

# Combine Wearable Technique with Raspberry Pi to Design Sports Assessment System

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## ABSTRACT

Wearable devices and sensors are becoming more readily available to the general public and athletic teams .

Technology advances have allowed individual athletes, sport teams, and clinicians to monitor functional activities, workloads, and biometric parameters to optimize performance and mitigate injury. The aim of this paper is to present an automatic monitoring system for the athlete player using open –source hardware platforms, Node MCU ESP32, Raspberry pi and sensors to measure heart rate, temperature, and rotary encoder sensor with router Wi-Fi and Message Queuing Telemetry(MQTT) protocol to store data in the database.The system is low-cost and more expandable in terms of sensors type and number of sensor nodes, which makes it suitable to measure the performance of athletes where coaches were able to obtain data on a scale for efficiency of the athlete and weaknesses to overcome them.

## Keywords

Sports, Sports performance, wearable technology, IOT, Raspberry pi , Node MCU ESP-32S,MQTT, Node-red.

## 1. INTRODUCTION

The rapid progress in the level of all sports and activities is a result of the correction of errors in the skill performance of athletes and identification of weaknesses in the physical side based on scientific foundations.Traditionally, the assessment of sport games players based on the differences between players skills during training. According to individual differences which depend based on coaches observation using their previous experience. This will lead to making a lot of mistakes and not to choose the right decision in the assessment operation.

In our day , it was found that reliance on modern technologies and the use of technology, will lead raise performance and improve the level and selection of players and guide them in to activities that suit them.

New technology, including wearable devices that show the appearance of fatigue indicators on the athlete during competitions by knowing the number of heart rate, breathing, lactic acid index, hormone activity, temperature and distance traveled, which trainers cannot previously know through observation. Hence the need for wearable devices and the important returns that gives to coaches to know the functional status of the players.wearable devices technology are now available to the general public, sports teams and doctors to monitor biometric and motor features to increase performance and reduce injury[1].

They can be worn as extensions, embedded in clothing or implanted within the human body and are characterized by ease of use and low energy consumption.

In sports, wearable electronic devices are used in four areas[1] :

- 1 -Training.
- 2- Monitoring.
- 3- Self-assessment.
- 4- Improve performance.

## 2. RELATED WORK

Many studies are presented in sports, some of them are: In 2009 Shirley Coyle , et .al[2]present a system that uses sensors to analyze sweat in real time to provide valuable information in sports performance and also in healthcare.

The sweat rate sensor is integred into a textile substrate to determine the onset of sweat activity. The substrate contains a sensitive dye to determine the pH sweat.

The sensors are placed in belt and controlled through a central unit with a wireless connection.

In 2013 Yogatheesan Varatharajah, et .al[3] a model of BASN networks was introduced using a number of sensors(Heart rate, Temperature, Accelerometer, Flow rate) placed on the athlete's body ,an IEEE 802.15.4(Zigbee) with mobile applications to estimate energy expenditure during a fitness exercise session.

In 2015 Enrica Papi, et.al[4] present a study to help compliance with osteoarthritis rehabilitation through the use of wearable sensor integrated in to clothing and inertial measurement units located in two different positions. The first sensor at the waist and second in thigh pocket provide purpose measures of performance a knee. Fourteen healthy volunteers participated to perform exercise approved from a knee osteoarthritis rehabilitation programme, this program include five times sit-to-stand test and treadmill walking. This study focused on the acceptable practical approaches of using wearable devices to assess the performance during the exercise.

In 2017 Mahanth Gowda, et .al[5] developed a technique for 3D path tracking and spin with the use of sensors and wireless communication that built into the ball to analyze the movement patterns of balls, rackets and players. This techniques contains three main metrics, which are: distance to the first bounce, direction of the ball motion, and speed of the ball at the end of the flight .

In 2018 Enrica Papia, et.al [6] present study aims to verify wearable sensor system's ability to measure peak knee l angles during gait. The system consists of a versatile

sensor unit and a sensor node powered by 2AA batteries for wireless data acquisition. It also includes a Bluetooth module that transmits data to a laptop at 122Hz. the sensor gave inaccurate results at low knee angle, while giving good output on knee peak.

