

A Wearable Device to Detect Stress and Anxiety with Therapy Treatment to Overcome Emotional Distress

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Abstract: This paper presents a groundbreaking multimodal sensor-based system intended for detecting hypertension, restlessness, and associated physiological indicators. By combining image processing with pulse, SpO₂, sweat, and restlessness sensors, the system provides non-invasive therapeutic solutions tailored to the specific needs of individuals. Its primary aim is to tackle the rising prevalence of hypertension resulting from lifestyle changes, offering crucial support to the general populace. Moreover, it serves as a vital tool for vulnerable groups like sexual assault survivors and train operators who undergo considerable psychological and physiological strain. Utilizing state-of-the-art sensor technologies and image processing algorithms, the system accurately identifies symptoms in real-time, facilitating timely interventions and personalized treatment approaches. With its comprehensive monitoring and intervention capabilities, the system shows potential in improving the well-being and recovery of individuals grappling with hypertension and related issues. Overall, this innovative approach signifies a substantial leap forward in health technology, with the promise of enhancing the lives of those affected by hypertension and its associated conditions.

Keywords: depression, anxiety, hypertension, physiological stress, SpO₂.

1. Introduction

Stress, whether from mental or physical sources, is ubiquitous in today's workplace and has a significant impact on people's wellbeing. Maintaining homeostasis and preventing disease need effective stress recognition and management. This essay emphasizes the intricacy of stress management by outlining several types of stress and concentrating on real stress, its widespread occurrence, and its harmful effects on health. It clarifies the growing significance of wearable smart sensors in stress monitoring by highlighting the critical impact of physiological parameters and the body's hormonal reaction. It also draws attention to the rising incidence of lifestyle-related health problems such as hypertension and insomnia, which call for creative solutions. The essay outlines a comprehensive strategy that combines cutting-edge sensor technologies, image processing, and non-invasive therapies to mitigate hypertension and restlessness. Finseth, T.T. et.al [1] proposes the paper emphasizes the significance of integrating pitch period data into speaker recognition models to enhance accuracy. Unlike traditional models that rely solely on MFCC cepstrum features, which are prone to imitation, the inclusion of pitch period data introduces complexity, making imitation more challenging. Furthermore, the paper explores the utilization of Gaussian mixture models (GMM) to compute the maximum probability by leveraging the distribution probability of test samples among the initial training samples with minimal values. This strategy is adopted to enhance recognition speed, as the direct segregation of Gaussian mixture models can potentially hinder the process. Syed Moosavi, S.K.R. et.al [2] suggests identification of mental stress, which is based on overall healthiness, which impacts on stress with various health concerns, this issue arises with various feature selection technique, this feature is compared with stressed and non-stressed comparing with dataset, with stress level in pandemic situation with collecting bio signals and survey collection. Yousefi, M.S. et.al [3] shows that to establish a reliable technique for detecting stress by leveraging eye tracking data, acknowledging the significance of early identification in addressing this widespread condition. The investigators investigate the feasibility of integrating eye tracking data with electrodermal activity (EDA) signals to enhance stress detection capabilities. Moser, M.K. et.al [4] recommends with improving accuracy which is used to identify the stress which is used to generate algorithm, with electro dermal method and skin temperature which provides noninvasive approach which evaluate stress response, this experimentation done with 16 Participants which has resulted in various outcomes of achieving overall 81.31% and 46.23% with accuracy of 92.74% with flexibility. Whiston, A. et.al [5] put forward the study between stress and various symptoms including depression, Department of Psychology researches the wearable electro dermal monitoring system which investigate with stress and depression in physiological manner.

