Journal of Electrical Engineering and Automation (ISSN: 2582-3051)
www.irojournals.com/iroeea/

Smart Thermal Regulation for Patient Care using Body Temperature and Room Temperature Monitoring

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Abstract

A speed control fan system has been designed to enhance the comfort level of patients and conserve energy. It is extremely helpful for those patients who may not be able to shift their positions, as it continues to monitor the body temperature of the patient along with the room temperature continuously. The fan itself automatically changes speed using sensors and PWM technology, leaving the user with no work to manually do so. The fan speed is modulated by temperature in a linear and accurate way, as determined by testing with Tinkercad simulations. A manual override through a potentiometer can be used if needed, and an LCD display using an I2C adapter provides for the ability to monitor system activity. Other enhancements to improve the system further involve more advanced control algorithms, integration with wearable technology for enhanced temperature sensing, and remote control and monitoring.

Keywords: Automated fan speed control, NTC thermistor, DHT11 sensor, energy optimization, patient comfort.

.DOI: https://doi.org/10.36548/jeea.2025.3.001
Received: 06.06.2025, received in revised form: 10.07.2025, accepted: 29.07.2025, published: 12.08.2025

1. Introduction

Temperature control is a key feature of healthcare buildings, and the ideal thermal condition must be achieved to ensure patient comfort and recovery. Traditional cooling equipment has proven difficult for patients, particularly those with mobility problems, to adapt to, causing discomfort as well as possible effects on health. Manual fan adjustment is not feasible in hospitals or care homes since it would require permanent adjustments whenever there is a change in temperature. Additionally, suboptimal cooling systems increase energy consumption, thus raising operating costs in the healthcare environment. There is a significant disadvantage to not having an adaptive and automatic temperature control system in terms of consistently maintaining thermal comfort among patients. To overcomes this drawback, this project suggests an automated learning-based fan speed control system with the ability to learn airflow based on real-time body temperature and room temperature. By continuously observing temperature changes the system eliminates the need for increased fan speed when temperatures rise and decreases cooling when temperatures drop. The automation reduces manual calibration to a minimum, which is especially helpful for patients with mobility problems or intensive care.

2. Literature Survey

Smart monitoring technologies and personal thermal comfort wearable technologies have received significant attention due to their potential to bring health, safety, and sustainability advantages. Čulić et al. [1] consolidated various monitoring systems, emphasizing advances in sensor technology, data analysis, and adaptive control to enable customized thermal comfort across various settings. In medicine, Rdhaiwi et al. [2] employed machine learning and temperature sensors to regulate thermal suits in operating rooms for enhanced patient safety and surgeon comfort. Beyond the clinic, Zuo et al. [3] explored smart textiles and fibers designed for thermal management wearables, enabling adaptive response to fluctuating environmental conditions

. Similarly, Kim et al. [4] demonstrated the feasibility of skin temperature-sensing smart patches, demonstrating their stability in chronic health monitoring. Fang et al. [5] and Wang et al. [6] showed the use of smart textiles for personalized thermoregulation and overall health care, integrating sensing, heating, and cooling ability into light and porous fabrics. Translating the principles into home use, Wang et al. [7] reviewed unobtrusive health monitoring in smart homes, where comfort optimization involves thermal sensing. Bai et al. [8] reported self-powered wearable electronics based on gel thermogalvanic electrolytes for health monitoring and addressing energy sustainability challenges. Xu et al. [9] designed robust and breathable fabrics that can function as multifunctional sensors and heaters, connecting comfort and functionality. Tat et al. [10] further explained the potential of smart textiles in promoting health and environmental sustainability, particularly through the use of recyclable and eco-friendly materials. Overall, these research studies show that the integration of smart materials, embedded sensing, and adaptive control systems can create holistic solutions for individualized thermal comfort and health management.

