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Wearable EDA Sensor Gloves Using Conducting Fabric and Embedded System

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Abstract- — This project presents a wearable electrodermal activity (EDA) sensor glove designed to monitor physiological signals related to human stress and health conditions. The glove integrates conducting fabric electrodes with embedded sensing modules, including a non- contact temperature sensor, GSR sensor, and pulse oximeter, to capture body temperature, skin conductivity, and heart-related parameters. An Arduino-based embedded system processes the collected signals and provides alerts through a buzzer while displaying measurements on an I2C LCD. The system is powered using regulated power supplies to ensure stable operation. By combining wearable textile technology with embedded electronics, the proposed design offers a compact and user-friendly platform for continuous physiological monitoring, supporting applications in healthcare observation, stress analysis, and personal wellness tracking.

Keywords— Electrodermal Activity (EDA), Galvanic Skin Response (GSR), Wearable Sensor Glove, Physiological Monitoring, Stress Detection, Arduino-based Embedded System, Pulse Oximeter, Non-contact Temperature Sensor, Biomedical Sensors, I2C LCD Display, Health Monitoring, Personal Wellness Tracking.

I. INTRODUCTION

In recent years, wearable technology has become an important part of modern healthcare systems due to its ability to continuously monitor physiological parameters in real time. Stress is a major factor affecting human health, leading to conditions such as anxiety, depression, cardiovascular diseases, and reduced productivity. Therefore, early detection and continuous monitoring of stress levels are essential for improving overall well-being and preventing serious health issues.

Electrodermal Activity (EDA), also known as Galvanic Skin Response (GSR), is a widely used physiological signal for stress detection. It measures the changes in skin conductivity caused by sweat gland activity, which is directly controlled by the sympathetic nervous system. This makes EDA a reliable and non-invasive indicator of emotional and psychological states.

Recent advancements in wearable devices have enabled the integration of multiple biosensors such as heart rate sensors, temperature sensors, and pulse oximeters along with EDA sensors. Studies show that combining multiple physiological signals improves the accuracy of stress detection systems compared to using a single parameter.

Wearable gloves have emerged as an innovative platform for physiological monitoring due to their ability to provide better skin contact and user comfort. Conducting fabric electrodes can be easily embedded into gloves, making them more flexible and suitable for continuous monitoring compared to traditional rigid electrodes.

Embedded systems such as Arduino play a vital role in processing sensor data and enabling real-time monitoring. These systems allow the integration of sensors, display units, and alert mechanisms into a compact and portable device. Based on these advancements, this project proposes a wearable EDA sensor glove that integrates conducting fabric electrodes with multiple sensors to monitor stress and health parameters.

1. Objectives

The primary objective is to develop a wearable EDA sensor glove capable of continuously monitoring human stress levels and physiological health parameters in real time. EDA is used as the core parameter because it reflects changes in the sympathetic nervous system, which directly responds to stress. The project integrates multiple physiological sensors such as temperature sensors and pulse oximeters, since combining signals like EDA, heart rate, and temperature provides better stress detection performance compared to using a single parameter. The system is designed in a wearable glove format using conducting fabric electrodes to improve comfort, flexibility, and signal quality, and it implements an Arduino-based embedded system for real-time data acquisition, processing, and display.

2. Problem Statement

In today's fast-paced world, stress has become a major factor affecting human health, leading to serious issues such as cardiovascular diseases, anxiety, and reduced productivity. Traditional methods for stress detection, such as questionnaires and clinical observations, are subjective and do not provide continuous real-time monitoring. Although wearable devices are widely used for health monitoring, most existing systems rely on limited parameters such as heart rate, which are not always accurate indicators of stress.

EDA is considered a reliable indicator of stress as it directly reflects the activity of the sympathetic nervous system. However, current EDA-based systems are often expensive, bulky, or restricted to laboratory environments, limiting their practical use in daily life. Existing wearable devices also face challenges such as poor sensor placement, motion artifacts, signal noise, and lack of continuous monitoring capability. Therefore, there is a need to develop a compact, cost-effective, and wearable system that can accurately monitor stress and physiological parameters in real time.

