ELEKTRONICA: *IAF PROJECT*

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ABSTRACT The Frostbite Detection Sock is an innovative wearable technology that continuously monitors the temperature of the feet in real time, providing early detection of potential frostbite in extremely cold environments.
Frostbite occurs when skin and underlying tissues freeze due to prolonged exposure to extreme cold, leading to reduced blood flow and tissue damage. If untreated, frostbite can result in permanent tissue loss, nerve damage, and in severe cases, amputation.

This advanced sock is equipped with strategically placed temperature sensors that accurately measure the skin temperature, allowing for the timely identification of any significant temperature drops that may signal the onset of frostbite. The data collected by the sensors is swiftly processed by a microcontroller, which promptly triggers an alert when the temperature falls below a specified threshold, alerting the user to take necessary preventive measures.
This innovative project primarily aims to address the critical issue of frostbite and its profound impact on soldiers stationed in the frigid climate of the Siachen area, where temperatures can plummet to a hazardous -40 degrees Celsius.

We aim to design a sock that is lightweight, comfortable, and designed to function reliably in harsh conditions, making it a practical and user-friendly solution for cold weather safety.

BACKGROUND

The implementation of this involves a Socks-type design which serves as a wearable that is equipped with sensors. We aim to keep this as thin as possible; perhaps less than 1 cm thick to ensure comfort as well as functionality.

MODALITIES OF SENSING

Monitoring skin temperature is crucial in the early detection of frostbite. Temperature sensors embedded in socks will continuously measure the surface temperature of the skin. For doing so, they need to be in contact with skin. A drop in skin temperature below critical thresholds indicates the risk of frostbite. Reduced blood flow to extremities is one of the primary physiological responses leading to frostbite.

There are two commonly used blood flow sensors : photoplethysmography (PPG) sensors and SpO2 (oxygen saturation) sensors.
They can measure changes in blood volume and change in oxygen levels in blood by using principles of light absorption. If blood flow or oxygen levels are too low for an extended period, it can trigger warnings and initiate corrective actions, such as activating heating elements.

A heating element can be incorporated as a preventive measure for frostbite. The heating element can generate warmth to maintain skin temperature within a safe range.

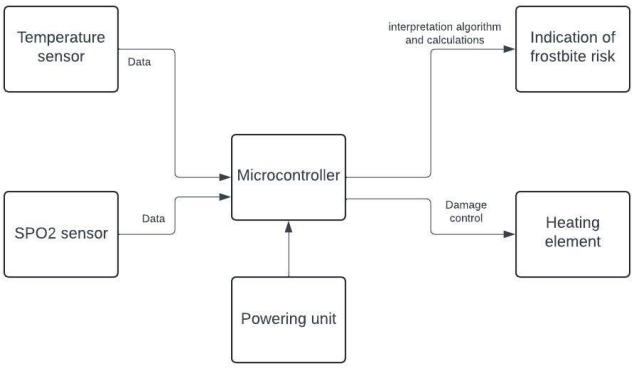

FIGURE 1. Block diagram representation of the systematic operation of the project.

The heat output is dynamically controlled based on real-time skin temperature readings, ensuring that localized warmth is provided as needed without overheating the area.

To provide a comprehensive solution for frostbite detection and prevention, it's essential to monitor a soldier's overall vital signs. information is processed by a microcontroller.

SENSORS

There are a lot of temperature sensors in the market, we need to select the one that can withstand extreme low temperatures and can give accurate temperature measurement. To figure that out we bought 3 temperature sensors with different properties.

To understand the temperature sensor's characteristics even better, we will test these sensors in cold environments on a vegetable. This will help us gain a better understanding of functionality of each of the 3 sensors.

SENSOR 1

A PT100 sensor, or platinum resistance temperature detector (RTD), works by measuring the electrical resistance of a platinum wire and converting that resistance to a temperature reading.
It has an accuracy of $\frac{1}{3}$B CLASS and the operating temperature range is -50°C to +250°C,

Cable and Probe Length are in order of a couple of millimeters. This ensures that the circuit does not create any stress or pressure to the skin. It has a quick response time.

SENSOR 2

NTC is a thermistor that works on the principle of the behavior of semiconductor materials.The charge carriers increase with rising temperature leading to decreased resistance.
It has a tolerance of 0.5°C and the operating temperature range is -40°C to +125°C.
It has a quick response time of 2 seconds.
It is known to provide stable readings for a very long period.

SENSOR 3

The 10K3A1I Series II Thermistor is an NTC type temperature sensor. It has two leads for connecting to a circuit, and its resistance change can be measured to determine the corresponding temperature.
This small and compact sensor has a minimum operating temperature of -40 degrees Celsius which should theoretically work well in cold conditions.

NEXT PLAN OF ACTION

We are working on implementing a heating element into the sock as an additional preventive measure. We are researching optimal materials that are thin, lightweight, and can evenly distribute heat.

We plan to implement algorithms that help customize a sock to a particular person. This customization ensures optimal comfort, thermal regulation, and performance, adapting to the wearer's specific needs and environmental conditions.

For powering the system, we plan to implement piezoelectric materials which convert variation in pressure to voltage difference. This can be used along with batteries.

In order to prevent incorrect readings, it is important to insulate the batteries and other components of the circuit, with the exception of the sensors.

To improve the efficiency and for further optimization, we are exploring the potential of utilizing printed electronics for further optimization.

REFERENCES

PT100 sensor
10K3A1I Series II Thermistor