With symptoms Sakthivel, S. et.al [6] proposes the EDTA data with analysis to generate stress level with low, moderate and high, with supervised manner by training the dataset, to identify stress detection's this based on method of EDA with factors like sweat gland density and skin which is result in misidentification, As this result in 85.06% accuracy with dataset and conventional model. Aristizabal, S. et.al [7] introduces the stress detection using deep learning with machine learning with electrodermal activity skin, temperature, heart temperature with anxiety and stress level, with adding data with wearable devices, model achieved with stress detection accuracy 96% with multi-dimensional datasets with feasible with stress-triggering with stress response. Padmaja, K.V. et.al [8] introduces a feature-rich system incorporating a 16-bit Analog to Digital Converter (ADC) for precise data conversion. This system is designed for early detection of anxiety disorders among patients, particularly in hospital settings. It utilizes Electrocardiogram (ECG) signals to monitor and compare anxiety levels, achieving an impressive 94% accuracy rate in detecting anxiety disorders with a 96% accuracy in the evaluation process. Ismail, N.M. et.al [9] propels to validate with data gathered with which engage in activities which aim to Social Anxiety Disorder (SAD), with wearable sensor device to record to signal, which measures with heart rate and skin temperature using sensor Electrocardiography (ECG) with heart rate and temperature sensor, with analysis using K-Nearest Neighbors with decision Parameter which analysis K-Nearest and decision algorithm with high accuracy. Kurniawan, E.D. et.al [10] imparts with biosensor development with android application with smart phone function with colorimeter sensor which is used cortisol concentration, stress level. Android app on the smartphone with identify biosensors due to change in cortisol concentration, as this translated with smartphone into red, green, Blue (RGB) which converted into stress level.

2. Existing System

Continuous leading to stress can have severe health implications and lead to significant economic losses for companies. To address this issue, there has been a focus on developing systems with stress monitoring [12]. These systems aim to mitigate the long-term effects of stress, including confusion, high blood pressure, insomnia, depression, headaches, and impaired decision-making. The healthcare industry has prioritized the accurate through physiological by wearable devices. While previous studies have demonstrated rates can achieve high accuracy, there has been limited effort to utilize consumer-based devices with lower sampling rates, potentially affecting the performance of stress detection systems.

3. Problem Statement

Hypertension and restlessness present significant health risks that affect individuals across diverse demographics and lifestyles. Despite the availability of medical interventions, timely detection and effective management of these conditions remain significant challenges. Current diagnostic methods often rely on sporadic clinic visits or invasive procedures, limiting their accessibility and effectiveness in providing real-time monitoring and intervention [11]. Moreover, vulnerable populations, such as rape victims and train drivers, face additional barriers in accessing appropriate healthcare support tailored to their unique circumstances. This underscores the pressing need for a comprehensive solution that integrates advanced sensor technologies, image processing algorithms, and non-invasive therapeutic interventions to enable early detection, continuous monitoring, and personalized treatment of hypertension and restlessness. Therefore, this project seeks to bridge the gap in current healthcare practices by developing an innovative, user-friendly system capable of detecting and managing hypertension and restlessness effectively, thereby enhancing the quality of life for individuals and communities alike.

4. Proposed System

The proposed system integrates advanced sensor technologies, image processing algorithms, and non-invasive therapeutic interventions to address the challenges associated with monitoring hypertension and restlessness. Wearable sensors are used for continuous monitoring of physiological parameters like pulse, SpO2, sweat, and restlessness. These sensors provide real-time data, allowing for the prompt detection and accurate assessment of symptoms [13]. One key advantage of these sensors is their portability and convenience, enabling individuals to monitor their health easily in their daily lives. This non-invasive approach offers an objective and quantitative assessment, reducing biases and inaccuracies associated with subjective observations. Additionally, the system includes tailored non-invasive therapeutic interventions, such as mindfulness meditation and biofeedback, to help individuals manage stress and improve overall well-being. By offering personalized interventions based on real-time data, the proposed system provides targeted support, enhancing the effectiveness of treatment

strategies. Furthermore, the system emphasizes integration and interoperability, allowing for seamless consolidation of data from multiple sources [14]. This comprehensive approach facilitates comprehensive health monitoring and promotes individual health and well-being effectively. Overall, the proposed system represents an innovative and comprehensive approach to managing hypertension and restlessness, offering numerous advantages in terms of accessibility, accuracy, and effectiveness in promoting individual health and well-being.