II. LITERATURE SURVEY

Y. B. Lee et al. (2006) presented a wearable glove embedded with EDA sensors using conducting fabric. The system measures skin conductance signals, including Skin Conductance Level (SCL) and Skin Conductance Response (SCR), to analyze human physiological conditions. Conducting fabric replaced traditional electrodes to improve comfort, and an embedded system was used for real-time signal acquisition instead of bulky computer-based systems.

Lee et al. (2010) proposed a wearable glove integrating EDA and pulse-wave sensors for healthcare monitoring. The system uses conducting fabric electrodes to enhance comfort and flexibility, measuring skin conductivity and pulse signals for e-health applications.

Schmidt et al. (2022) focused on stress monitoring using wearable devices equipped with heart rate and respiratory rate sensors, developing a dataset by collecting physiological signals during stress-inducing activities. The results indicate that wearable sensors can effectively detect stress variations in real-life conditions.

Meijer et al. (2023) highlight EDA as a reliable signal for monitoring human stress and well-being, showing a strong correlation between EDA responses and emotional states, and concluding that EDA can be continuously measured using wearable devices.

Zhu, Spachos, et al. (2023) investigated stress detection using EDA signals analyzed with machine learning. The study compared different classifiers and found that Support Vector Machine (SVM) provides high accuracy (up to 92.9%) in stress prediction.

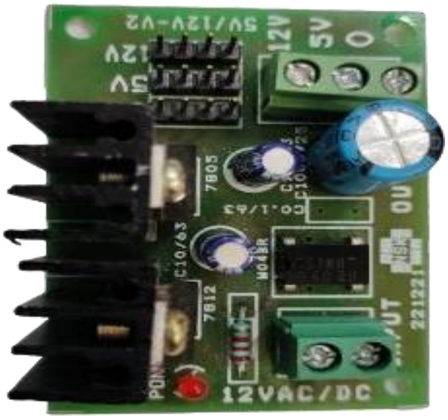
Schouten et al. (2023) published a scoping review of wearable EDA sensors for stress detection, concluding that EDA is a promising biomarker with reported accuracies up to 82%, while identifying challenges such as lack of real-time processing.

Hepsiba and Vijay Anand (2018) focused on stress detection using a GSR sensor that measures changes in skin conductivity. Jebelli et al. (2019) evaluated the feasibility of using EDA signals from wearable devices to assess human stress in real-world environments.

III. METHODOLOGY

1. Existing System

Existing systems for stress and physiological health monitoring are mainly based on traditional methods and wearable devices such as smartwatches, wristbands, and clinical monitoring equipment. These systems use physiological signals like heart rate, EDA, temperature, and respiration to estimate stress levels. Traditional stress detection methods, including questionnaires and clinical assessments, are subjective and cannot provide continuous real-time monitoring.



Modern wearable systems have improved monitoring by using sensors; however, most devices rely on limited parameters such as heart rate or basic EDA signals, which are not always sufficient for accurate stress detection. Most current wearable devices are wrist-based, which limits signal quality, since wrist-based measurements are less sensitive compared to finger-based measurements, where skin conductivity responses are stronger.

1. Disadvantages of Existing System

- **Motion Artifacts:** body movements cause disturbances in signals like EDA and heart rate.
- **Signal Noise and Distortion:** poor contact or environmental interference.
- **Environmental Effects:** temperature, humidity, external conditions.
- **Poor Sensor Placement:** reduces signal quality and reliability.
- **Individual Variability:** physiological signals vary person to person.
- **Confusion with Physical Activity:** exercise can mimic stress signatures.
- **Data Quality Issues:** missing data and inconsistent readings.
- **Lack of real-time Accuracy:** many systems fail in real-world monitoring.
- **Calibration Issues:** no universal standard for stress measurement.