3. Methodology

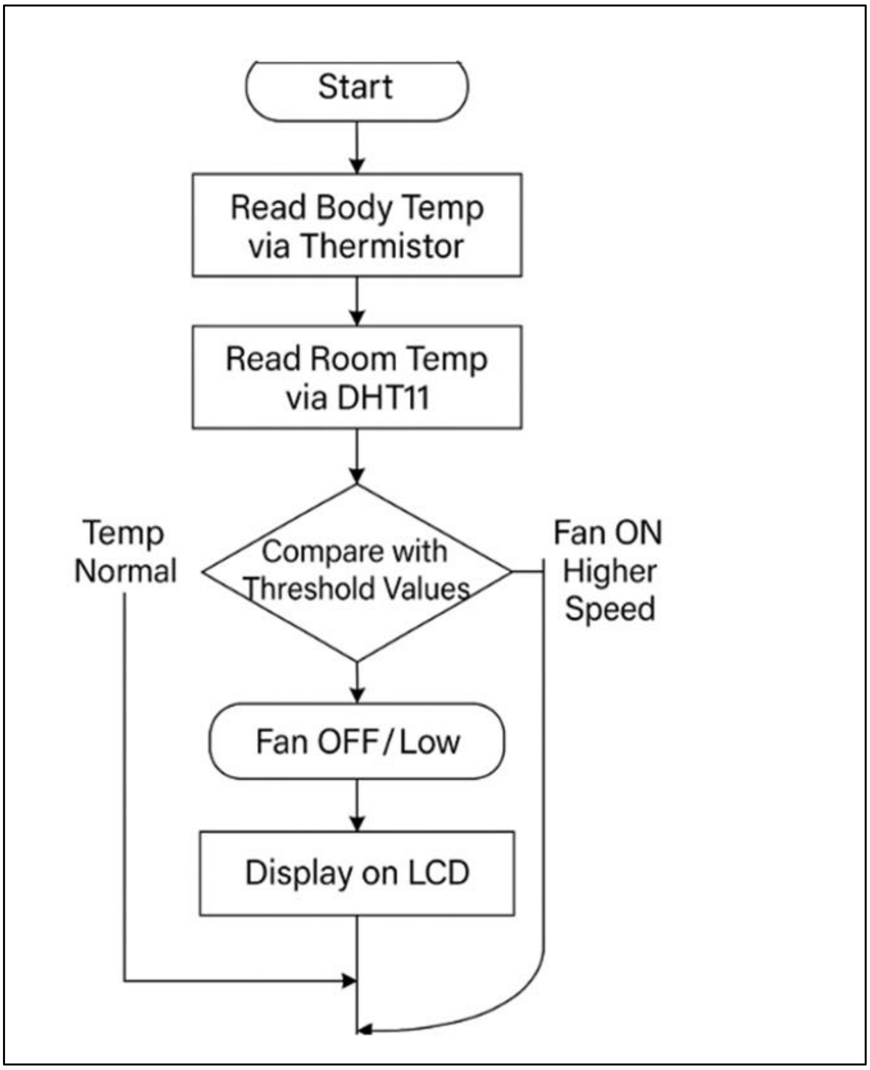

Figure 1. Workflow of the Proposed Method

Effective demonstration was made of the system's ability to automatically adjust fan speed in response to changes in body and ambient temperature. The fan speed increased linearly as the patient's simulated body temperature rose, demonstrating flawless PWM control. In order to increase the accuracy of the room temperature, data obtained from the DHT11 sensor, ambient variables were also incorporated. Real-time temperature and fan speed updates were shown on the 16x2 LCD, and the contrast was adjusted for visibility using a potentiometer. The device can be utilized by anyone with mobility problems because the simulation demonstrated that no human involvement was required. The outcomes, which demonstrated increased automation, power efficiency, and patient comfort, significantly supported the viability of the design in the medical field. Figure 1 illustrates the workflow of the proposed approach.

4. Proposed System

An intelligent fan speed control system is used in the suggested method to automatically adjust airflow in response to real-time body temperature and room temperature readings. To keep patients comfortable in medical settings, the system continuously tracks temperature changes, analyzes the data, and modifies the fan speed accordingly.

