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Enhanced Device for Monitoring the Vital Functions of Athletes Using Arduino UNO with Alcohol and Drug Sensor and Wi-Fi Module

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Abstract: ***This paper presents the development of a smart monitoring system designed to measure and analyze key physi- ological parameters of athletes using an Arduino UNO micro- controller. The system integrates multiple sensors to monitorvital signs and enhance athlete safety during training and competitions.ThecorecomponentsincludeaDHT11sensor for environmental monitoring (temperature and humidity), a BMP180 sensor for measuring pressure and a GY-MAX30100 module for heart rate. Notably, the system estimates blood pressure (BP) by calculating Pulse Transit Time (PTT), which measures the time delay between the pulse detected by the MAX30100 and pressure changes captured by the BMP180.PTT is inversely correlated with BP and provides accurate estimations.AdditionalsafetyfeaturesincludeanMQ-3sensorto detect alcohol levels and an MQ-135 sensor to identify benzene- based compounds commonly associated with drug use. The outputs are displayed on a 16x2 LCD screen, and a buzzer triggersauditoryalertsforabnormalconditions.AWi-Fimodule facilitates real-time data transmission to a remote monitoring system, enabling coaches and medical professionals to assess the athlete's condition instantly. By continuously tracking essential health parameters, the system enhances athlete safety, promotes optimal performance, and ensures early detection of potential health risks.***

Keywords: Arduino-UNO,BMP180-sensor,DHT11 sensor,GY-MAX30100,MQ-3 sensor,MQ-135 sensor, Wi-Fi module, buzzer, Athlete Health Monitoring

I. INTRODUCTION

Performance of athletes and athlete safety are critical com- ponents of modern sports science, requiring continuous mon- itoringofphysiologicalparameterstoensureoptimalhealth and prevent potential risks. Wearable and embedded moni- toring systems have gained substantial attention due to their ability to provide real-time health data, enabling coaches and medical professionals to make timely and informed decisions. Traditional health assessments often rely on periodic medical checkups, which may fail to capture sudden physiological changes that could affect an athlete's performance or well- being.To address these challenges, this paper presents an enhanced monitoring system that continuously tracks vital signsusinganArduinoUNO-basedmicrocontrollerintegrated with multiple sensors. The proposed system measures key physiological parameters, including barometric pressure, tem- perature, humidity, heart rate, and blood oxygen levels. In ad- dition, it incorporates an MQ-3 sensor to detect alcohol levels and an MQ-135 sensor to identify benzene-based compounds commonlyfoundindrugs,ensuringathlete safetybydetecting potentialsubstanceuse.AWi-Fimoduleisintegratedtoenable real-time data transmission, allowing remote monitoring by coaches and medical personnel. The system also includes a 16×2LCDdisplayforlocaldatavisualizationandabuzzer to provide alert notifications in case of abnormal readings. Implementing such a system ensures that athletes' health con- ditions are continuously assessed, reducing the risk of injuries or medical emergencies during training and competitions. By integrating multiple sensors with wireless connectivity, the system enhances the accessibility and efficiency of health monitoringinsports.Thispaperdiscussesthesystem'sdesign, working principles, and potential applications in the field of sportsmedicineandathletehealthmanagement,demonstrating itsvalueasareliablesolutionforcontinuousphysiological monitoring.

II. LITERATURE SURVEY

A. *AdvancementsinHealthMonitoringSystems*

- A 2020 study explored wearable biosensors for real-time monitoring of athletes' physiological parameters, emphasizingtheroleofmicrocontroller-basedsystemsin sports science.

- A 2021 study integrated biometric sensors with cloud platforms,enhancingreal-timedataaccessibilityformed- ical professionals, optimizing athlete performance, and preventing injuries.

B. Wi-Fi-EnabledRemoteMonitoringSystems

- A 2021 study emphasized the role of ESP8266 Wi-Fi modules in IoT-based healthcare applications, enabling real-time data transmission to cloud storage or mobile applications.
- Researchin2023demonstratedtheintegrationofwireless health monitoring with buzzer alerts and LCD displays, improvingaccessibilityandimmediateresponsetoabnor- mal readings.

C. Power Optimization in Microcontroller-Based Health Sys- tems

- Low-power sensor modules have been developed to en- sure energy efficiency in continuous health monitoring applications.
- Studies in 2022 explored clock management techniquesinwearablehealthdevices,reducingenergyconsumption without affecting performance.