2. Proposed System

The proposed system is a wearable EDA sensor glove designed to monitor human stress levels and physiological health parameters in real time. The system integrates conducting fabric electrodes, multiple biosensors, and an Arduino-based embedded system into a compact and portable wearable device. The EDA sensor is the core component, which measures changes in skin conductivity caused by sweat gland activity controlled by the sympathetic nervous system. In addition, the system incorporates a temperature sensor and a pulse oximeter to measure body temperature, heart rate, and oxygen saturation. The sensors continuously collect physiological signals from the user's body, especially from the fingers, where EDA signals are strongest. Signals are transmitted to the Arduino microcontroller, which processes the data using built-in analog-to-digital conversion. The processed data is displayed on an I²C LCD, and a buzzer alert system notifies the user when abnormal conditions are detected.


Fig. 1. Prototype of the wearable EDA sensor glove.

IV. HARDWARE DESCRIPTION

1. Arduino UNO

The Arduino UNO is an open-source microcontroller board based on the Microchip ATmega328P. The board has 14 digital pins, 6 analog pins, and is programmable with the Arduino IDE via a type B USB cable. It accepts voltages between 7 and 20 V. The Uno uses the ATmega16U2 programmed as a USB-to-serial converter.


Fig. 2. Arduino UNO development board.

Key specifications: Microcontroller ATmega328P; Operating Voltage 5 V; Input Voltage 7–20 V; Digital I/O Pins 14 (6 PWM); Analog Input Pins 6; Flash Memory 32 KB; SRAM 2 KB; EEPROM 1 KB; Clock Speed 16 MHz.
Specialized pin functions include Serial/UART (pins 0, 1), external interrupts (pins 2, 3), PWM (3, 5, 6, 9, 10, 11), SPI (10–13), and I²C (A4/SDA, A5/SCL).

2. Power Supply

The 7812 and 7805 voltage regulators provide stable DC outputs of +12 V and +5 V, respectively, from a higher input voltage source. The 7812 typically requires 14–16 V input; the 7805 requires 7–25 V input.

Fig. 3. Regulated power supply PCB (7812/7805).

Decoupling capacitors are crucial: a 1000 µF / 25 V capacitor is placed on the input side, while a 10 µF / 63 V capacitor is placed on the output side to filter noise. Both regulators can generate heat, so adequate heat sinking may be required.

3. Galvanic Skin Response (GSR) Sensor

A GSR sensor measures the electrical conductance of the skin, which fluctuates with moisture level linked to sweat gland activity. Emotional states such as stress trigger the sympathetic nervous system, causing sweat glands to become more active. The sensor measures conductance through two electrodes placed on the skin, usually on the fingers or palm.

The typical GSR setup consists of electrodes (often silver), an amplifier circuit, and an interface for data processing. Two types of measurements are observed: tonic conductance (baseline, slow-varying) and phasic conductance (Skin Conductance Responses, rapid changes in response to stimuli). The GSR sensor requires 5 V and data is acquired in the 1–10 Hz range.

Fig. 4. GSR sensor interfaced with Arduino UNO.

Table 1: GSR Sensor to Arduino Uno Connections

GSR Sensor	Arduino UNO Board
VCC	5V
GND	GND
SIG	A0

A sample Arduino sketch reads the analog value from A0 and converts it to voltage:

```
const int GSR = A0; int sensorValue;
void setup() { Serial.begin(9600); } void loop() {
sensorValue = analogRead(GSR); float v =
sensorValue*(5.0/1023.0); Serial.println(sensorValue);
delay(100);
```

serial format, requiring only four connections: VCC, GND, SDA, and SCL.

}

4. MLX90614 Temperature Sensor

The MLX90614 is a contactless infrared digital temperature sensor that measures object temperature from −70 °C to 382.2 °C using the I^{2}C protocol. Key specifications: Operating Voltage 3.6–5 V; Supply Current 1.5 mA; Accuracy 0.02 °C; Field of View 80°; measurement distance 2–5 cm.

