Real-Time IoT-Based Physiological Stress Assessment System

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Abstract - *The main motive of body stress detection is health monitoring which works as a warning system in the case of the human body. This system integrates a temperature sensor, pulse sensor, GSR sensor, ECG sensor, and BP sensor and the output of these sensors gives physiological parameters that predict stress level. The result of the monitoring system provides a clear pattern between sensor data and stress levels. These results show the real-time prediction of body stress and it is accessed via a mobile application. The system provides a cost-effective and efficient solution for continuous stress monitoring. The paper offers valuable insights into health monitoring with technology, making it a worthwhile contribution.*

***Key Words*: Body stress, Heart rate sensor, Temperature sensor, GSR sensor, Blood Pressure, LCD, Microcontoller, Bluetooth.**

1.INTRODUCTION

The detrimental effects of stress on health are well-documented, with links to cardiovascular diseases, hypertension, diabetes, anxiety, and depression. The need for easily accessible stress monitoring techniques has become increasingly apparent. Stress affects the body in various ways, stemming from both psychological and physical triggers. Physiological changes such as increased heart rate, elevated blood pressure, accelerated respiration, higher body temperature, abnormal ECG patterns, and changes in skin conductivity are all indicators of heightened stress levels. By implementing a stress monitoring system, it becomes possible to prevent adverse health effects due to changes in these parameters.

The conventional methods of stress monitoring, such as questionnaires, interviews, and clinical evaluations, are time-consuming and provide only a snapshot of an individual's stress level at a specific moment. To address these limitations, the Body Stress Monitoring System has been developed. This system measures stress by analyzing key physiological responses associated with the body's reaction to stress. It utilizes an NTC thermistor to detect changes in body temperature, reflecting increased metabolic activity and blood flow during stressful conditions. The ECG sensor monitors heart activity, capturing heart rate variability (HRV) and detecting irregular heart rhythms, both of which are common during stress. The heart rate sensor provides additional insight into fluctuations in heart rate, which often accelerates under stress. Finally, the Galvanic Skin Response (GSR) sensor measures changes in skin conductivity caused by increased sweat gland activity, a well-known physiological response to stress. By combining the data from these four sensors, the system calculates an individual's stress level in real-time, providing a comprehensive overview of the body's stress response.

Based on a Survey conducted with local hospital valuable insights were gathered regarding physiological parameters and their relationship to stress. This information is instrumental in refining the Body Stress Monitoring System, as it highlights key factors like blood pressure, pulse rate, and oxygen levels, which fluctuate under stress conditions. The survey results support further sensor calibration efforts for early stress detection and effective monitoring, which are crucial for accurate and timely health assessments.

Key Physical Symptoms and Parameters Affecting Stress:

Blood Pressure (BP):

A normal BP range is 120/80 mm Hg. Stress-induced hypertension occurs when BP exceeds 140/90 mm Hg, often signaling elevated stress levels. BP is measured in millimeters of mercury (mm Hg) with systolic (upper value) and diastolic (lower value) readings.

Sugar Levels:

For diabetic patients, stress can raise blood glucose levels, while it typically has minimal impact on non-diabetics.

Body Temperature:

Average body temperature is around 98.2°F (37°C). Although stress does not usually increase temperature, fevers above 98.9°F (37.16°C) may occur due to other health conditions.

Pulse Rate:

The normal pulse rate falls between 72-82 bpm, but stress can increase beyond 100 bpm, resulting in tachycardia.

Oxygen Level:

A healthy oxygen level is above 95%. If oxygen drops below this threshold, it may indicate physical or mental stress, potentially causing symptoms similar to suffocation.

Sweating:

Visible perspiration on the face, scalp, or forehead is a common sign of stress and may be linked to elevated sugar levels.

Chest Pain:

Although not directly measurable through sensors, chest pain can be stress-induced, particularly in individuals with cardiovascular conditions.

ECG Changes:

For those with pre-existing heart conditions, stress may indirectly alter ECG readings, though it does not significantly impact ECG data in healthy individuals.

Personal Life Issues:

Emotional events, arguments, injuries, or accidents can heighten stress.

Psychiatric Disorders:

Anxiety, insomnia, depression, and related disorders are known to amplify stress.

Chronic Diseases:

Hypertension, diabetes, osteoarthritis, and spondylosis are stress-exacerbated conditions that tend to worsen as stress increases.

2. LITERATURE REVIEW

In today's fast-paced society, stress has become a pervasive issue affecting individuals across various domains of life. The detrimental impact of stress on physical health, mental well-being, and overall productivity underscores the need for effective stress management strategies. In response to this growing concern, researchers and technologists have increasingly turned their focus toward developing innovative solutions for stress monitoring and intervention.

