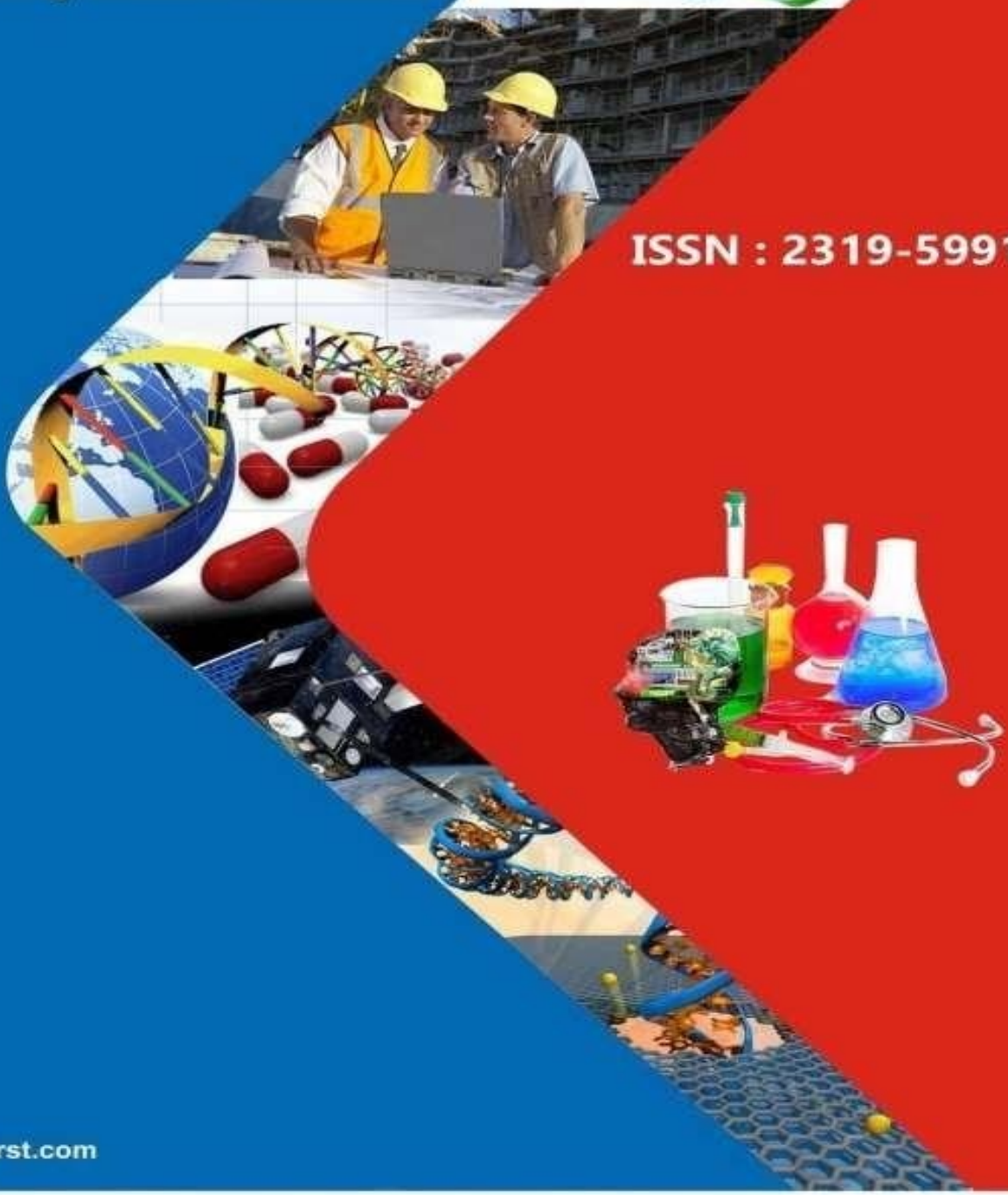
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MACHINE LEARNING BASED ASSESSMENT OF PSYCHOLOGICAL STRESS USING WEARABLE SENSORS