Fig. 5. MLX90614 contactless IR temperature sensor module.

The sensor consists of an MLX81101 IR thermopile detector and an MLX90302 conditioning ASSP with a 17-bit ADC that converts the signal to digital and communicates via I^{2}C. The sensor is factory-calibrated.

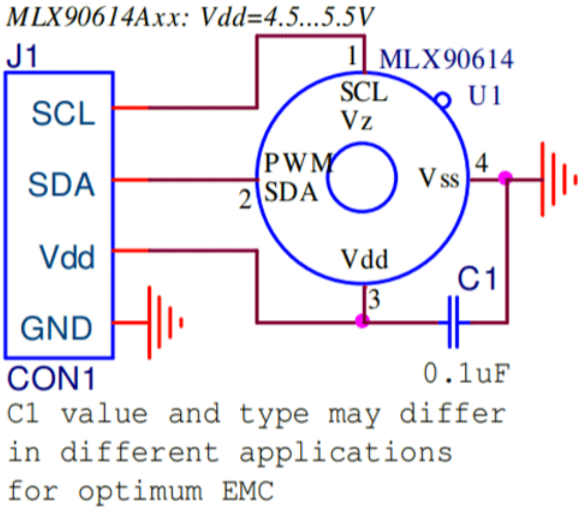


Fig. 6. MLX90614 interfacing schematic.

5. I^{2}C LCD Display

I^{2}C LCD displays interface with microcontrollers using minimal wiring. The 16×2 variant displays up to 32 characters; the 20×4 variant displays up to 80 characters. An I^{2}C controller module (typically PCF8574-based) converts parallel data to serial format, requiring only four connections: VCC, GND, SDA, and SCL.

Fig. 7. I²C LCD 16×2 module with PCF8574 adapter

Fig. 8. I²C LCD 20×4 module.

6. MAX30102 Pulse Oximeter and Heart Rate Sensor

The MAX30102 is an I²C-based integrated pulse oximeter and heart rate sensor that combines two LEDs (RED at 660 nm and IR at 880 nm), a photodetector, and low-noise analog signal processing to detect SpO2 and heart rate.

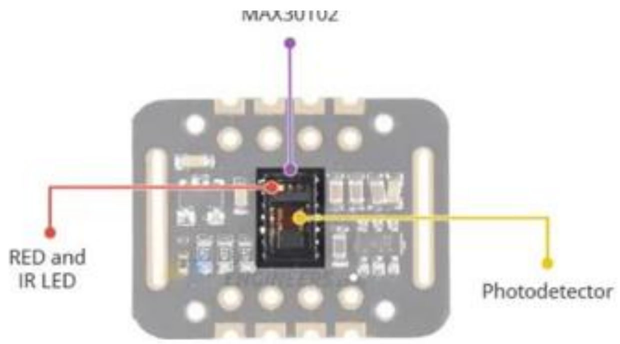


Fig. 9. MAX30102 module showing RED/IR LEDs and photodetector.

The chip requires 1.8 V for the IC and 3.3 V for the LEDs, supplied by onboard regulators. Power consumption is under 600 µA during measurement and 0.7 µA in standby, ideal for battery-powered wearables.

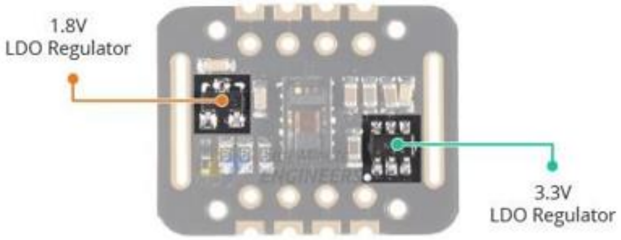


Fig. 10. Onboard 1.8 V and 3.3 V LDO regulators on the MAX30102 module.