D. Integrated Healthand Safety Monitoring inSports Science

- A 2021 study proposed an IoT-driven sports health mon- itoring system, integrating biometric sensors, substance detectionmodules,andwirelessconnectivityforcompre- hensive athlete assessment.
- Thecombinationofsensor-basedmonitoringandwireless transmission ensures an efficient and accessible solution for enhancing athlete performance and safety in profes- sional sports.

III. METHODOLOGY

The proposed system monitors athletes' vital signs and detects substance use using an Arduino UNO with multiple sensors. It integrates an MQ-135 sensor for benzene-based compounds,anMQ-3sensorforalcohol,aBMP180for measuring pressure, a DHT11 for temperature and humidity, and a GY-MAX30100 for heart rate and blood oxygen levels. Detected abnormal trigger a buzzer alert, while a 16×2 LCD displays real-time data. An ESP8266 Wi-Fi module ensures remote monitoring via a mobile app or cloud. This system enablescontinuoushealthassessment,enhancingathletesafety andperformancethroughreal-timephysiologicalandenviron- mental data tracking.

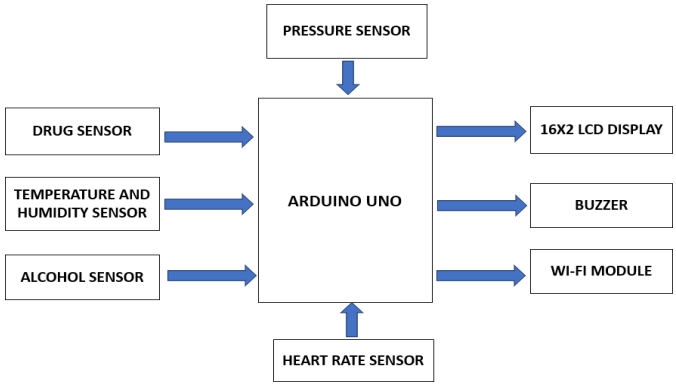

Fig. 1.Experimental block diagram of Enhanced Device for Monitoring theVitalFunctionsofAthletesUsingArduinoUNOwithAlcoholanddrugSensorand Wi-Fi Module

IV. COMPONENTS

A. ArduinoUno

Arduino UNO is a low-cost, flexible, and easy-to-use programmable open-source microcontroller board that can be integrated into a variety of electronic projects.The Arduino UNO features an AVR microcontroller, the Atmega 328, with 6 analogue I/O pins and 14 digital I/O pins, out of which 6 are used as PWM. This board con- tains a USB interface; a USB cable is used to connect the board to the computer, and the Arduino IDE (Integrated Development Environment) software is used to program the board. The unit comes with 32KB of flash memory

Fig.2.ArduinoUno

B. Wi-FiModule

TheESP8266Wi-Fimoduleisalow-cost,power-efficient wireless module that connects Arduino and microcon- trollers to the internet. Operating on 2.4 GHz Wi-Fi, it supports TCP/IP protocols for real-time communication. Poweredby3.3Vto5VDC,itenablesremotemonitoringandIoTapplications.WithbuiltinWiFi,GPIOpins,andATcommandfirmware,itiswidelyusedinsmarthomes, security, and automation.

Fig.3.Wi-FiModule

C. BMP180sensor

The BMP180 sensor, when used with the MAX30100 heartratesensor,helpsestimatebloodpressure(BP) by detecting slight pressure changes caused by arterial pulses. The pulse detected by the MAX30100 and the correspondingpressurefromtheBMP180areusedtocal- culatePulseTransitTime(PTT),whichisthencorrelated to BP for accurate estimation.

Fig.4.BMP180sensor

D. MQ-3sensor

The MQ-3 sensor is a highly sensitive alcohol detection sensor designed to detect ethanol vapors in the air. It operates on a 5V DC power supply and provides an analog output that can be easily processed by micro-controllerslikeArduinoUNOandRaspberryPi.With adetectionrangeof0.04mg/Lto4mg/L,itworks on a resistive principle, where its internal resistance de- creases as ethanol concentration increases, causing vari- ations in output voltage.

This enables real-time alcohol level monitoring with high accuracy. The MQ-3 sensoris widely used in breath analyzers, automotive safety systems, industrial applications, and IoT-based alcohol detection devices. Its low cost, high reliability, and fast response time make it ideal for various alcohol detection applications.

