Development of Core Body Temperature Monitoring System for Injection Devices

Degree programme: BSc in Mechatronics and Systems Engineering (Medical technology | Robotics)
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Accurate monitoring of core body temperature is crucial for effective treatment and managing various health conditions. However, current methods are often inconvenient. This project aims to integrate a sensor system into an injection device to provide a reliable non-invasive core body temperature measurement method.

Introduction

The main challenge of this project is to incorporate a sensor system into an injection device that can accurately measure core body temperature without compromising the patient's comfort. Achieving this integration would enhance various medical applications, improving overall treatment effectiveness.

Goals

The system should measure core body temperature during two phases:

- Outside active injection: Verify if the patient has a fever and issue a warning accordingly
- During injection: Measure core body temperature continuously

Methods

An initial analysis identified the most suitable sensor system to be integrated into the injection device. This involved preliminary research into current technologies and their medical applications.
For pre-injection measurement, an infrared sensor (2) that detects radiation emitted by the skin was chosen. During the injection, an NTC sensor (3) was chosen for its cost-effectiveness, accuracy, and quick response, accompanied by a heart rate sensor (1).

Each sensor was tested and validated against reference devices for accuracy and reliability. The NTC sensor was evaluated in a temperature-controlled chamber, the infrared sensor was validated against a thermal imaging camera, and the heart rate sensor readings were compared with a real-time pulse oximeter.

Results

In the pre-injection phase, a precise infrared sensor is integrated into the top of the device to measure forehead values, ensuring the patient can proceed with the injection. During the injection phase, a heart rate sensor measures from the index finger, while an NTC sensor measures skin temperature from the palm. The palm was chosen because of significant blood vessels and for patient comfort. All components are integrated into a compact and space-optimized PCB. The NTC sensor showed rapid thermal response but was affected by skin heat and environmental factors in long-term readings. The infrared sensor provided accurate readings, and the heart rate sensor reliably measured changes in blood flow, although motion artefacts compromised its accuracy.

Outlook

As heart rate and skin temperature can be used to predict core body temperature, an important next step would be to implement a prediction filter based on a mathematical model, such as a Kalman filter. This will allow a patient-specific prediction of core body temperature during injection.

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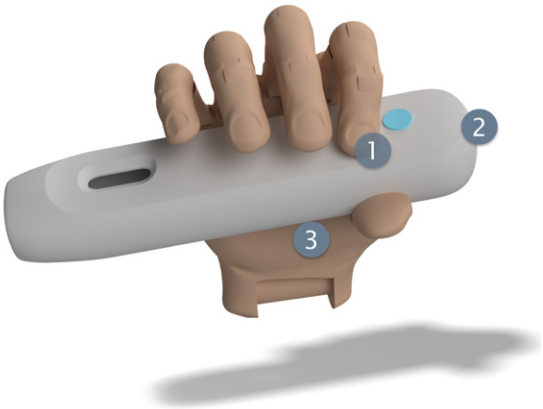

Figure 1: Overview of the injection device system.