5. Methodology

The proposed system for monitoring hypertension and restlessness integrates advanced sensor technologies, image processing algorithms, and non-invasive therapeutic interventions to provide comprehensive care. The process begins with the patient seated in front of a computer or laptop. Using a sophisticated convolution neural network (CNN) algorithm, the system recognizes the patient's facial expressions, focusing specifically on the mouth area using the Haar frontal face classifier [15]. This allows for accurate determination of whether the patient is experiencing happiness or sadness. To ensure the accuracy detection, the system incorporates a 5-second observation period. Once the facial expression is analyzed, the data is sent to an Arduino Uno for further processing. Simultaneously, the system employs an accelerometer to detect the patient's level of restlessness, providing additional insight into their state of mind. A water sensor is also utilized to detect any signs of sweating, which can be indicative of stress or discomfort. If two or more of these parameters (facial expression, restlessness, sweating) indicate distress, the system activates a therapy treatment using a cap equipped with a vibrating motor. This non-invasive therapeutic intervention aims to alleviate stress and promote relaxation. Additionally, the system includes an SpO2 sensor connected to an Arduino Nano, which monitors the patient's heart rate and oxygen levels. This data is crucial for assessing the patient's overall health and well-being. All collected data, including facial expressions, restlessness levels, sweating, heart rate, and oxygen levels, is stored in an IOT platform and transferred to a website for further analysis and monitoring.

Furthermore, the system features a panic button that the patient can press in case of a panic attack or urgent need for assistance. When activated, the panic button sends a message to a pre-defined contact number via a GSM module, alerting them to the patient's distress and ensuring timely intervention. This comprehensive approach to monitoring hypertension and restlessness offers numerous advantages, including real-time monitoring, personalized treatment strategies, and improved accessibility to care.

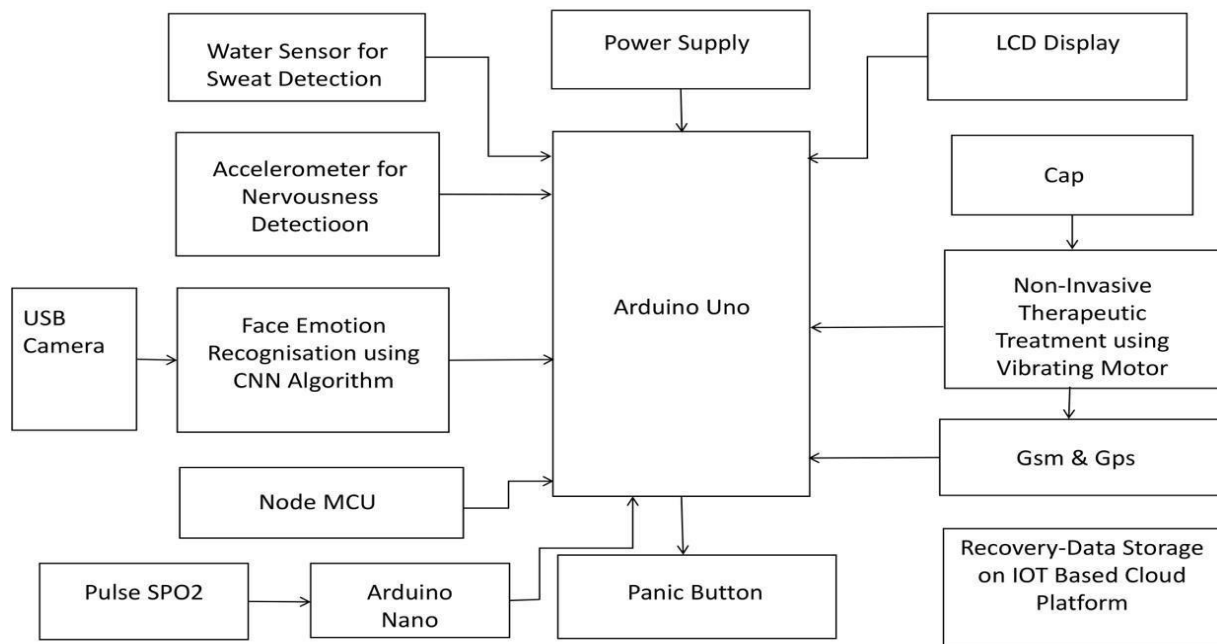


Fig. 1. Block Diagram of Stress and Anxiety Detection with Therapy Treatment

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Fig. 2. GSM module

Accelerometer sensor is a component proposed system for monitoring and anxiety, detects with Patient's level with restlessness with measuring forces with system to the patients with the state of mind, were as this contributes the patient's emotional level with parameters along facial expression and sweating, were integration with sensor implementation of effective stress and relax.