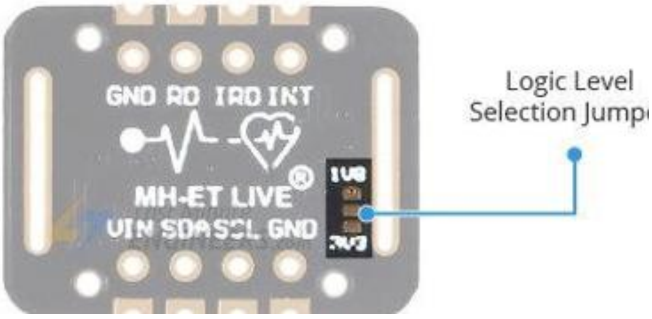


Fig. 11. Logic-level selection jumper on the MAX30102 module.

The module has an on-chip temperature sensor (−40 °C to +85 °C, ±1 °C) for calibration, a 32-sample FIFO buffer, and an open-drain INT pin. Communication uses I²C addresses 0xAE (write) and 0xAF (read).

Working Principle

The MAX30102 works by shining both LEDs onto the finger and measuring reflected light with a photodetector — a method called photoplethysmography.

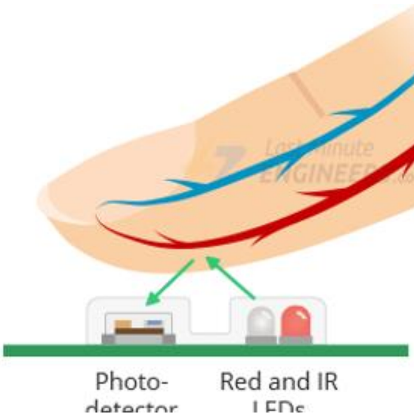


Fig. 12. Photoplethysmography: RED and IR LEDs illuminate the finger and the photodetector captures reflected light.

Oxygenated hemoglobin (HbO2) in arterial blood absorbs IR light. As blood is pumped with each heartbeat, the reflected light changes, producing a pulse waveform at the photodetector output.

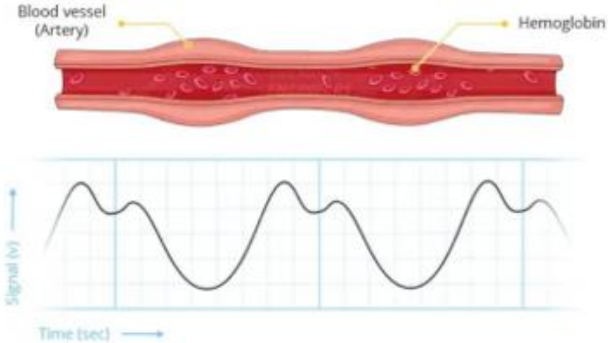


Fig. 13. Pulse waveform produced as hemoglobin flow changes the reflected IR intensity.

Pulse oximetry is based on the principle that deoxygenated blood absorbs more RED light while oxygenated blood absorbs more IR light. By measuring the ratio of reflected IR and RED light, SpO2 is calculated.

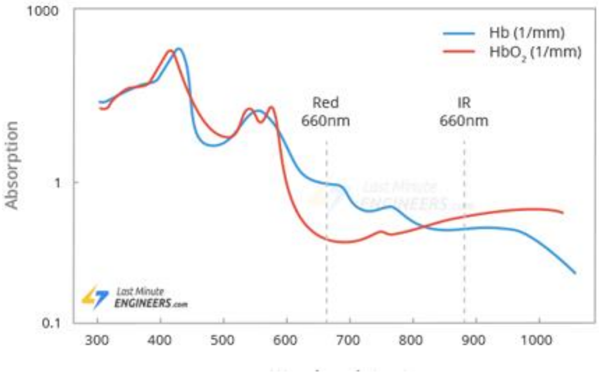


Fig. 14. Absorption spectra of oxygenated (HbO2) and deoxygenated (Hb) hemoglobin.