### 3. THE PROPOSED SYSTEM

A hardware and software utilized to integrated the design of the presented monitoring system ; as a software, Message Queuing Telemetry Transport(MQTT), Node-Red is open source programming based development tool for IoT applications, while the hardware component of system monitoring design consist of : Raspberry pi , NODE MCU ESP-32S microcontroller, MAX30100 sensor, Temperature sensor and Rotary encoder sensor. Figure 1 shows Block diagram of the proposed hardware design system.

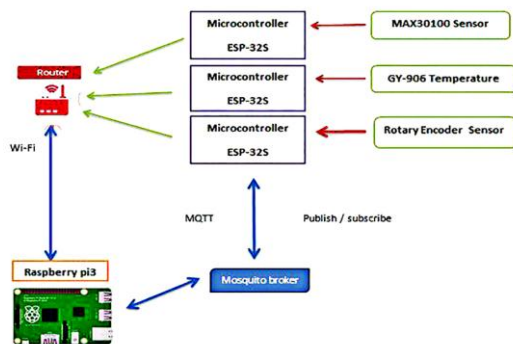


Figure 1: Block diagram of the proposed hardware design system

In the followings, a brief illustration about each component:

#### 3.1 Node MCU ESP-32S and Sensors

Node MCU ESP-32S is an open source network platform, easy-to-use hardware and software components, It has 16 analog inputs and 32 digital I/O pins, so it is possible to connect number of sensors that responsible for the measurements of vital and physical variables .Figure 2 shows Node MCU ESP-32S board which is used in this project.

Data is transmitted from sensors digitally or analogically, but

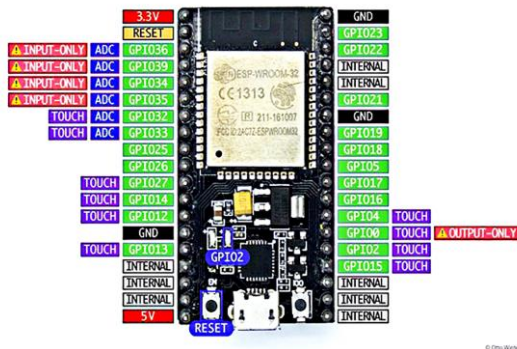


Figure 2: Node MCU ESP-32S layout

some sensors that have pins for both analog and digital , like a max30100 sensor connected with the Node MCU, VCC and GND sensors pins are connected to 5V and GND pin respectively, whereas SCL and SDL are connected to

GPIO 22,GPIO 21 pins of MCU[7].The rest of the sensors used in this project apply the same connection, but the sensors that have analog transmission connect to Node via analog pins.

After the sensors (heart rate, temperature, rotary encoder) are fixed on Node ESP-32S and the code is loaded on NODE MCU ESP-32S, the data sent via the Wi-Fi router link through the MQTT (Message Queuing Telemetry Transport) to Raspberry Pi.

Figure 3 shows the physical connection between the heart rate and temperature sensor sensors with the Node MCU, while Fig 4 shows the rotary encoder sensor.

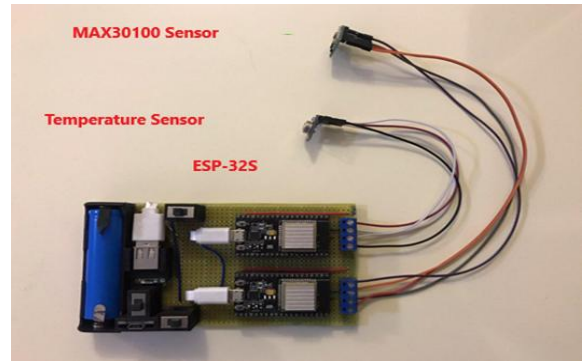


Figure 3: The connection of Node MCU ESP-32S with the sensor MAX30100, MLX90614 and the batteries

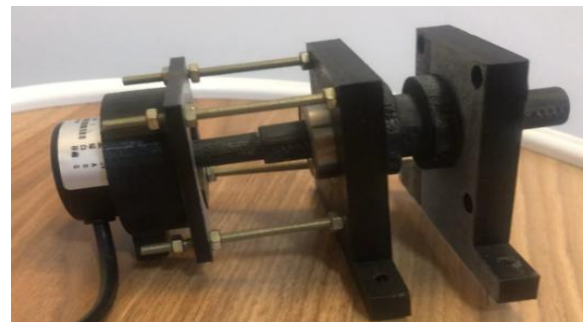


Figure 4: rotary encoder incremental which is used in this project

#### 3.2 Message Queuing Telemetry Transport (MQTT)

MQTT is messaging transfer protocol, a lightweight uses the network bandwidth with a 2 byte fixed header. For IoT nodes with limited capabilities and assets, MQTT is ideally suited and it is a protocol based on publication / subscription [8].