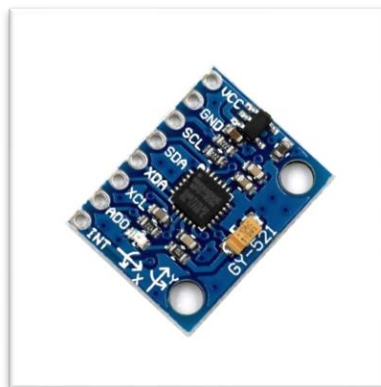


Fig. 3. Accelerometer

The Arduino Uno serves as the central processing unit in the proposed system. It receives data from various sensors, such as the accelerometer and water sensor, and processes this information using algorithms, such as the convolution neural network (CNN) for facial expression recognition. Additionally, the Arduino Uno coordinates the activation of the therapy treatment, utilizing a vibrating motor in the cap when distress indicators are detected. Overall, the Arduino Uno plays a vital role in integrating sensor data and implementing therapeutic interventions to address stress and anxiety effectively.



Fig. 4. Arduino Uno

The LCD (Liquid Crystal Display) serves as the user interface in the proposed system. It provides visual feedback to the patient, displaying important information such as their current stress level, heart rate, and oxygen levels. Additionally, the LCD may show prompts or instructions for the patient, such as when to sit still for facial expression analysis or when therapy treatment is being administered.

The MAX30100 is an SpO2 sensor used in the proposed system to monitor the patient's heart rate and oxygen levels. It is connected to the Arduino Nano and provides crucial physiological data for assessing the patient's overall health and well-being. By continuously monitoring heart rate and oxygen levels, the MAX30100 sensor enables real-time detection of any abnormalities or distress indicators, allowing for timely intervention and personalized treatment strategies to be implemented.



Fig. 5. MAX30100 sensor

The NodeMCU is a crucial component of the proposed system, facilitating the transfer of collected data to an IOT platform and website for further analysis and monitoring. As a microcontroller with built-in Wi-Fi capabilities, the NodeMCU establishes an internet connection, enabling wireless transmission of data.



Fig. 6. NodeMCU

The vibration motor is an integral part of the proposed system's therapy treatment for stress and anxiety. When

distress indicators are detected, such as through facial expression analysis, restlessness, or sweating, the system activates the vibration motor. This non-invasive therapeutic intervention aims to alleviate stress and promote relaxation by providing tactile feedback to the patient. Water sensor which is used proposed system used to detect with the sweating, which is more stress discomfort in patients, were which will monitor moisture level, with water sensor with the parameter of facial expression and restlessness, which is used combine with indicator, detection of sweating triggers the activation of therapy treatment, which used to enhance system ability for effective monitor.

6. Result and Discussions

Substantial progress has been made in the project, with successful integration of essential hardware components. The core of the system comprises Arduino Uno/Mega microcontrollers, Arduino Nano, and Node MCU with an inbuilt WiFi module, facilitating seamless communication and control. Key sensors such as pulse detection, water sensing, and nervousness detection, along with a power supply, enhance the system's capability to monitor vital signs and stress levels effectively. Additionally, features like vibration motors for therapy, GSM, and an LCD 16*2 display contribute to therapeutic interventions.



