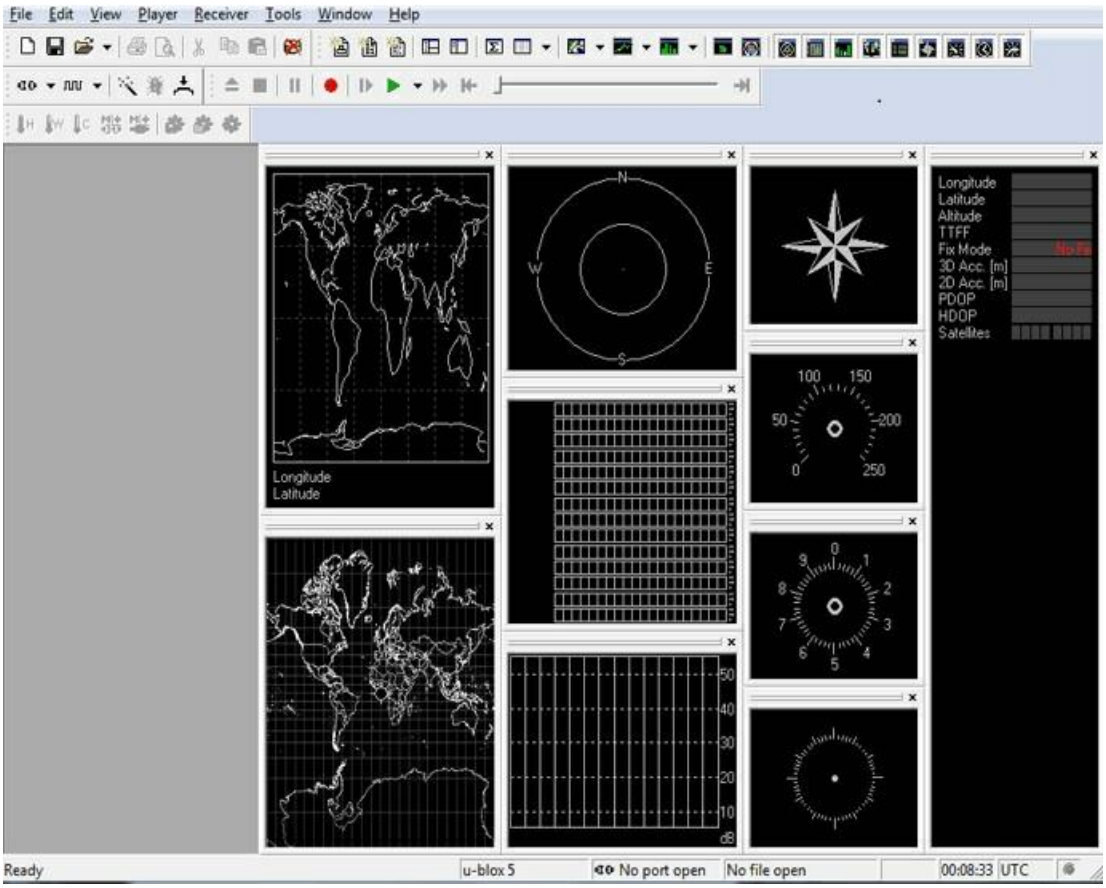

Figure 7. U-center Output.

Figure 7 shows the connections in the Fritzing software. The equipment will be installed on the body in a package form by eliminating the unneeded wires.