Module Pinout and Wiring

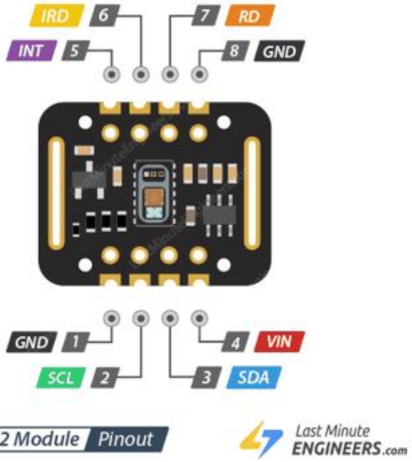


Fig. 15. MAX30102 module pinout diagram.

VIN is the power pin (3.3 V or 5 V), SCL and SDA are the I²C clock and data lines, INT is the interrupt output, IRD and RD drive the IR and RED LEDs, and GND is ground.

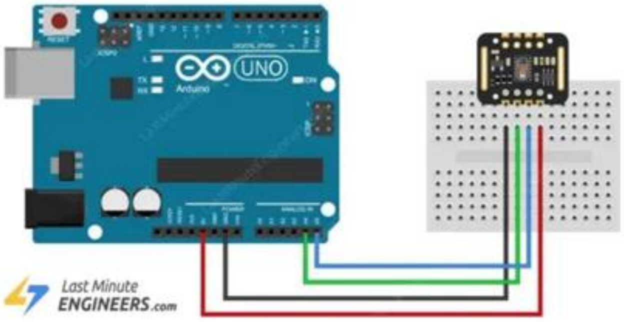


Fig. 16. Wiring the MAX30102 module to the Arduino UNO.

Buzzer

A buzzer provides audible feedback, alerts, or warnings. In this project, an active magnetic buzzer is used: its positive leg connects to a digital output pin (e.g., pin 9) and the negative leg to GND.

Fig. 17. Active magnetic buzzer component

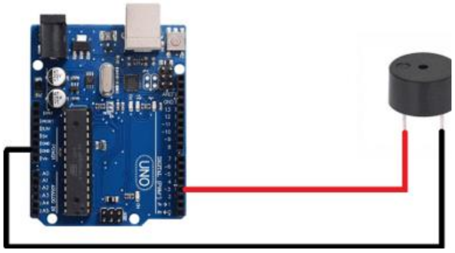


Fig. 18. Buzzer connected to the Arduino UNO.

V. SOFTWARE DESCRIPTION

1. Arduino IDE

The Arduino Integrated Development Environment (IDE) is a cross-platform Java application used to write and upload programs to Arduino boards. Programs are called sketches (.ino) and contain two required functions: setup() and loop().

```
void setup() {
  // put your setup code here, to run once:

}

void loop() {
  // put your main code here, to run repeatedly:

}
```

Fig. 19. Arduino IDE with a blank sketch template.

Libraries provide extra functionality and can be imported via Sketch > Include Library > Manage Libraries.

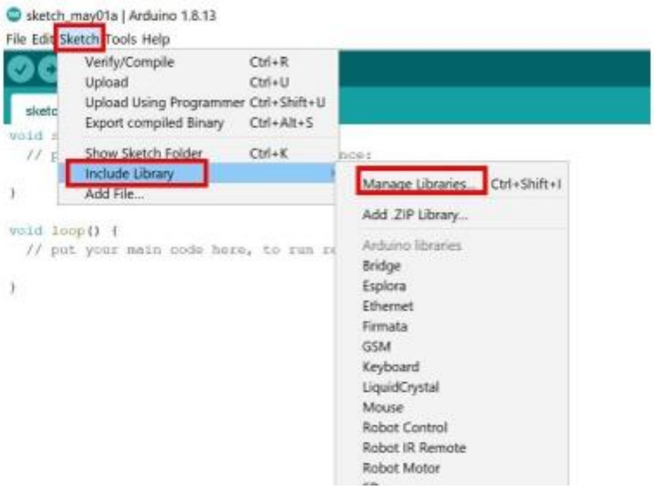


Fig. 20. Accessing the Arduino IDE Library Manager.