Fig. 7A. Visual depiction of Sweat Detection

The Fig. 7A. simulation graph depicts the sweat level over time, measured by a water sensor. On the x-axis, the sweat level is represented, while the y-axis signifies time. Initially, when no hand is placed on the sensor, the sweat level remains at zero. However, once the hand is placed on the sensor, the sweat level gradually increases over time. A threshold level has been set to determine when the sweat level surpasses a certain point, indicating significant sweat accumulation. This threshold level serves as a reference point for detecting variations in sweat levels beyond normal conditions. By monitoring the sweat level over time and comparing it to the predefined threshold, the system can effectively detect changes in sweat levels, providing valuable insights into physiological responses.



Fig. 7B. Visual depiction of Heart Rate

In the Fig. 7B. simulation graph, the x-axis represents heart rate, while the y-axis represents time. Initially, with no hand placed on the SpO2 sensor, the heart rate remains at zero or at a baseline level. Once the hand is placed on the sensor, the heart rate value begins to register and is plotted against time. This indicates that the sensor is effectively detecting the heart rate from the pulsatile signal obtained from the finger or other measurement site. This type of sensor typically utilizes photoplethysmography (PPG) to measure blood volume changes in the microvascular bed of tissue. When the heart pumps blood through the circulatory system, it causes periodic changes in blood volume, which can be detected by the sensor. By analyzing these changes over time, the sensor can accurately determine the heart rate of the individual.



Fig. 7C. Visual depiction of SPO2

In the Fig. 7C. simulation graph, the x-axis represents the SpO2 (peripheral capillary oxygen saturation) level, while the y-axis represents time. Initially, when no hand is placed on the SpO2 sensor, the SpO2 level remains at zero or at a baseline level. Once the hand is placed on the sensor, the SpO2 value begins to register and is plotted against time. SpO2 sensors typically work by shining light through the skin and measuring the amount of light absorbed by oxygenated versus deoxygenated hemoglobin in the blood. This measurement provides an estimate of the oxygen saturation level, which reflects the percentage of hemoglobin molecules bound with oxygen. This indicates that the sensor is effectively detecting the oxygen saturation level of the blood in the peripheral capillaries.

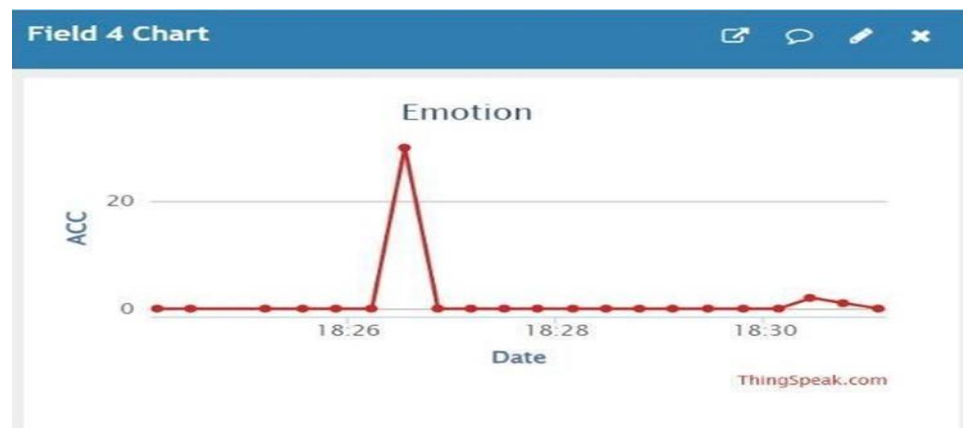


Fig. 7D. Visual depiction of Accelerometer

In the MATLAB simulation graph, the x-axis represents the accelerometer (acc) values, while the y-axis represents time. When there are no movements, the accelerometer readings remain at zero or at a baseline level. However, when there are movements detected by the accelerometer sensor, the values start registering on the graph against the respective time intervals. To identify restlessness, a threshold value of 4 has been set. This means that if the accelerometer readings exceed 4 within a specified time range, for example, 10 seconds as mentioned, it indicates significant movement indicative of restlessness. When such a condition is met, it suggests that the person is exhibiting restlessness or physical agitation.