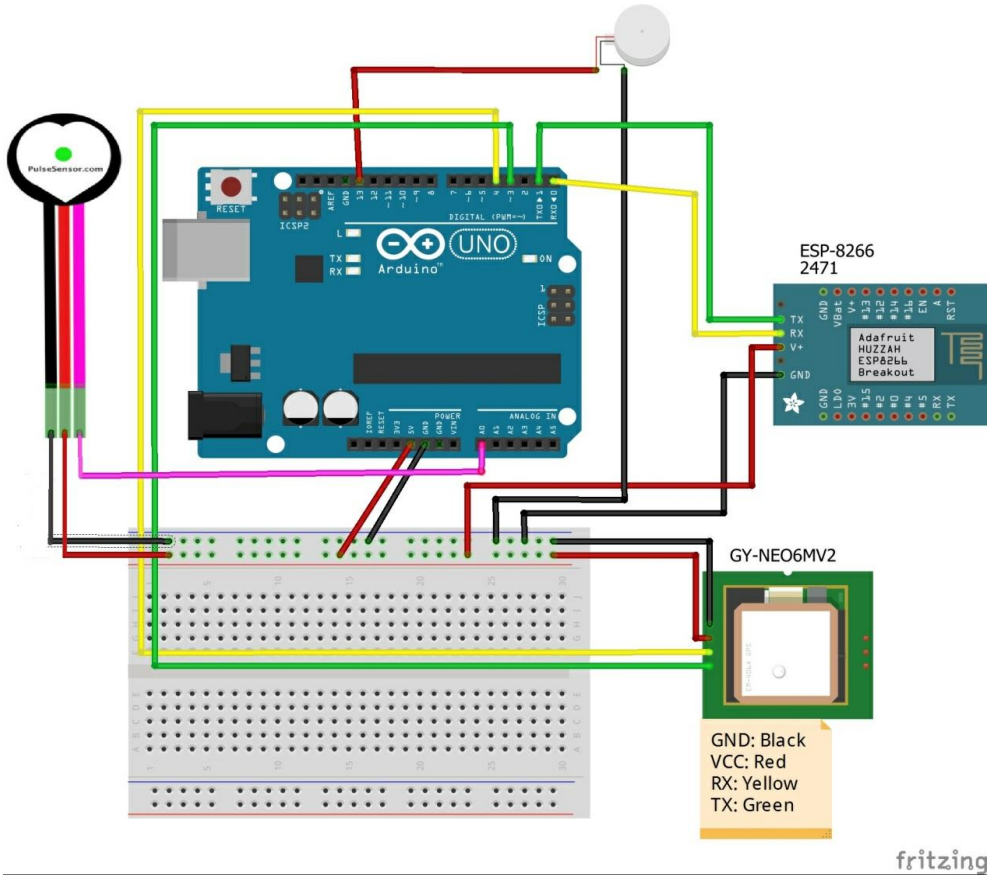

Figure 8. Equipment connection in Fritzing

Conclusions

In this project, wearable equipment for recording the performances of the athletes designed using the Arduino board on the basis of the internet of things which is capable of measuring the data such as instantaneous velocity, average velocity in the desired time periods, covered distance and heart rate and put them online available to the coach in real-time. The measuring parameters could be changed according to the athlete, because the program is open source in the Arduino software.

By the acceptable accuracy of this equipment, it could be used for the athletes; furthermore, to have better accuracy, it's feasible to use the image processing technics.

Acknowledgment

The authors would like to acknowledge the valuable comments and suggestions of the reviewers, which have improved the quality of this paper.

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چکیده فارسی

طراحی نمونه اولیه دستگاه هوشمند ثبت عملکرد ورزشی بر پایه اینترنت اشیا با استفاده از برد آردوینو

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امروزه ثبت عملکرد و فعالیت بدنی ورزشکاران در هنگام تمرین و مسابقه از اهمیت فراوانی برخوردار است. از همین رو فناوری‌های پوشیدنی ورزشی پیشرفت قابل قبولی در چند سال اخیرداشته است. دستگاه پوشیدنی سنسوردار تحت مفسر آردوینو بر پایه اینترنت اشیا که برای ثبت عملکرد ورزشکاران طراحی شده است اطلاعات سنسورها از طریق اینترنت و به صورت آنلاین بر روی کامپیوتر قابل نمایش می‌دهد و مربی ورزشی می‌تواند عملکرد ورزشکار را در حین یا بعد از فعالیت تجزیه تحلیل نماید. این دستگاه با وزن کمتر از ۱۰۰ گرم طراحی شده است. این سیستم با فرکانس ۵ هرتز کار می‌کند. یعنی اطلاعات دریافتی را هر ۲۰۰ میلی‌ثانیه۱ بار به روز می‌کند. دستگاه حاضر در اندازه کوچک و با هزینه بسیارکمتر از نمونه‌های مشابه خارجی آن طراحی شده است.

واژه‌های کلیدی: تجهیزات پوشیدنی، ورزش، جی پی اس، وای- فای.