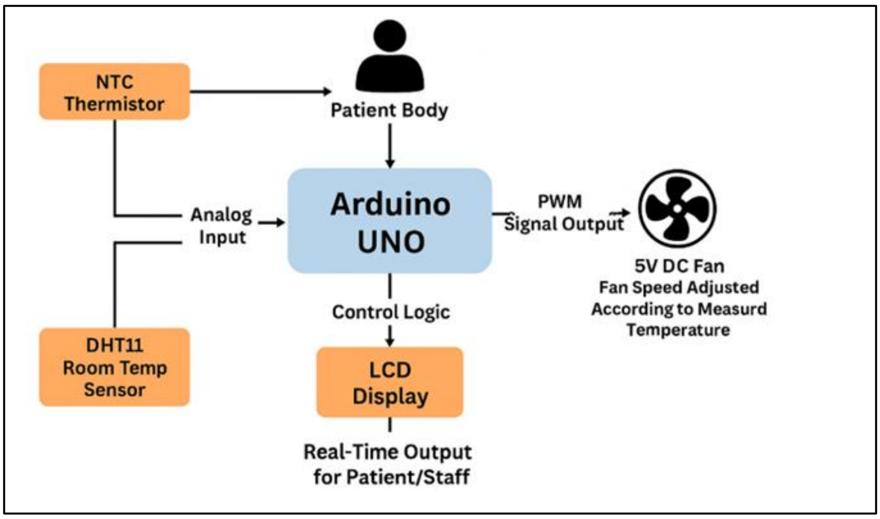

Figure 2. System Architecture

The suggested system's architecture is shown in Figure 2.

Temperature Monitoring Phase: The temperature of the patient is measured using a temperature sensor, while the surrounding temperature is measured by a room temperature sensor. These readings are constantly gathered and examined. The collected temperature values are compared with predetermined threshold levels by the system during data processing and decision-making. The fan speed rises in proportion to the temperature if it is over the threshold; if it stays within a suitable range, the fan speed falls or stays off to save energy. By doing this, a cooling system that is appropriate for the situation is guaranteed.

Fan Speed Management and Operation: Pulse width modulation (PWM) is used by the system to dynamically adjust the fan speed based on temperature data. The fan speed lowers when conditions are stable and increases when additional cooling is required. For patients with limited mobility, the efficiency and automation of this system eliminate the need for manual adjustments. Additionally, by reducing unnecessary power usage, the device promotes energy efficiency by only activating the fan when necessary.

5. Block Diagram

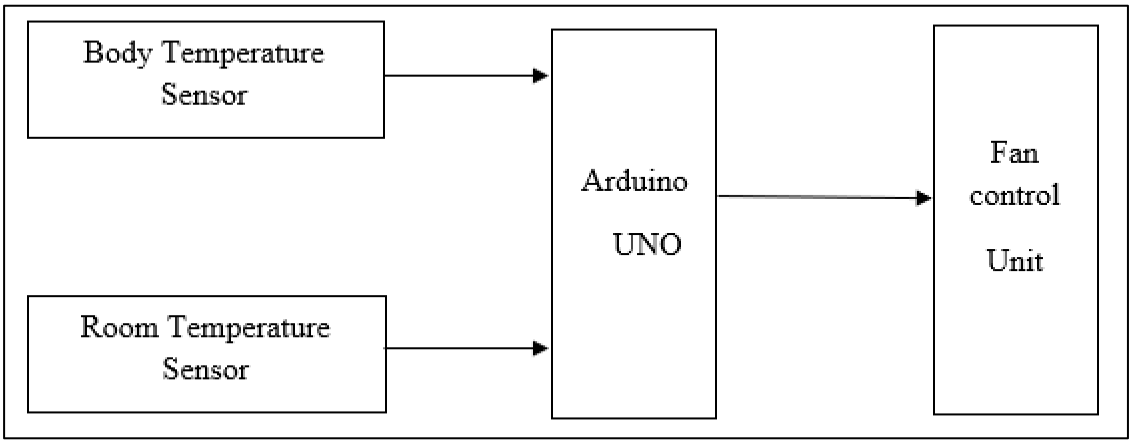

Figure 3. Block Diagram of the Proposed System

The hardware and software components used are summarized below:

5.1 Arduino UNO

The ATmega328P is the foundation of the Arduino UNO, an open-source microcontroller board frequently used in automation and embedded systems projects. It runs at 5V, has six analog inputs, fourteen digital I/O pins, and supports PWM, I2C, and SPI communication. Programming is done using the Arduino IDE with C/C++, and it can be powered via USB or an external adapter. Because it is inexpensive, versatile, and simple to use, it is ideal for applications in robotics, automation, healthcare, and the Internet of Things.

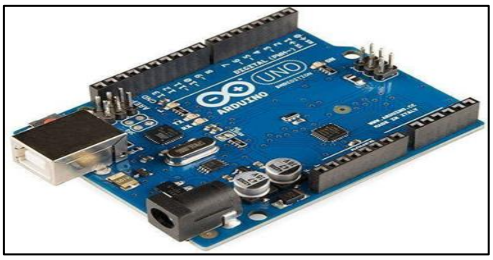

Figure 4. Arduino UNO

5.2 DHT11 Sensor

The DHT11 is a well-liked, reasonably priced temperature and humidity sensor for automation and weather monitoring applications. It generates digital output with minimal power consumption. The sensor measures humidity (20–90% RH, ±5% accuracy) and temperature (0–50°C, ±2°C accuracy) using a thermistor and a capacitive humidity sensor. Because it uses a single-wire data interface to connect to microcontrollers like Arduino, it is simple to use and efficient for environmental sensing applications.

Figure 5. DHT11 Sensor

5.3 Resistor

One passive electrical component that divides voltage and limits current flow in a circuit is a resistor. You use 10KΩ resistors in your project as pull-up/pull-down resistors to stabilize sensor readings, especially for the thermistor in a circuit with a voltage divider. They help convert the thermistor's change in resistance into a voltage signal that the microcontroller can interpret. Resistors are also used in applications that limit current, including protecting

LEDs from high current. For accurate sensor readings and safe circuit operation, they are essential.

Figure 6. Resistor

5.4 Thermistor Sensor

A temperature-sensitive resistor, the 10K thermistor adjusts its resistance in response to changes in temperature. Usually, it is a Negative Temperature Coefficient (NTC) thermistor, which means that as the temperature rises, its resistance falls. It has an exponential resistance-temperature relationship and has a resistance of 10KΩ at 25°C. Because of their high accuracy, quick response, and affordability, thermistors are frequently used in medical applications, temperature sensing, and fan control. A straightforward voltage divider circuit makes it simple to interface them with Arduino and microcontrollers.

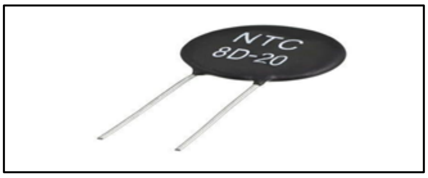

Figure 7. Thermistor Sensor

5.5 DC Fan

A 5V DC fan is a small, effective cooling tool that is frequently used in electronics and embedded systems projects. Because of its low power consumption, it is perfect for microcontroller-based applications involving temperature control. To ensure maximum comfort, the fan in your project modifies its speed in response to readings of body and ambient temperatures. For smooth speed variation, Pulse Width Modulation (PWM) can be used to control it. A MOSFET or motor driver can be used for effective operation if a higher current is needed. For automated cooling systems, the 5V DC fan offers a dependable and cost-effective solution.

Figure 8. DC Fan

5.6 LCD Display

The 16x2 LCD display, which can display two lines of 16 characters each, is a common module for displaying real-time data in embedded projects. It is powered by 5V and may be more readily connected to microcontrollers such as the Arduino UNO via an I2C adapter or a parallel (4-bit or 8-bit) interface. The display is commonly used in projects to show temperature measurements, fan speed, and system status in order to enhance user involvement. The 16x2 LCD's low power consumption and excellent visibility make it a popular choice for real-time monitoring applications.