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ABSTRACT

Stress is a psychological condition resulting from the body's response to challenging situations, which can negatively impact physical and mental health if experienced over prolonged periods. Early detection of stress is crucial to prevent chronic health problems. Wearable sensors offer an effective solution for continuous and real-time stress monitoring due to their non-intrusive nature and ability to monitor vital signs, e.g., heart rate and activity. Typically, most existing research has focused on data collected in controlled environments. Yet, our study aims to propose a machine learning-based approach for detecting stress in a free-living environment using wearable sensors. We utilized the SWEET dataset, which includes data from 240 subjects collected via electrocardiography (ECG), skin temperature (ST), and skin conductance (SC). We assessed four machine learning models, i.e., K-Nearest Neighbors (KNN), Support Vector Classification (SVC), Decision Tree (DT), Random Forest (RF), and XGBoost (XGB) in four different settings. This study evaluates the performance of various machine learning models for stress classification using the SWEET dataset. The analysis included two binary classification scenarios (with and without SMOTE) and two multi-class classification scenarios (with and without SMOTE). The Random Forest model demonstrated superior performance in the binary classification without SMOTE, achieving an accuracy of 98.29 % and an F1-score of 97.89 %. For binary classification with SMOTE, the K-Nearest Neighbors model performed best, with an accuracy of 95.70 % and an F1-score of 95.70 %. In the three-level classification without SMOTE, the Random Forest model again excelled, achieving an accuracy of 97.98 % and an F1-score of 97.22 %. For three-level classification with SMOTE, XGBoost showed the highest performance, with an accuracy and F1-score of 98.98 %. These results highlight the effectiveness of different models under various conditions, emphasizing the importance of model selection and preprocessing techniques in enhancing classification performance.

Keywords: NODE MCU, IOT, mobile app, switches, server, hand gloves, Buzzer, etc

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I. INTRODUCTION

1.1 INTRODUCTION

Microcontroller are widely used in Embedded Systems products. An Embedded product uses the microprocessor (or microcontroller) to do one task & one task only. A printer is an example of Embedded system since the processor inside it perform one task only namely getting the data and printing it. Although microcontroller is preferred choice for many Embedded systems, there are times that a microcontroller is inadequate for the task. For this reason, in recent years many manufactures of general-purpose microprocessors such as INTEL, Motorola, AMD & Cyrix have targeted their microprocessors for the high end of Embedded market. One of the most critical needs of the embedded system is to decrease power consumptions and space. This can be achieved by integrating more functions into the CPU chips. All the embedded processors have low power consumptions in additions to some forms of I/O, ROM all on a single chip. In higher performance Embedded system, the trend is to integrate more & more function on the CPU chip & let the designer decide which feature he/she wants to use.

1.2 EMBEDDED SYSTEM

Physically, embedded systems range from portable devices such as digital watches and MP3 players to large stationary installations like traffic lights, factory controllers, or the systems controlling nuclear power plants. Complexity varies from low, with a single microcontroller chip, to very high with multiple units, peripherals and networks mounted inside a large chassis or enclosure

In general, "embedded system" is not an exactly defined term, as many systems have some element of programmability. For example, Handheld computers share some elements with embedded systems such as the operating systems and microprocessors which power them but are not truly embedded systems, because they allow different applications to be loaded and peripherals to be connected. Embedded systems span all aspects of modern life and there are many examples of their use. Telecommunications systems employ numerous embedded systems from telephone switches for the network to mobile phones at the end-user. Computer networking uses dedicated routers and network bridges to route data.

EXAMPLES OF EMBEDDED SYSTEM:

Automated teller. machines (ATMS). Integrated system in aircraft and missile. Cellular telephones and telephonic switches. Computer network equipment, including routers timeservers and firewalls. Computer printers, Copiers. Disk drives (floppy disk drive

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and hard disk drive). Engine controllers and antilock brake controllers for automobiles. Home automation products like thermostat, air conditioners sprinkles and security monitoring system. House hold appliances including microwave ovens, washing machines, TV sets DVD layers/recorders. Medical equipment. Measurement equipment such as digital storage oscilloscopes, logic analysers and spectrum analysers. Multimedia appliances: internet radio receivers, TV set top boxes.Small hand-held computer with P1M5 and other applications. Programmable logic controllers (PLC's) for industrial automation and monitoring. Stationary video game controllers.