Fig.5.MQ-3sensor

E. MQ-135sensor

The MQ-135 sensor designed to detect benzene-based compounds and other harmful gases. It operates on a 5V DC power supply and interfaces with microcontrollers like Arduino UNO. The sensor detects gases such as benzene,ammonia,sulfurdioxide,enablingreal-timeair quality monitoring. When the concentration of harmful substances exceeds a predefined threshold, the system triggers an alert, making it useful for environmental monitoring and industrial safety applications.

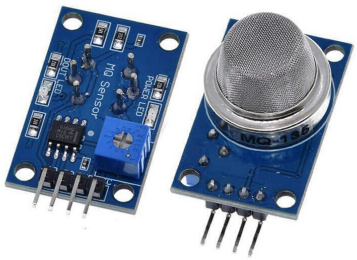

Fig.6.MQ-135sensor

F. DHT11sensor

The DHT11 is a digital temperature and humidity sensor designed for environmental monitoring applications. It operates on a voltage range of 3.3V to 5V DC and uses a single-wire digital interface for efficient communication with microcontrollers.

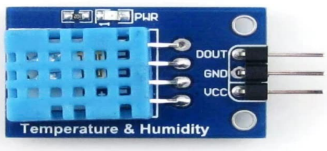

Fig.7.DHT11sens

G. GY-MAX30100sensor

The GY-MAX30100 sensor utilizes the I2C communi- cationprotocoltointerfacewithmicrocontrollerssuch as Arduino. It is a compact and efficient component designed for real-time heart rate (BPM) monitoring. In this project, the I2C interface facilitates communication between the GY-MAX30100 sensor and Arduino, ensur- ing accurate and continuous heart rate measurement.

Fig.8.GY-MAX30100

H. BuzzerAnd16×2LCDDisplay

Abuzzerisanelectronicalertdevicethatproducessound when abnormal gas levels are detected by the MQ-135 or MQ-3 sensors. It operates on a low-voltage DC supply, ensuring energy efficiency for real-time alerts. The 16×2 LCD is a display module used for real-time sensor data, showing heart rate, environmental conditions, and alerts. It interfaces with the Arduino UNO via I2C or parallel communication for efficient monitoring.

Fig.9.Buzzer,16×2LCDdisplay

V. IMPLEMENTATIONANDRESULTS

TheEnhancedDeviceforMonitoringtheVitalFunctionsof Athletes using Arduino UNO, integrated with an alcohol and drug sensor along with a Wi-Fi module, has been successfully developed. This advanced system continuously monitors key physiological and environmental parameters, ensuring real- time health tracking for athletes. By leveraging embedded technology and IoT capabilities, it provides a comprehen-sive solution for monitoring vital signs, detecting harmful substances, and transmitting data remotely. The system con- sists of essential components, including Arduino UNO, MQ- 135 Sensor, MQ-3 Sensor, GY-MAX30100 Sensor, BMP180 Sensor, DHT11 Sensor, ESP8266 Wi-Fi Module, 16×2 LCD Display,Buzzer,anda5VPowerSupply.Analgorithmwas developed in Arduino IDE and uploaded to the Arduino UNO microcontroller, which serves as the CPU of the device. The MQ-135 and MQ-3 sensors play a crucial role in detecting harmful substances. The MQ-135 sensor identifies benzene- based compounds in drugs, while the MQ-3 sensor detects alcohol levels. These sensors continuously monitor air qual- ity,comparingcollecteddatawithpredefinedsafetylimits. If the alcohol level exceeds a threshold value of 400, the system displays a message indicating ”Alcohol Detected” and triggers an alert. Similarly, if the concentration of benzene- based compounds surpasses a threshold value of 600, the system displays ”Benzene Detected” and activates the buzzer to warn of potential health risks. To monitor cardiovascular health,theGY-MAX30100sensortracksheartrateandoxygen saturation (SpO). This ensures that athletes maintain optimal oxygen levels during training and competition. If abnormal heart rate readings are detected, a warning message appearson the 16×2 LCD display, allowing immediate response. Environmental factors also impact an athlete’s performance and well-being. The BMP180 sensor measures air pressure, and when used with the MAX30100, it helps estimate blood pressure by tracking small pressure changes. These changes are used to calculate Pulse Transit Time (PTT), which islinked to blood pressure, while the DHT11 sensor records temperature and humidity. All collected data is processed in real time by the Arduino UNO and compared against preset safety thresholds. If any values exceed normal conditions, the system generates alerts via the LCD display and buzzer to ensure quick intervention.