Figure 9. LCD Display

5.7 I2C

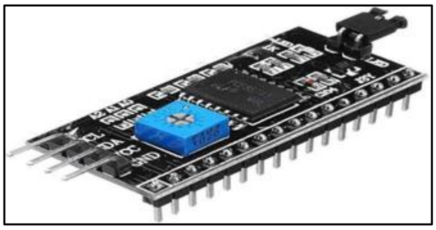

Figure 10. I2C

Multiple devices can be connected with little wiring by using the two-wire communication protocol known as I2C (Inter-Integrated Circuit). Its SDA (Serial Data) and

SCL (Serial Clock) lines allow microcontrollers and peripherals like sensors, LCDs (with an I2C adapter), and OLED screens to transfer data efficiently.

5.8 Potentiometer

A potentiometer is a type of variable resistor that can be used to manually adjust resistance, which makes it helpful for regulating circuit voltage levels. One of its three terminals is connected to the power source, the other to ground, and the middle terminal offers a voltage output that can be adjusted. The fan speed, temperature thresholds for the thermistor or DHT11 sensor, and contrast of a 16x2 LCD display can all be manually adjusted in this project using a potentiometer. Turning the knob causes the resistance to change, which alters the output voltage and affects how the circuit behaves.

Figure 11. Potentiometer

5.9 Arduino IDE

The tool employed for this project was the Arduino Integrated Development Environment (IDE), a free platform that allows one to program Arduino boards using a basic version of C/C++. The Arduino IDE provides an easy-to-use interface with capabilities for code editing, syntax highlighting, error checking, and a serial monitor built in for real-time data monitoring and debugging. In this project, the IDE was used to program and upload the code onto the Arduino UNO to integrate a thermistor and DHT11 sensor to sense body and room temperatures, respectively. Depending on these sensor values, control logic was implemented to automatically regulate the fan speed. The serial monitor was especially handy for calibration and testing, as it permitted real-time observation of fan control behavior and sensor data, which facilitated the process of development and troubleshooting.