1.3 CHARACTERISTICS:

Embedded systems are designed to do some specific tasks, rather than be a general-purpose computer for multiple tasks. Some also have real-time performance constraints that must be met, for reasons such as safety and usability; others may have low or no performance requirements, allowing the system hardware to be simplified to reduce costs. Embedded systems are not always standalone devices. Many embedded systems consist of small, computerized parts within a larger device that serves a more general purpose. For example, the Gibson Robot Guitar features an embedded system for tuning the strings, but the overall purpose of the Robot Guitar is, of course, to play music. Similarly, an embedded system in an automobile provides a specific function as a subsystem of the car itself.

The software written for embedded systems is often called firmware, and is usually stored in read- only memory or Flash memory chips rather than a disk drive. It often runs with limited computer hardware resources: small or no keyboard, screen, and little memory.

1.4 MICROPROCESSOR (MP):

A microprocessor is a general-purpose digital computer central processing unit (CPU). Although popularly known as a "computer on a chip" is in no sense a complete digital computer. The block diagram of a microprocessor CPU is shown, which contains an arithmetic and logical unit (ALU), a program counter (PC), a stack pointer (SP), some working registers, a clock timing circuit, and interrupt circuits.

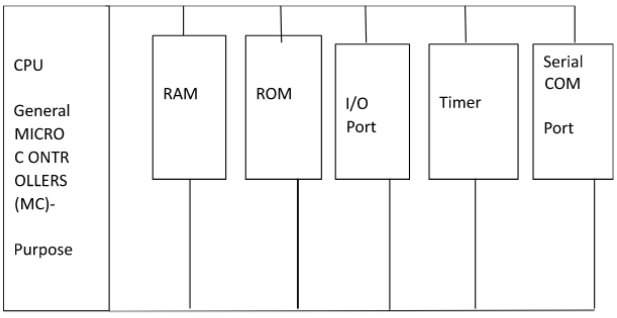


Fig 1.1 Block diagram of microprocessor

1.5 MICROCONTROLLER (MC):

Figure shows the block diagram of a typical

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microcontroller. The design incorporates all of the features found in micro-processor CPU: ALU, PC, SP, and registers. It also added the other features needed to make a complete computer: ROM, RAM, parallel I/O, serial I/O, counters, and clock circuit.

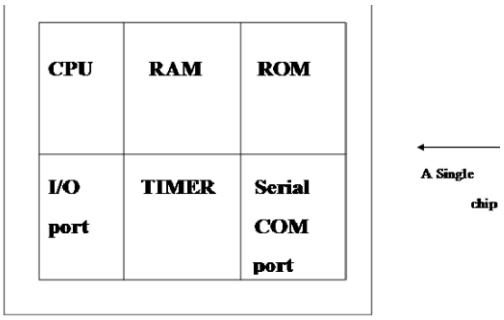


Fig 1.2 Microcontroller

1. 6 COMPARISION BETWEEN MICROPROCESSOR AND MICROCONTROLLER

The microprocessor must have many additional parts to be operational as a computer whereas microcontroller requires no additional external digital parts. The prime use of microprocessor is to read data, perform extensive calculations on that data and store them in the mass storage device or display it. The prime functions of microcontroller is to read data, perform limited calculations on it, control its environment based on these data. Thus the microprocessor is said to be general-purpose digital computers whereas the microcontroller are intend to be special purpose digital controller. Microprocessor need many opcodes for moving data from the external memory to the CPU, microcontroller may require just one or two, also microprocessor may have one or two types of bit handling instructions whereas microcontrollers have many.

II. LITERATURE SURVEY

2.1 INTRODUCTION

Stress has become a widespread and influential factor in modern life, affecting individuals mentally and physically. Therefore, it is crucial to identify stress early and take appropriate action. Our research aims to identify stress using machine learning models effectively and before. The ability of machine learning to analyze patterns and complex relationships within data makes it a promising area for research. In engineering and medicine, early stress detection presents unique challenges and opportunities. Advancements in technology have led to the creation of innovative tools and methods for collecting, analyzing, and determining stress parameters objectively.