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Arduino SigFox for MKRFox1200
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Helper library for MKRFox1200 board and ATAB8520E Sigfox module This library allows some high level operations on Sigfox module, to ease integration with existing projects
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Arduino Uno WiFi Dev Ed Library
by Arduino
This library allows users to use network features like rest and mqtt. Includes some tools for the ESP8266. Use this library only with Arduino Uno WiFi Developer Edition.
More info

Fig. 21. Library Manager window.

To enable heart rate and SpO2 functionality, the MAX3010x library by Daniel Wiese is installed from the Library Manager.

MAX3010x Sensor Library
by Daniel Wiese Version 1.0.5 INSTALLED
An Arduino library for the MAX3010x sensor family. Allows to control the sensor LEDs and acquire the raw data for PPG and pulseoximetry.
More info

Fig. 22. Installed MAX3010x Sensor Library.

After connecting the board, select Tools > Board (Arduino UNO or Mega 2560) and Tools > Port, then use the Verify and Upload buttons to compile and flash the sketch.

VI. RESULTS AND DISCUSSION

1. Results

The wearable EDA sensor glove successfully monitored skin conductivity, temperature, heart rate, and oxygen levels in real time. The system provided continuous data, clear LCD output, and effective buzzer alerts during abnormal conditions. Results confirmed that EDA increases under stress, making it a reliable indicator, especially when combined with other signals for improved accuracy. The glove design enhanced signal quality and user comfort. Although minor variations occurred due to motion and environment, the system proved to be effective and suitable for real-time health and stress monitoring.

2. Discussion

The proposed wearable EDA sensor glove demonstrates that electrodermal activity is a reliable indicator of stress, especially when combined with other physiological parameters. The multi-sensor approach improves overall accuracy and reduces false interpretations, while the glove-based design captures stronger EDA responses from the fingers. However, the system is affected by factors such as motion artifacts, environmental conditions, and individual differences, which can impact accuracy.

Advantages and Applications

Advantages

- Real-time monitoring: continuous monitoring of stress and health parameters.
- Non-invasive: measures physiological signals without pain.
- Accurate stress detection: EDA reflects nervous-system activity directly.
- Multi-parameter measurement: combines EDA, temperature, heart rate.
- Wearable and portable: glove-based, easy to wear for daily use.
- Improved signal quality: finger-based sensing gives stronger signals.
- Comfortable: conducting fabric electrodes are flexible.
- Low power consumption: suitable for battery operation.
- User-friendly interface: LCD and buzzer alerts.
- Cost-effective: uses inexpensive Arduino-based components.

Applications

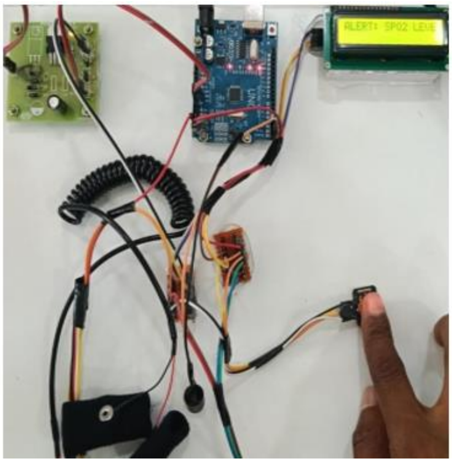
- Healthcare monitoring: continuous monitoring of patient health.
- Stress management: identifying and managing stress using EDA.
- Mental health assessment: detecting anxiety and emotional imbalance.
- Fitness and wellness tracking: monitoring during exercise.
- Remote patient monitoring: IoT-based healthcare.
- Biofeedback systems: feedback for relaxation techniques.
- Workplace stress monitoring: employee wellbeing.
- Sports performance: monitoring stress and fatigue in athletes.
- Rehabilitation and therapy: supporting recovery programs.
- Military and safety: monitoring soldiers, drivers, high- risk workers.