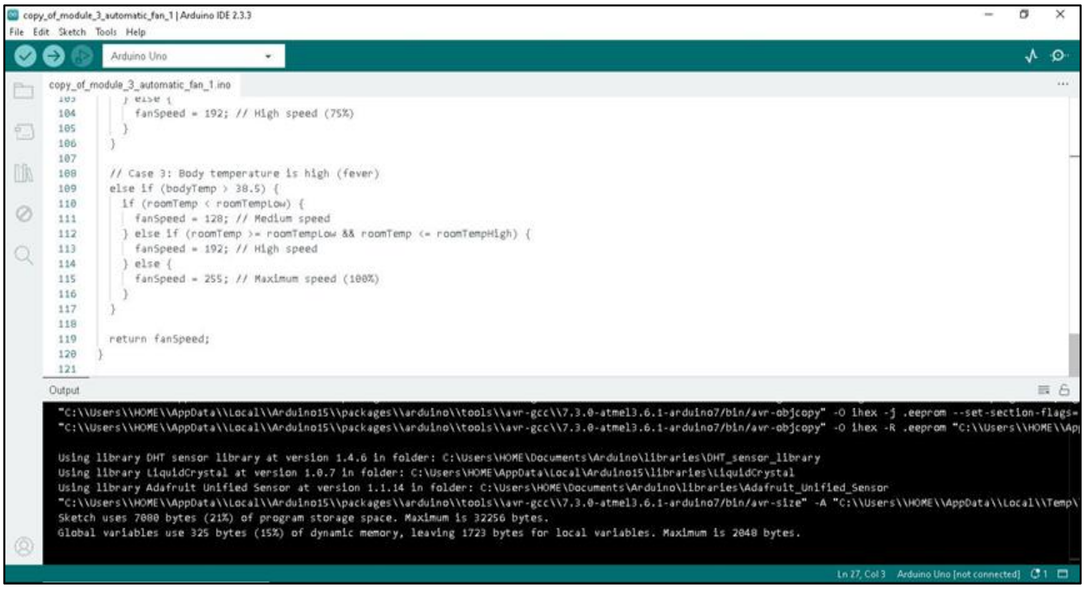

Figure 12. Arduino IDE

6. Simulation and Results

Simulation: The simulation of the fan speed control system was carried out using Tinkercad, which is a web-based simulation software that supports Arduino-based virtual circuits. The simulation was used to test the logic and functionality of the system prior to its physical implementation. In the Tinkercad, environment, virtual components like the DHT11 sensor, 10K thermistor, PWM-controlled 5V DC fan, 16x2 I2C LCD, and potentiometer were selected and implemented in a simulated Arduino UNO. The software written in the Arduino Integrated Development Environment was transferred to the virtual board, facilitating real-time simulation of temperatures and fan response. This made it possible for debugging and performance optimization in a secure, economical virtual environment. Visual feedback on temperature readings and fan speed was provided by the LCD display and serial monitor in Tinkercad, verifying appropriate system response to different temperature levels. Figure 13 shows the simulation diagram of the proposed work.

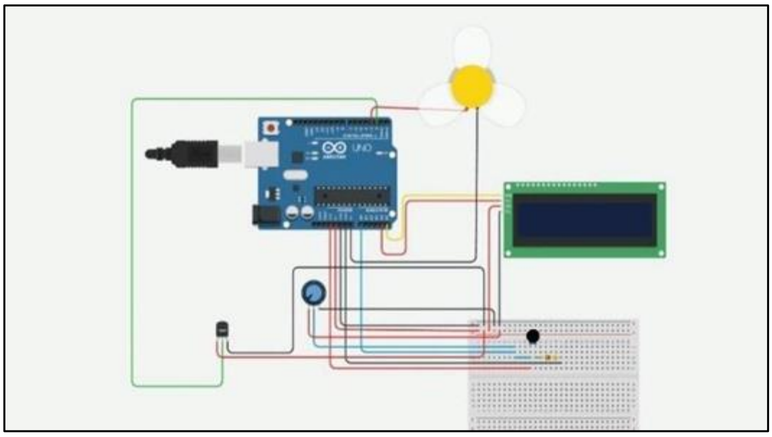

Figure 13. Simulation diagram

Results and Observation: The system successfully demonstrated its capacity to automatically control fan speed according to changes in body and room temperatures. The fan speed responded in proportion as the patient's simulated body temperature increased, demonstrating smooth execution of PWM control. The DHT11 sensor-measured room temperature further contributed to environmental conditions for precise adjustment. The 16x2 LCD displayed live updates of temperature readings and fan speed, while the potentiometer was provided to make contrast adjustments for visibility. The simulation ensured that the system did not need manual input, making it suitable for patients with mobility issues. Overall, the outcomes confirmed the practicality of the design in medical environments, indicating increased patient comfort, automation, and power efficiency. Figure 14 shows the hardware setup of the proposed model.