As a result of continuous research and development, wearables, physiological sensors, and biometric data analytics have emerged as key components in the engineering arsenal of stress detection. This study analyzes measurements obtained from wearable sensors by machine learning algorithms to create robust models capable of discriminating stress-related subtle patterns. In medical terms, stress refers to the body's reaction to a difficult situation, such as severe anxiety when receiving an important e-mail or a phone call at an

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inappropriate time. Clinically, it refers to a psychological state of fear, severe anxiety, or distress that leads to physical and mental health problems. The most common physical problems associated with stress include weight loss, vascular disease, headaches, sleep problems, impaired immune function, and heart disease. In addition, stress can affect mental health and cause severe anxiety and depression.

Stress does not just affect a person's mental and physical well-being; it affects the wellbeing of a nation's population, which has an economic and social impact, so it is essential to recognize stress early on. In general, identifying the environment.

researchers to treat stress in its early stages, reduce the risk of chronic health conditions, and the ability to improve the quality of life. Thus, developing reliable early intervention strategies for stress detection shall involve lifestyle adjustments, behavioral interventions, and traditional targeted therapy

III. PROBLEM STATEMENT

This work used the dataset presented in [30] with prior permission. In [30], the study known as SWEET (stress in the work environment) was carried out on 1002 healthy adult volunteers (484 males and 451 females, in addition, of whom 76 volunteers did not fill out the questionnaires correctly) whose vital signs were monitored over five days a week (Thursday to Monday) for two years. The ages of the 1,002 volunteers ranged from 29.6 to 49.4. They work in 11 companies, some of which are in the public sector, some of which are banking and technology-oriented. The volunteers in this study conducted four psychological questionnaires to assess the level of general health, anxiety, basic stress, sleep, and depression. Vital signs collected were ST, SC, and ECG via two portable devices. Both were used to measure the 3D ACC signal, which is used to control motion artifacts and estimate the intensity of physical activity. The first of the two devices is a chest patch intended for measuring the ECG and ACC with a sampling rate of 256 and 32 Hz, respectively. The second wearable device is the imec's Chillband; this device is worn on the wrist and designed to measure SC, ST, and ACC and sampled at 256, 1, and 32 Hz, respectively. The experiment participants were instructed to wear the bracelet during the day and remove it at night. The chest patch is worn during the day and night. Additionally, participants were asked to take off the bracelet when showering and both devices when doing intense physical activity. This dataset contained physiological data and periodic questions indicating the most important aspects of daily life activities and consumption.

The smartphone application alerts the participants in the experiment twelve times a day to fill out questionnaires randomly so that

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the duration between the two consecutive questionnaires is approximately 30 minutes. The questionnaire consists of four brief questions. The first question is about emotional feelings related to stress, namely dominance, pleasure, and arousal (i.e., level of control). The second question was about the stress level on the 5-point Likert scale, and stress was not asked by choosing between three options: low, medium, and high stress.

2.1 EXISTING SYSTEM BLOCK DIAGRAM

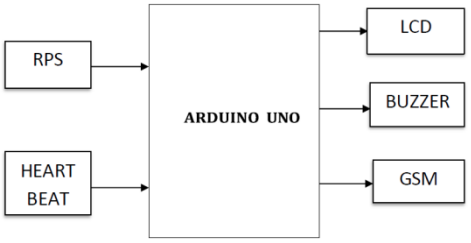


Fig 2.1 Block Diagram

2.4 Disadvantages of Existing System:

Imbalanced Datasets: Many existing systems struggle with imbalanced datasets, leading to inaccurate stress detection.

Limited Accuracy: The accuracy of stress detection models can be limited due to the imbalance in data and the variability in physiological responses.

Single-Modality: Many systems rely on a single type of sensor, which may not capture the full range of physiological responses to stress.