A key feature of this system is its ability to transmit data remotely. The ESP8266 Wi-Fi mod- ule enables real-time data transfer to cloud-based platforms, allowing coaches, doctors, and supervisors to monitor an athlete's health from any location. This data is accessible viaaserverormobileapplication,makingiteasytointerpretvital parameters and make informed decisions. The Wi-Fi module ensures health metrics remain accessible even when athletes are on the field or at a training facility, enhancing safety by allowing rapid intervention in case of health concerns. The system operates efficiently on a 5V power supply, ensuring compatibility with the Arduino UNO and other components. Its low-power design makes it portable and convenient for continuous health monitoring. To enhance user experience,the 16×2 LCD display provides real-time feedback on sensor readings,whilethemobileapplicationensureseasyaccess to health insights. Extensive testing and validation confirmed the system's accuracy, efficiency, and reliability. The GY- MAX30100 sensor consistently provided accurate heart rate. The MQ-3 and MQ-135 sensors successfully detected alcohol and benzene-based compounds, triggering alerts when haz- ardous concentrations were recorded. The buzzer and LCD display provided instant notifications, ensuring quick action. The ESP8266 Wi-Fi module enabled seamless cloud-based datatransmission,enhancingremotemonitoring.Thissystem's integration of sensor-based monitoring, real-time alerts, and remote data transmission helps trainers and medical personnel take proactive health measures, ensuring athlete safety.

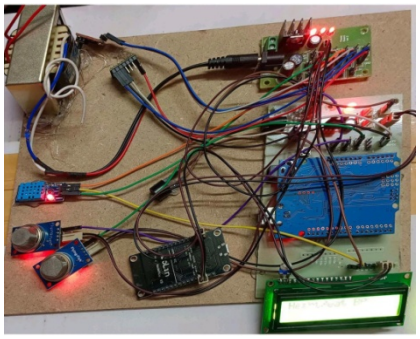

Fig.10.ExperimentalSetup

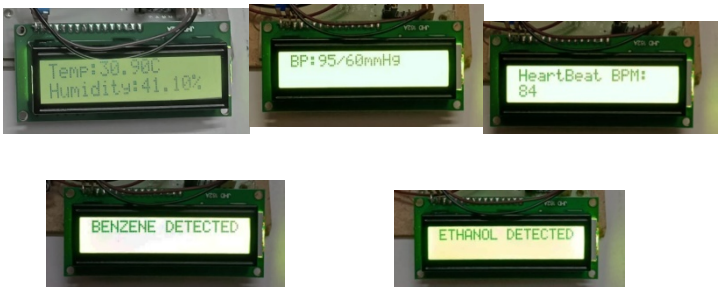

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Fig.11.Resultsdisplayedon16x2LCDdisplay

VI. CONCLUSION

The primary objective of this project is to develop a real- time monitoring system for athletes' vital functions and sub- stance detection using an Arduino UNO and multiple sensors. The system aims to ensure athlete safety by continuously tracking heart rate, environmental conditions, and detecting harmful substances. It provides real-time alerts through a buzzer, displays data on a 16×2 LCD, and enables remote monitoring via an ESP8266 Wi-Fi module, enhancing overall healthassessmentandperformanceoptimization.Theproposed system successfully integrates multiple sensors with an Ar- duino UNO to monitor athletes' vital parameters and detect substance use. Real-time alerts and remote access capabilities ensuretimelyinterventionincaseofabnormalreadings. The system enhances athlete safety, offering a cost-effective, energy-efficient, and user-friendly solution. Future advance- ments could incorporate AI-based predictive analytics, cloud storage for long-term health data, and additional biosensorsformorecomprehensivemonitoring,makingitavaluabletool for sports science and athlete health management.

VII. FUTURE WORK

The Enhanced Device for Monitoring Athletes' Vital Func- tions can be significantly improved through advanced sen- sorintegration,connectivityupgrades,energyefficiency,and emergency response enhancements. Future versions could in- corporate biosensors to track hydration levels and stress indi- cators, while hyperspectral imaging could detect dehydration, muscle fatigue, and oxygen deficiency. Upgrading to 5G or LPWANwouldenhancereal-timedatatransmission,andcloud storage would enable long-term health tracking. A dedicated mobile app with AI-driven insights, alerts, and notifications would improve accessibility.To enhance portability and effi- ciency, the device could include solar-powered charging and optimized low-power components, extending its operational lifespan. An advanced emergency response system could automaticallyalertmedicalpersonnelifcriticalthresholds are exceeded, ensuring quick intervention. Additionally, voice alerts or vibration feedback would allow athletes to receive warnings without checking the display. These advancements wouldoptimizetrainingregimens,improveathletesafety, and make health monitoring more effective, accessible, and reliable.