V. CONCLUSIONS

In this project, a wearable electrodermal activity (EDA) sensor glove was successfully designed and developed for real-time monitoring of stress and physiological health parameters. The system integrates EDA, temperature, and pulse oximeter sensors with an Arduino-based embedded system to provide a compact and efficient solution for continuous health monitoring.

The results confirm that EDA is a reliable indicator of stress, as it reflects the activity of the sympathetic nervous system. The integration of multiple sensors improves the accuracy and reliability of stress detection. The glove-based design using conducting fabric electrodes provides better comfort and signal acquisition than traditional wearable devices. Although motion artifacts, environmental effects, and individual variability remain common challenges, the proposed system demonstrates a low-cost, portable, and effective solution with strong potential for healthcare, fitness, and personal wellness applications.

Output



REFERENCES

1. Y. B. Lee, S. W. Yoon, C. K. Lee, and M. H. Lee, "Wearable EDA sensor gloves using conducting fabric and embedded system," in Proc. Int. Conf. Biomedical Engineering, 2006.
2. Y. Lee, B. Lee, and M. Lee, "Wearable sensor glove based on conducting fabric using electrodermal activity and pulse-wave sensors for e-health application," Telemedicine and e-Health, vol. 16, no. 2, pp. 209–217, 2010.
3. A. Schmidt et al., "Stress monitoring using wearable sensors: A pilot study and stress-predict dataset," Sensors, vol. 22, 2022.
4. A. L. Meijer, L. P. A. Arts, R. Gomez, and E. L. van den Broek, "Electrodermal activity: A continuous monitor of well-being," IEEE Sensors J., 2023.
5. L. Zhu, P. Spachos et al., "Stress detection through wrist-based electrodermal activity monitoring and machine learning," IEEE J. Biomed. Health Inform., 2023.
6. G. Schouten, E. J. M. Wouters, and M. W. H. Peeters, "Wearables measuring electrodermal activity to assess perceived stress in care: A scoping review," Int. J. Med. Inform., 2023.
7. D. Hepsiba and L. D. Vijay Anand, "Stress detection using galvanic skin response sensor in wearable systems," in Proc. Int. Conf. Circuits and Systems, 2018.
8. M. J. Jebelli et al., "Feasibility analysis of electrodermal activity acquired from wearable sensors," J. Constr. Eng. Manage., 2019.
9. S. Conti, "Electrodermal activity sensors for monitoring mental and physical activity," Nature Reviews Electrical Engineering, 2025.
10. A. S.-R. Kim et al., "Electrodermal activity as a proxy for sweat rate monitoring during physical and mental activities," Nature Electronics, 2025.
11. S. Santos, J. Sousa, and J. Ferreira, "Wearable electrodermal activity sensor for real-time stress detection using machine learning," in Proc. SCITEPRESS / BIOSTEC Conf., 2025.
12. D. Žagar and G. Geršak, "Performance comparison of wired and wireless electrodermal activity sensors," Electronics (MDPI), 2025.
13. P. V. Suraparaju and S. Udhayakumar, "Electrodermal activity as a critical modality for wearable sleep monitoring," medRxiv / Wearable Research, 2025.
14. H. Y. Y. Aldosky and D. S. Bari, "Could electrodermal activity detect emotions soon?," J. Electr. Bioimpedance, 2025.
15. "Electrodermal activity and skin temperature characteristics related to stress and depression," J. Affect. Disord. Rep., Elsevier, 2025.
16. A. "Recent trends in electrodermal activity signal processing and deep learning methods for emotion recognition," Neuroscience J., Elsevier, 2026.