created_at	entry_id	Sweat	Heart Rate	SPO2	Accelerometer	Emotions
2024-03-06T18:24:11+05:30	1	0	0	0		0 Neutral
2024-03-06T18:24:30+05:30	2	0	0	0		0 Neutral
2024-03-06T18:25:13+05:30	3	0	0	0		0 Neutral
2024-03-06T18:25:35+05:30	4	0	0	0		0 Neutral
2024-03-06T18:25:54+05:30	5	0	0	0		0 Neutral
2024-03-06T18:26:14+05:30	6	71	0	0		0 Neutral
2024-03-06T18:26:33+05:30	7	71	0	0	30	0
2024-03-06T18:26:52+05:30	8	72	24	0		0 Neutral
2024-03-06T18:27:12+05:30	9	0	0	0		0 Neutral
2024-03-06T18:27:31+05:30	10	0	0	0		0 Neutral
2024-03-06T18:27:50+05:30	11	0	0	0		0 Neutral
2024-03-06T18:28:10+05:30	12	0	0	0		0 Neutral
2024-03-06T18:28:29+05:30	13	0	0	0		0 Neutral
2024-03-06T18:28:48+05:30	14	0	0	0		0 Neutral
2024-03-06T18:29:08+05:30	15	0	0	0		0 Neutral
2024-03-06T18:29:28+05:30	16	0	0	0		0 Neutral
2024-03-06T18:29:48+05:30	17	63	69	96		0 Neutral
2024-03-06T18:30:08+05:30	18	65	77	96		0 Neutral
2024-03-06T18:30:27+05:30	19	68	63	95		2 Neutral
2024-03-06T18:30:46+05:30	20	68	65	96		1 Neutral
2024-03-06T18:31:06+05:30	21	0	102	93		0 Neutral

Fig. 8. Data Table

The Fig. 8. Excel sheet serves as a comprehensive repository for the data collected from various sensors and facial recognition systems in the project. Each row in the sheet represents a unique entry, with the first column containing the date and time stamp of when the data was recorded, ensuring chronological organization. The second column consists of an entry ID, facilitating easy tracking and reference to specific data points. Subsequent columns capture the measurements obtained from different sensors: sweat level, heart rate, SpO2 level, and accelerometer readings. These measurements provide insights into physiological responses such as stress levels, cardiovascular activity, respiratory function, and movement patterns. Finally, the last column records the facial emotion detected using a CNN model and Haar cascade frontal face recognition, categorizing emotions into states like happy, sad, or neutral. This comprehensive data storage format enables researchers and healthcare professionals to analyze and interpret the collected information efficiently, gaining valuable insights into individuals' physiological responses, activity levels, and emotional states over time. Additionally, Excel's functionalities allow for further data processing, visualization, and statistical analysis, enhancing the understanding of the gathered data. The integrated hardware forms a solid basis for further development and optimization. The cohesive framework of assembled components, including various sensors and modules crucial for health monitoring and therapeutic interventions, signifies significant progress towards project goals. Features like pulse detection and nervousness sensors, as well as vibration motors for therapy and GSM, enhance the system's potential for non-invasive interventions and communication capabilities. Furthermore, the LCD 16*2 display aids user interaction and feedback. As the project progresses, the integrated hardware sets the stage for subsequent software integration and fine-tuning, paving the way for a comprehensive solution addressing hypertension and restlessness monitoring.

7. Conclusion

In conclusion, our proposed system represents a significant advancement in healthcare technology, offering a holistic solution for monitoring hypertension and restlessness. Through the integration of wearable sensors, image processing algorithms, and non-invasive therapeutic methods, it enhances health outcomes and quality of life. Real-time monitoring and precise symptom assessment, coupled with personalized interventions, underscore its efficacy. Future developments could focus on improving sensor technologies, incorporating machine learning for personalized insights, expanding monitored parameters, integrating telemedicine, and refining therapeutic interventions. Collaboration with healthcare professionals and users will be crucial for adapting the system to evolving needs, ensuring continued relevance and effectiveness in promoting individual health and well-being. These enhancements have the potential to revolutionize hypertension and restlessness management, ultimately improving global health outcomes and enhancing quality of life.

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