Any MQTT connected is consist: client and public server or broke. The MQTT client is any device connected to the Network and using exchange message application, and accordingly can be either publish or subscribe. MQTT broker is connected to MQTT client and exchange message among multiple MQTT clients. In this design, Messages from a specific Node, are published to the MQTT broker with topic, ESP/node name/out, each Node has a unique node name (Temperature, Heart Rate, Rotary encoder).

MQTT broker is subscribe to topic ESP/node name/in and forward the messages received on this topic among

multiple clients. Figure 5 illustrate the flow operation of MQTT Protocol.

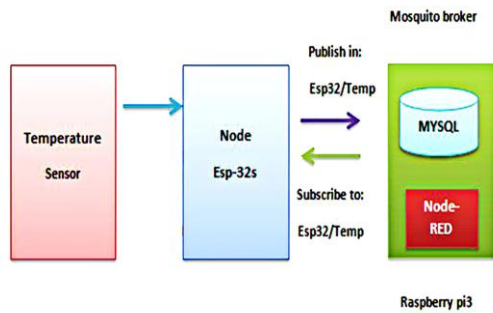


Figure 5: Operation of MQTT protocol

### 3.3 Node-Red Application

NODE-RED is open source programming based on development tool for IoT applications, a adaptable and an easy to use. It is integrated hardware devices such as sensors and powerful tool that is used to create prototypes.

In this project, the flow is consists:

1. The MQTT node input data sensor (`msg.payload`) and the name of the message is `msg.topic`.
2. Function node represents a function block that enables programming in JavaScript language.
3. Node MYSQL that store data in MYSQL database.
4. Timestamp node is used to display current date and time.
5. A debug node is the last part of the stream, displaying the sensor data that the function node. Processed in the debug tab [9], as Figure 6 Flow construction.

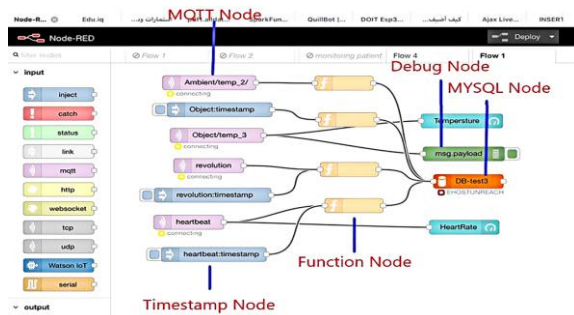


Figure 6: Node-RED Flow of the System

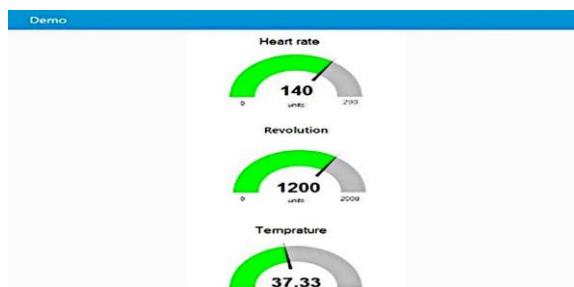


Figure 7: illustrate Heart Rate and Temperature measurement

### 3.4 Board of Raspberry Pi

Raspberry pi is a small, credit-card-sized, powerful, affordable computer.

It includes program memory, processor, graphics chip and various links and connectors for external devices. The Raspberry Pi works the same way as a PC which requires a keyboard, display unit, power supply, and a flash memory card like that are used in digital cameras [10].

Raspberry Pi is connected to the Internet through an Ethernet/LAN cable, but the new version of Raspberry Pi 3 model B released to provide built-in Wi-Fi, which lower the number of works and installing a separate Wi-Fi module for Microcontroller. Figure 8 shows Raspberry Pi3 board.