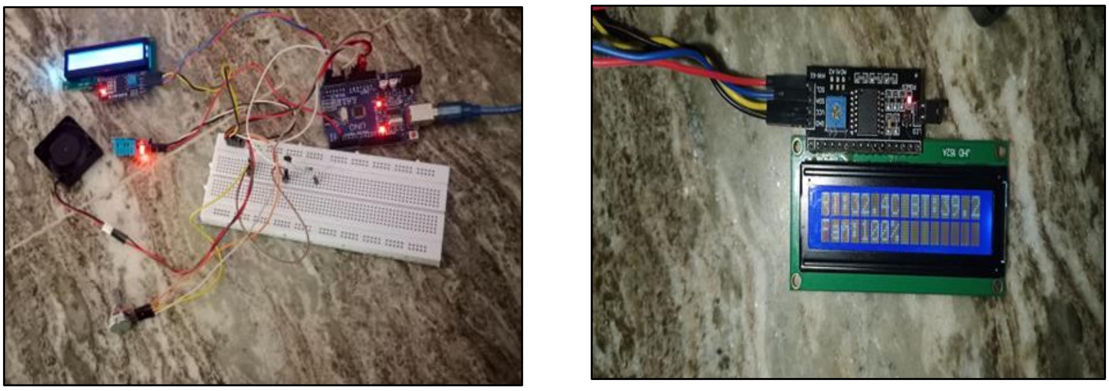

Figure 14. Developed Hardware Setup

ISSN: 2582-3051

7. Conclusion

The project effectively deployed an automatic fan speed control system based on patient body temperature and room temperature for comfortable and energy-saving purposes. By using sensors to monitor temperature in real time and employing PWM control to vary fan speed, the system avoids the need for manual operation, making it particularly useful for people with mobility constraints. The simulation in Tinkercad validated the precision and efficiency of the system, exhibiting smooth fan speed control with respect to temperature changes. The LCD display with an I2C adapter provided good real-time feedback, with a potentiometer enabling manual tuning where needed. The project not only increases patient comfort but also maximizes energy efficiency by operating the fan only when required. Future developments may involve incorporating wireless connectivity for remote monitoring, wearable sensors for improved body temperature sensing, and an adaptive control algorithm for improved efficiency.

References

[1] Čulić, Ana, Sandro Nižetić, Petar Šolić, Toni Perković, and Velimir Čongradac. "Smart monitoring technologies for personal thermal comfort: A review." Journal of Cleaner Production 312 (2021): 127685.

[2] Rdhaiwi, Hassan Flaeh, Ahmed Rashid Ajel, and Saleem Lateef Mohammed. "Regulating A Thermal Suit Inside the Operating Room-Based Machine Learning Algorithms Using Temperature Sensors." In 2024 IEEE 12th Conference on Systems, Process & Control (ICSPC), IEEE, (2024): 101-106.

[3] Zuo, Xingwei, Xueji Zhang, Lijun Qu, and Jinlei Miao. "Smart fibers and textiles for personal thermal management in emerging wearable applications." Advanced Materials Technologies 8, no. 6 (2023): 2201137.

[4] Kim, Heejung, Sunkook Kim, Mingoo Lee, Yumie Rhee, Sungho Lee, Yi-Rang Jeong, Sunju Kang, Muhammad Naqi, and Soyun Hong. "Smart patch for skin temperature: Preliminary study to evaluate psychometrics and feasibility." Sensors 21, no. 5 (2021): 1855.

[5] Fang, Yunsheng, Guorui Chen, Michael Bick, and Jun Chen. "Smart textiles for personalized thermoregulation." Chemical Society Reviews 50, no. 17 (2021): 9357-9374.

[6] Wang, Huimin, Yong Zhang, Xiaoping Liang, and Yingying Zhang. "Smart fibers and textiles for personal health management." ACS nano 15, no. 8 (2021): 12497-12508.

[7] Wang, Ju, Nicolai Spicher, Joana M. Warnecke, Mostafa Haghi, Jonas Schwartze, and Thomas M. Deserno. "Unobtrusive health monitoring in private spaces: The smart home." Sensors 21, no. 3 (2021): 864.

[8] Bai, Chenhui, Zhaosu Wang, Shuai Yang, Xiaojing Cui, Xuebiao Li, Yifan Yin, Min Zhang et al. "Wearable electronics based on the gel thermogalvanic electrolyte for self-powered human health monitoring." ACS Applied Materials & Interfaces 13, no. 31 (2021): 37316-37322.

[9] Xu, Dewen, Zhaofeng Ouyang, Yanjuan Dong, Hou-Yong Yu, Shuang Zheng, Shenghong Li, and Kam Chiu Tam. "Robust, breathable and flexible smart textiles as multifunctional sensor and heater for personal health management." Advanced Fiber Materials 5, no. 1 (2023): 282-295.

[10] Tat, Trinny, Guorui Chen, Xun Zhao, Yihao Zhou, Jing Xu, and Jun Chen. "Smart textiles for healthcare and sustainability." ACS nano 16, no. 9 (2022): 13301-13313