Recent developments in human stress monitoring systems using wearable sensors are reviewed, highlighting trade-offs in system design and sensor selection. The focus is on balancing the information content related to stress with wearability, addressing key challenges and considerations.[1]

An approach to detecting mental stress using unobtrusive wearable sensors is described, emphasizing the analysis of heart rate variability to estimate the state of the autonomic nervous system.[2]

A study explores the development of "Stress-Track," a system that integrates IoT, machine learning, and wearable sensors to monitor stress levels in real time. It utilizes body temperature, sweat levels, and motion detection while emphasizing data storage and comprehensive stress analysis.[3]

The use of machine learning and edge computing in stress detection systems was explored. Wearable sensors were used to collect physiological data, which was then analyzed to identify stress indicators. This research highlighted the potential of combining advanced computing techniques with wearable sensors for efficient, real-time stress detection. The research also discusses integrating stress monitoring into smart home setups to make the technology more practical and accessible. This approach highlights the potential for delivering efficient, real-time stress detection by combining advanced computing techniques with wearable sensor systems.[4]

A sensor-based method was developed to identify and classify stress levels using Galvanic Skin Response (GSR) data. This research focused on workplace stress, addressing challenges like data variability and aiming to improve stress detection accuracy. The goal was to provide reliable data insights for effective stress management strategies.[5]

A new diagnostic approach was proposed that combines case-based reasoning, fuzzy logic, and a calibration phase to account for individual differences in stress responses. This system aimed to overcome the limitations of traditional methods by providing personalized stress assessments and aiding clinicians in decision-making for stress management.[6]

Building on these insights, the proposed Body Stress Monitoring System uses wearable sensors to provide accurate, real-time stress evaluations. The system estimates stress levels by analyzing data from various sensors and calculating sensor-specific thresholds and offers users actionable feedback regarding potential health concerns. Emphasizing privacy and ethical considerations, the system combines precision, usability, and accessibility, making it a practical tool for stress detection and management in both personal and clinical settings.

3. METHODOLOGY

The goal of the Body Stress Monitoring System is to measure stress levels by analyzing physiological parameters using a PIC18F4550 microcontroller, along with sensors and Bluetooth-enabled data display. The system is designed to track body temperature, heart activity, heart rate, and skin conductivity, which are all indicators of stress. The processed data is then displayed both on an LCD screen and transmitted to a mobile application using Bluetooth for real-time monitoring.

PIC18F4550 micro-controller

This serves as the central processing unit, controlling sensor inputs, processing data, and managing communication with the LCD and Bluetooth module.

Temperature sensor

The temperature sensor is a crucial component used to measure body temperature, which is essential for detecting stress responses. It utilizes an NTC thermistor to detect small changes in skin temperature and compares this data with normal body temperature. An increase in temperature indicated by the NTC thermistor signals the presence of stress.

Heart-rate sensor

This sensor continuously monitors the user's heart rate, a key parameter as stress often causes an elevated heart rate. The heart rate sensor measures the number of heart beats per minute for confirming an elevated heart rate under stress.

ECG sensor

The electrocardiogram sensor tracks the heart's electrical activity, allowing for the analysis of heart rate variability (HRV) and abnormal heart rhythms caused by stress. The ECG sensor data is analyzed to assess HRV. Lower HRV is often associated with stress, while irregular heart patterns further strengthen the likelihood of a stress response.

GSR sensor

The Galvanic Skin Response sensor measures skin conductivity, which increases due to heightened sweat gland activity, another stress indicator. Each sensor outputs analog signals, which are then digitized by the microcontroller for further processing. The GSR sensor detects an increase in skin conductivity, which is directly related to stress-induced sweat gland activity. The processed data is analyzed by an algorithm that assigns different weightages to each physiological parameter, generating a final stress score.

