

WEARABLE DEVICE FOR CONTINUOUS MONITORING OF STRESS

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Abstract- In modern society, increasing work pressure and lifestyle changes have made stress a major factor affecting both physical and mental health. Continuous and real-time monitoring of stress can help in early detection and timely intervention, thereby reducing long-term health risks. This project presents the design and development of a wearable device for continuous monitoring of human stress using a multimodal approach. The system integrates physiological sensors such as heart rate, skin temperature, and galvanic skin response (GSR) along with facial emotion recognition techniques. Sensor data is processed in real time using a microcontroller, while facial expressions are analyzed using image processing and machine learning techniques such as Local Binary Patterns (LBP) and Support Vector Machine (SVM). Stress levels are determined by comparing sensor values with predefined and personalized threshold levels and correlating them with detected facial emotions. When high stress levels are identified, the system generates alerts through buzzer or notification mechanisms. The proposed solution is cost-effective, portable, and suitable for applications in healthcare, workplace wellness, and personal stress management. This project demonstrates the feasibility of combining wearable biosensors and artificial intelligence for accurate and continuous stress monitoring

Keywords- Wearable Device, Stress Detection, Physiological Sensors, Galvanic Skin Response (GSR), Heart Rate Monitoring, Facial Emotion Recognition, Machine Learning, Internet of Things (IoT), Arduino, Health Monitoring.

INTRODUCTION

In recent years, rapid urbanization, increased workload, and competitive lifestyles have significantly contributed to rising stress levels among individuals. Prolonged exposure to stress can lead to serious physical and mental health issues such as hypertension, anxiety, depression, and reduced productivity. Traditional methods of stress assessment often rely on self-reporting or clinical evaluations, which are not continuous and may lack accuracy in real-world environments. Hence, there is a growing need for automated, real-time, and non-invasive.

Advancements in wearable technology, biosensors, and artificial intelligence have opened new possibilities for continuous health monitoring. Wearable devices equipped with physiological sensors can capture real-time biological signals such as heart rate, skin temperature, and sweat response, which are closely associated with stress conditions. Additionally, facial expressions serve as an important non-verbal indicator of emotional states and can be analyzed using computer vision techniques.

RELATED WORK

A wearable device for continuous monitoring of stress has significant real-world relevance due to the increasing prevalence of stress-related health issues in modern society. These devices are designed to continuously measure physiological parameters such as heart rate, heart rate variability, skin temperature, and electrodermal activity, which are closely associated with human stress responses. In healthcare, such wearable systems enable early detection of prolonged stress, anxiety, and emotional imbalance, allowing doctors and mental health professionals to provide timely interventions and personalized treatment. Continuous stress monitoring also reduces the need for frequent hospital visits and supports remote patient care through smart healthcare systems.

In professional and academic environments, wearable stress monitoring devices play an important role in understanding stress patterns caused by workload, deadlines, and performance pressure. By analyzing real-time stress data, individuals can adopt better stress management techniques such as relaxation exercises, proper rest, and improved work-life balance. Organizations and educational institutions can use aggregated stress data to design healthier schedules, improve productivity, and reduce burnout among employees and students.

SYSTEM ARCHITECTURE

The proposed system follows a modular architecture consisting of five main layers:

- **Data Acquisition Layer:** Collects physiological signals and facial images in real time.
- **Processing Layer:** Microcontroller filters and manages sensor and camera data
- **Feature Extraction Layer:** Extracts stress-related physiological and facial features.
- **Storage Layer:** Stores data and displays stress trends on a dashboard.
- **Stress detection Layer:** Classifies stress as low, moderate, or high using combined features.

This layered architecture ensures scalability, easy maintenance, and efficient system performance.

METHODOLOGY

The proposed system performs real-time stress monitoring by integrating wearable physiological sensors with facial emotion recognition and intelligent decision-making. The system continuously collects physiological data such as heart rate, skin temperature, and galvanic skin response (GSR) using wearable biosensors, while a camera module captures facial images for emotion analysis. The

collected signals are preprocessed using filtering and normalization techniques to remove noise, and important features like heart rate variability, sweat intensity, and temperature variations are extracted. Facial emotion features are obtained using computer vision techniques such as facial landmark detection and Local Binary Patterns (LBP). The extracted physiological and facial features are then analyzed using predefined and personalized thresholds and machine learning algorithms like Support Vector Machine (SVM) to classify stress levels. When high stress is detected, the system activates alert mechanisms such as a buzzer or LED and can also send notifications through IoT modules. All components are integrated into a compact wearable prototype using Arduino for sensor interfacing and Python with OpenCV for image processing, ensuring reliable real-time performance suitable for healthcare and personal stress management applications.

SYSTEM IMPLEMENTATION

In this system, multiple biomedical sensors work together to continuously monitor the user's physiological condition. The MAX30102 sensor measures the heart rate by detecting blood flow variations, the DS18B20 sensor accurately measures body temperature, and the GSR sensor records skin conductivity, which changes with emotional and stress responses. All these sensor readings are transmitted to the Arduino Nano, which acts as the central processing unit of the system.

The Arduino Nano reads the incoming sensor data in real time and applies a simple rule-based logic to analyze the user's condition. When the body temperature rises above 37 °C, the heart rate exceeds 100 beats per minute, and the GSR value is greater than 500, the system interprets this combination as a stress condition. Based on this decision, the processed information is immediately sent to an LCD display, which continuously shows the current heart rate, body temperature, GSR-based stress status, and overall condition of the user.

Additionally, the system can store the collected sensor data for long-term monitoring and analysis. This stored data can be used to train or feed a separate AI or machine learning model that identifies emotional states such as Happy, Sad, Angry, or Neutral. Such an extension makes the system useful for applications like mental health monitoring, wearable health devices, and real-time stress and emotion detection systems. A typical workflow for a wearable device used in continuous stress monitoring starts with **data acquisition**, where sensors embedded in the wearable (such as heart rate, heart rate variability, skin conductance, temperature, and motion

sensors) continuously collect physiological signals from the user.

CONCLUSION AND FUTURE SCOPE

The wearable stress monitoring system demonstrates a strong foundation for future enhancements and practical healthcare applications. The successful integration of biomedical sensors with embedded systems enables real-time monitoring of physiological parameters such as heart rate and body temperature, allowing effective stress detection through a rule-based approach with instant feedback on an LCD. The system's low-cost, portable, and user-friendly design makes it suitable for daily personal and clinical use. Future improvements may include the integration of advanced non-invasive hormone sensors to estimate cortisol levels, providing more accurate stress assessment, and the use of AI-based machine learning models to predict stress patterns and deliver personalized insights. With added features such as wireless connectivity, improved sensor accuracy, and intelligent real-time prediction, the system has strong potential for commercial deployment and can contribute significantly to proactive healthcare, stress management, and early detection of stress-related disorders.

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