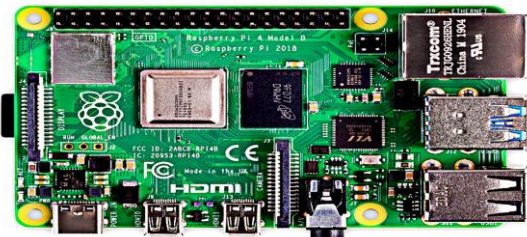


Figure 8: Raspberry Pi3 board

In this system, Raspberry pi is received heart rate, temperature and speed data signals from sensors using MQTT protocol in Node-Red tool that are configured in Raspberry pi and store data in MySQL database that are installed in Raspberry pi. Then it can monitor functional movements, workloads and vital parameters. Monitoring may also assist the development of training systems to improve athlete's performance.

### 4. EXPERIMENTAL RESULTS

The proposed system is applied to monitor the performance of a number of football players using wearable wireless sensor attached to their bodies using a stationary bike for 10 minutes. This test was carried out in a suitable laboratory environment at a temperature of 29 and 34% for humidity.

The heart rate is affected by physical exercise of various intensity, but it varies depending on the size of the exercise and the level of intensity.

There is a difference in heart rate between trained and untrained persons. In exercise, the heart rate is 200-220 (bpm) in non-trainers, whereas in trainers with the same physical effort was 170 (bpm) or may be low. Figure 9 Heart Rate of players during exercise.

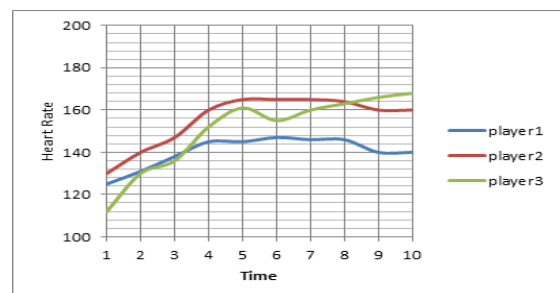
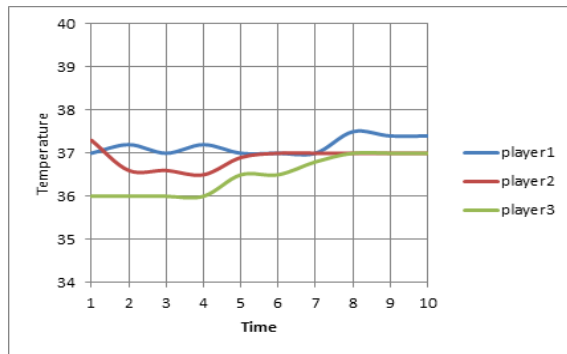


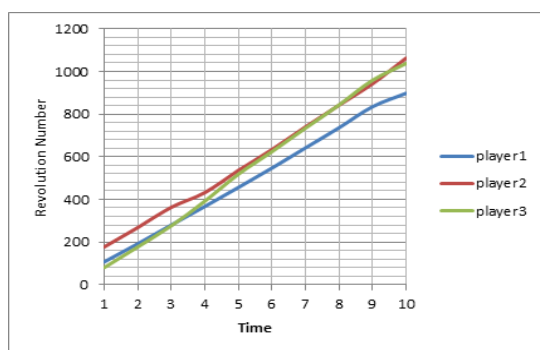
Figure 9: Heart Rate of players during exercise

The temperature has an effect on the functional responses on the heart muscle and circulatory system, where the center temperature in the case of rest and moderate conditions is 36.7 C to 37 C and is usually very constant. Figure 10. Shows Temperatures during exercise.



**Figure 10: Temperature of the player during exercise**

Speed is one of the main fitness components, whether one plays sports or not. Speed is influenced by the athlete's mobility, special strength, strength endurance and technique. The closer the run to an increase in speed, the more it falls under the influence of some foundations that affect this speed, including the length of the step and its frequency. Figure11 shows the number of revolution per minute



**Figure 11. Revolution number (RPM) of the players**

## 5. CONCLUSION

By applying the system to a sample of football players through wearable devices to monitor the physiological and kinetic parameters of the player in real time during a test period in a laboratory environment for 10 minutes.

These parameters can be used to find out the athletic performance of players and whose needs to improve their performance and also examine the possible causes of injury.

Further, experienced fitness trainers will monitor each player progress and will provide useful instructions on improvement .

Future work will include the following:

- The possibility of conducting this training outdoors.

- Improving the system by introducing more features such as blood pressure, oxygen concentration and sweat rate.

- project can be carried out for other games.

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