VIII. ACKNOWLEDGEMENT

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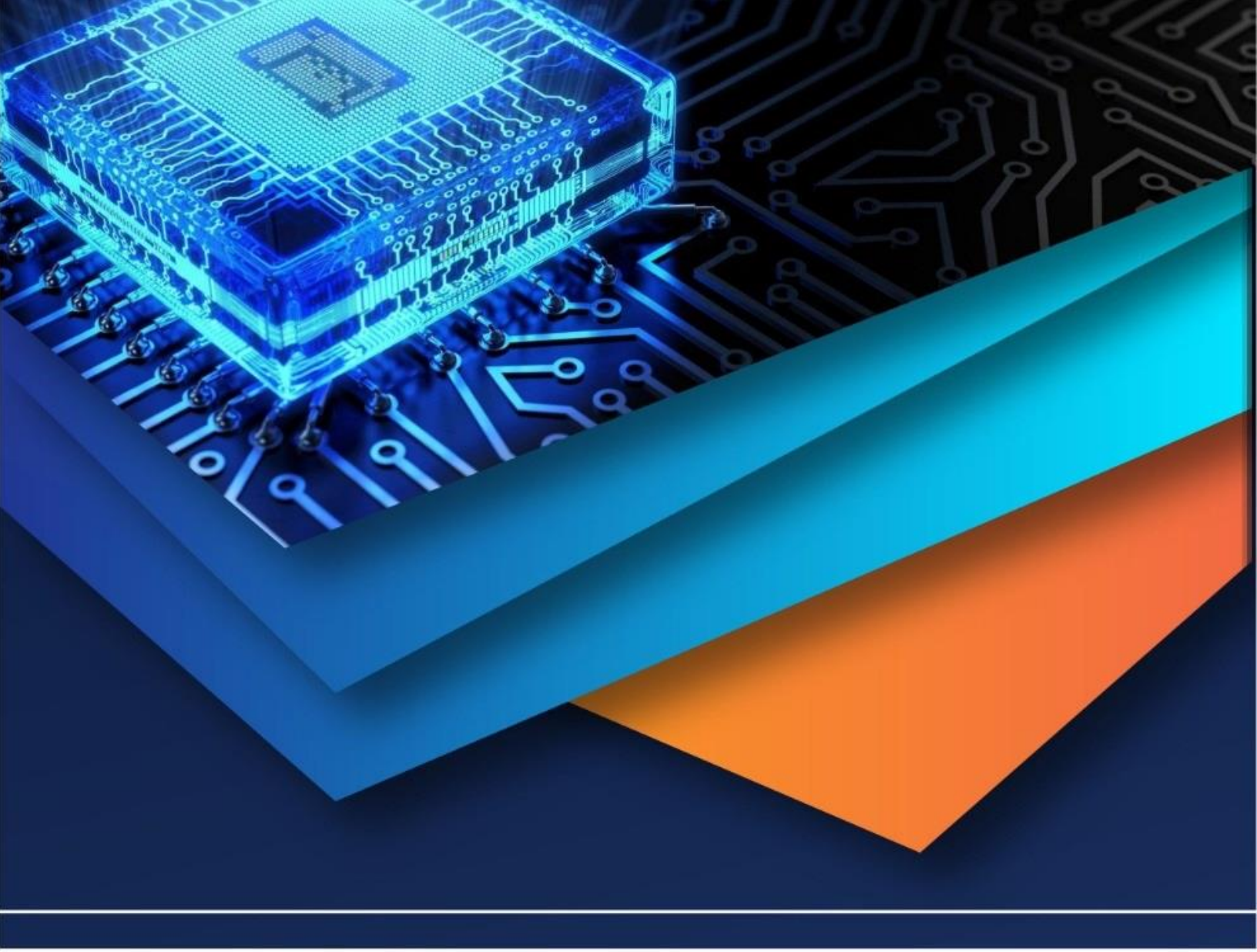

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