IV. PROPOSED SYSTEM

Overall, these findings suggest that the proposed SMA using wearable sensors and machine learning classifiers can be effective in detecting stress levels in humans. The random forest classifier in particular showed excellent performance in this study. However, further research is needed to validate these results on a larger dataset and to determine the applicability of this algorithm in real-world settings. Additionally, the use of other types of sensors, such as heart rate monitors and electro encephalo graphy (EEG) sensors, could be explored to improve the accuracy of stress level detection

4.1 BLOCK DIAGRAM OF PROPOSED SYSTEM

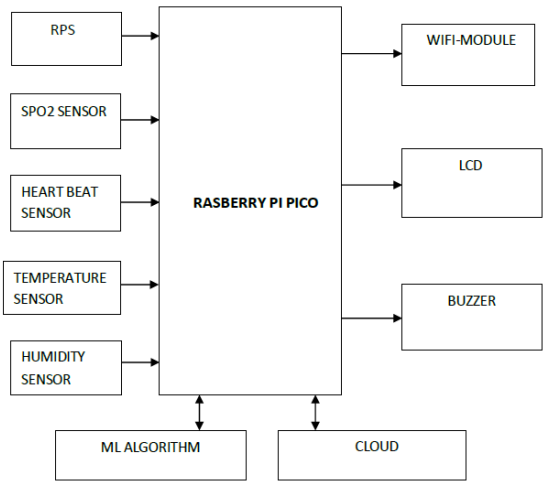


Fig 2.2 Block Diagram

V. BLOCK DIAGRAM OF PROPOSED SYSTEM

HARDWARE COMPONENTS

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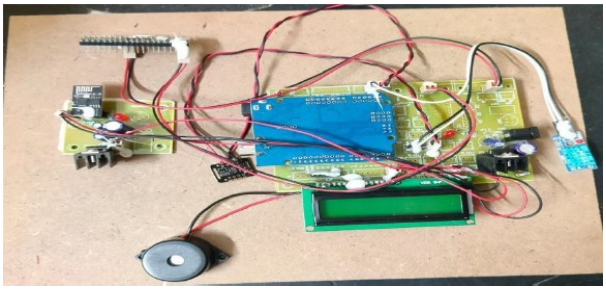
- Power Supply
- Raspberry Pi PICO
- Arduino UNO
- SPO2 Sensor
- Heartbeat Sensor
- Temperature Sensor
- Humidity Sensor
- Wi-Fi Module
- LCD
- Buzzer

SOFTWARE COMPONENTS

- Arduino IDE
- Proteus

VI. RESULT AND DISCUSSION

6.1 PROTOTYPE (THROUGH KIT



The first image displays the overall hardware setup of the psychological stress assessment project.It includes components like a microcontroller, sensors, LCD display, buzzer, and connecting wires

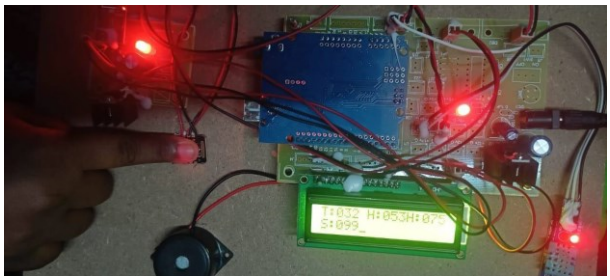


Fig : 6.1.b Working Condition of the project

The second image shows the project in its working state with power supplied. LEDs are glowing, and the sensor is actively responding to input. Real-time values such as temperature, heart rate, and Humidity, SPO2 are displayed on the LCD.

EXPERIMENTAL RESULTS

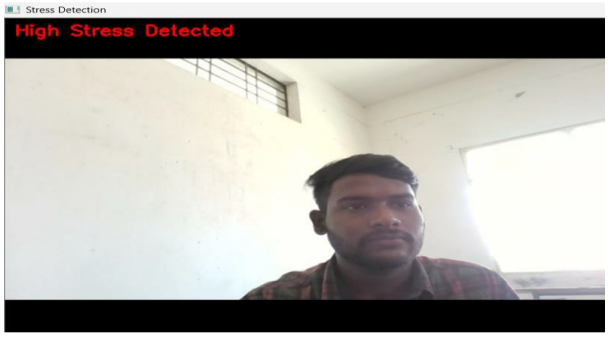


Person At Low Stress



PersonAt Medium Stress

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Person At High Stress

The three images show experimental results of stress detection using machine learning, identifying low, medium, and high stress levels in individuals.Each stress level is accurately classified and displayed on the screen based on the person's facial features and physiological data.