Integrated Hardware System

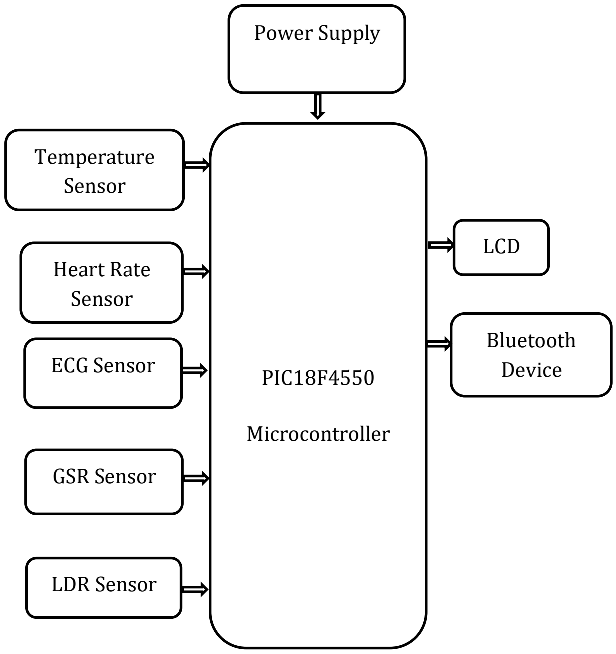

Fig-1: Block diagram of Stress monitoring System

The Body Stress Monitoring System utilizes various sensors connected to the PIC18F4550 microcontroller to gather physiological data. The temperature sensor (NTC thermistor) on analog pin RA1 measures body temperature by converting thermal energy into an analog voltage, which is digitized by the microcontroller's ADC to calculate the temperature. The heart rate sensor (Pulse Sensor) on analog pin RA0 detects blood flow changes under the skin, generating an analog voltage that is converted and processed to determine heart rate. Similarly, the ECG sensor on analog pin RA2 measures the heart's electrical activity, providing a digital representation for heart health analysis. An LDR, connected to analog pin RA3, measures light intensity by generating an analog voltage that the ADC digitizes for light-level evaluation. The microcontroller processes the data from all sensors and compares the readings to predefined thresholds to detect potential stress. If the thresholds are exceeded, the system identifies stress and transmits the calculated stress level, along with other sensor data, to a mobile device via Bluetooth.

4. IMPLEMENTATION

The Body Stress Monitoring System integrates a mobile application to display real-time stress levels by combining sensor data, microcontroller processing, and Bluetooth communication. Physiological data is collected using sensors, including an NTC thermistor for body temperature, ECG and heart rate sensors for cardiac activity, a GSR sensor for skin conductivity, and an LDR sensor for blood pressure estimation. The PIC18F4550 microcontroller processes this data and calculates stress levels using predefined algorithms. A Bluetooth module transmits the processed data to the mobile application, which features a user-friendly interface. The app displays live sensor readings and stress levels, categorizing them as "Normal," "Moderate," or "High Stress" for clarity. It also offers alerts for critical stress levels, encouraging timely user action. By providing immediate feedback, the application enhances the practicality of the system, allowing users to monitor their stress conveniently while supporting better stress management and overall well-being.

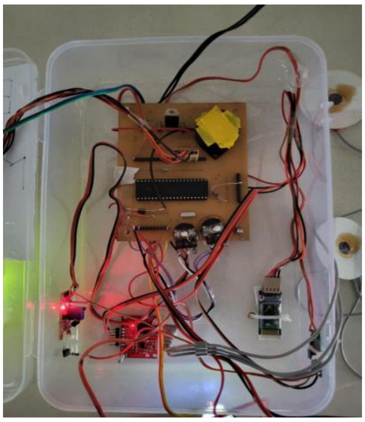

Fig-2: Hardware

The Body Stress Monitoring System developed here adopts a unique approach by integrating a range of physiological sensors alongside the PIC18F4550 microcontroller for efficient data processing and output. Compared with existing systems in the literature, this system demonstrates key advancements. Traditional systems frequently use single or dual-sensor configurations, often limited to monitoring heart rate variability (HRV) or Galvanic Skin Response (GSR) data. For example, Choi and Gutierrez-Osuna's (2009) work relies on HRV alone, while Bakker et al. (2011) emphasize GSR for recognizing stress patterns. In contrast, this Body Stress Monitoring System combines an NTC thermistor (temperature), heart rate sensor, ECG sensor, and GSR sensor, delivering a comprehensive, multi-faceted stress analysis. Integrating multiple sensors enhances stress detection accuracy by capturing a broader physiological response profile that includes heart rate, temperature, and skin conductivity.

5. Result & Discussion

Stress detection among the individuals is determined by deviations in physiological parameters temperature, heart rate, blood pressure, and skin response from their normal ranges. Stressed individuals (E, F, G, H) consistently exhibit elevated blood pressure (ranging from 125 mmHg to 140 mmHg, compared to the normal 120/80 mmHg) and, in some cases, elevated heart rates (e.g., 107 BPM for F and 109 BPM for G, above the normal range of 60–100 BPM). Despite slightly lower-than-normal temperatures (33–36°C compared to 36.5–37.5°C), the heightened blood pressure and heart rate indicate stress. Conversely, non-stressed individuals (A, B, C, D, I) mostly have parameters within normal limits: heart rates between 77–90 BPM, blood pressure at or near 120 mmHg, and temperatures below the normal range, but not indicative of stress. Although skin response values are uniformly high (around 1000 units) across all individuals, stress detection appears to rely more heavily on elevated blood pressure and heart rate. This suggests that these two parameters play a key role in identifying stress, whereas skin response may serve as a less variable baseline in this dataset.