VII. CONCLUSION AND FUTURE SCOPE

We designed and implemented an ECG monitoring system based on cutting-edge IoT techniques. The architecture of the ECG monitoring system was presented at first. Typical ECG sensing networks including Wi-Fi, Bluetooth, and Zigbee were introduced and compared. Based on the proposed architecture, an IoT-based ECG monitoring system was implemented. Through a wearable monitoring node with three electrodes, real - time ECG signals can be collected with satisfactory accuracy. The gathered data were transmitted to the IoT cloud using Wi-Fi, which supports high data rates and wide coverage areas. The IoT cloud is responsible for visualizing the ECG data to users and storing these valuable data for further analysis, which is implemented on the basis of three servers, i.e., the HTTP server, MQTT server, and storage server.

VIII. FUTURE SCOPE

The future scope of machine learning-based assessment of mental stress using wearable sensors is vast. It includes real-time stress analysis with personalized relaxation techniques and continuous remote monitoring for timely mental health support. AI-powered assistants can provide stress management advice, while predictive algorithms detect and prevent mental health issues. In workplaces, stress analysis can help create healthier environments. Early diagnosis of anxiety and depression becomes possible through data analysis. Advanced sensors like EEG and ECG will improve detection accuracy. Enhanced data security with robust encryption will protect sensitive information. Additionally, lightweight and user-friendly wearable devices will enhance user experience. Continuous research will further refine machine learning models for improved accuracy and clinical reliability.

REFERENCE

1. Gedam S, Paul S. A Review on Mental Stress Detection Using Wearable Sensors and Machine Learning Techniques. IEEE Access. 2021;9: 84045–84066. https://doi.org/10.1109/ACCESS.2021.3085502. Mahesh B, Hassan T, Prassler E, Garbas JU. Requirements for a Reference Dataset for

ISSN 2319-5991 www.ijerst.com
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Multimodal Human Stress Detection. In: 2019 IEEE International Conference on Pervasive Computing and Communications Workshops (PerCom Workshops). IEEE; 2019. p. 492–498. https://doi.org/10.1109/PERCOMW.2019.8730884.

3. Zainudin Z, Hasan S, Shamsuddin SM, Argawal S. Stress Detection using Machine Learning and Deep Learning. Journal of Physics: Conference Series. 2021;1997(1): 012019. https://doi.org/10.1088/1742-6596/1997/1/012019.

4. Siam AI, Gamel SA, Talaat FM. Automatic stress detection in car drivers based on noninvasive physiological signals using machine learning techniques. Neural Computing and Applications. 2023 Jun;35(17):12891-904.

5. Jiménez-Mijangos LP, Rodríguez-Arce J, Martínez-Méndez R, Reyes-Lagos JJ. Advances and challenges in the detection of academic stress and anxiety in the classroom: A literature review and recommendations. Education and Information Technologies. 2023 Apr;28(4):3637-66.

6. Kadhim KT, Alsahlany AM, Wadi SM, Kadhum HT (2020) An overview of patient's health status monitoring system based on Internet of Things (IoT). Wirel Pers Commun 114(3):2235–2262

7. Mohammed CM, Askar S (2021) Machine learning for IoT healthcare applications: a review. Int J Sci Bus 5(3):42–51

8. Bolhasani H, Mohseni M, Rahmani AM (2021) Deep learning applications for IoT in health care: a systematic review. Inform Med Unlocked 23:100550

9. Chen Y, Shi P, Bai Y, Li J, Feng J, Sareh P (2023) Engineered origami crease perforations for optimal mechanical performance and fatigue life. Thin-Walled Struct 185:110572

10. Jalali E, Soltanizadeh H, Chen Y, Xie YM, Sareh P (2022) Selective hinge removal strategy for architecting hierarchical auxetic metamaterials. Commun Mater 3(1):97

11. Chen Y, Xu R, Lu C, Liu K, Feng J, Sareh P (2023) Multistability of the hexagonal origami hypar

12. based on group theory and symmetry breaking. Int J Mech Sci 247:108196