Table -1: Analysis Table

Person	Temperature (°C)	Heart Rate (BPM)	Blood pressure	Skin Response	Stress Detection (Yes/No)
A	31	81	120	1019	No
B	32	78	110	1014	No
C	32	78	115	1015	No
D	33	77	118	1019	No
E	33	92	125	1019	Yes
F	34	107	130	1015	Yes
G	35	109	135	1015	Yes
H	36	95	140	1008	Yes
I	33	90	130	1016	No

Fig-3: Output Shown On Mobile via Bluetooth

Fig-4: Spo2 Result on LCD

Fig-5: Heart Rate Result on LCD

Fig-6: Temperature Result on LCD

Fig-7: ECG Result on LCD

Chart-1: Evaluation of Person's Heart Rate

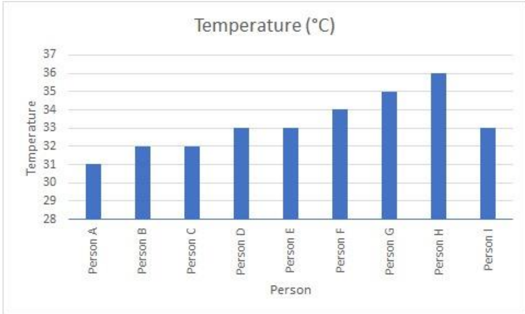

Chart-2: Evaluation of Person's Body Temperature

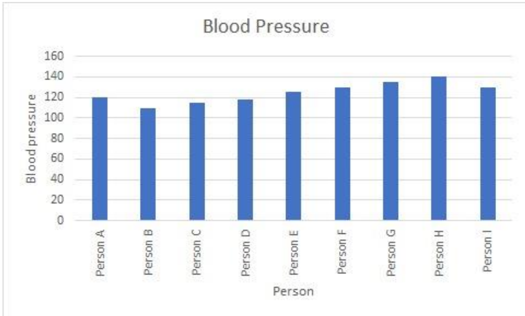

Chart-3: Evaluation of Person's Blood Pressure

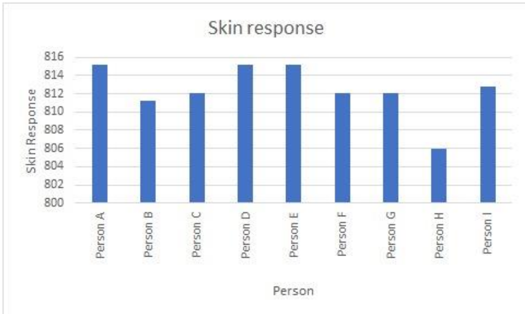

Chart-4: Evaluation of Person's Skin Response

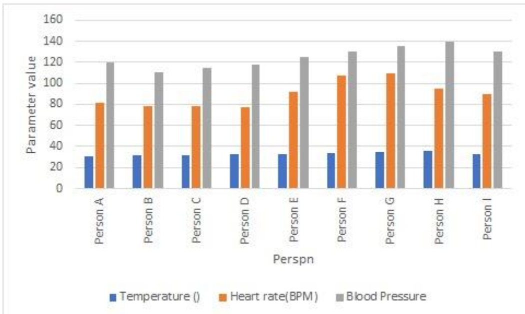

Chart-5: Overall Analysis

6. CONCLUSION

The Body Stress Monitoring System described in this project is a simple and non-invasive way to track stress in real-time. It uses the PIC18F4550 microcontroller and several sensors to measure different signs of stress. These include an NTC thermistor to check body temperature, an ECG sensor to monitor changes in heart rate, a heart rate sensor, a GSR sensor to measure how much the skin sweats and an LDR sensor to measure blood pressure. The system collects and processes this information to calculate stress levels. The results are shown on an LCD screen and sent to a mobile app through Bluetooth, giving users quick feedback. This system offers a complete solution for tracking stress continuously and can be useful for both personal health care and medical settings. It helps to identify stress-related problems early, allowing people to take action and manage their stress to improve overall well-being. Overall, this system provides a more complete, affordable, and user-friendly option than many other stress monitoring systems. Its focus on real-time data and ease of use makes it ideal for everyday health and wellness use. By offering clear and immediate insights, this Body Stress Monitoring System could be valuable in helping people manage stress and support preventative health care.

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