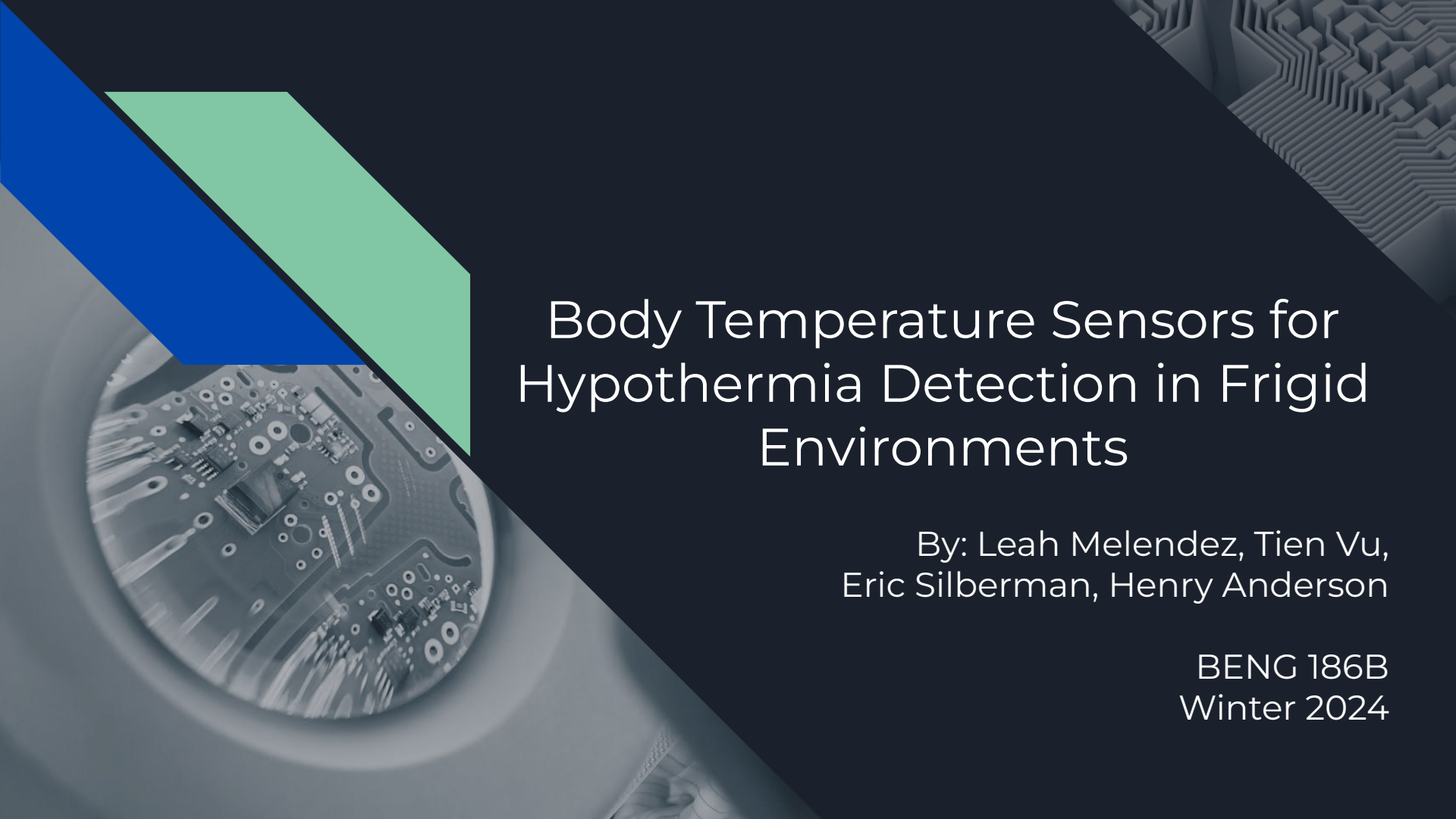

Body Temperature Sensors for Hypothermia Detection in Frigid Environments

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Introduction

- **Hypothermia** is a medical emergency when the human body begins to lose heat faster than it is produced.
  - Examples of professions at high risk of hypothermia include divers, mountain climbers, snow athletes, etc.

- Bodily extremities are the first to lose blood flow due to prolonged exposure to the cold. This is to increase blood flow to, and sustain, more important organs.
  - This can lead to frostbite and possible loss of limbs

Design Motivation

Ensuring the protection of extremities while preserving necessary movement and dexterity proves to be a significant challenge.

Hypothermia can cause extreme discomfort and, in rare instances, can even culminate in injury.

Addressing this issue is crucial for the safety and effectiveness of potentially affected groups, highlighting the need for advancements in **protective gear**.

Our Solution: Smart Gloves/Socks

01

Measure Extremities with Wearable Gloves and Socks

- Wearable sensors which detect temperature on each finger and toe

02

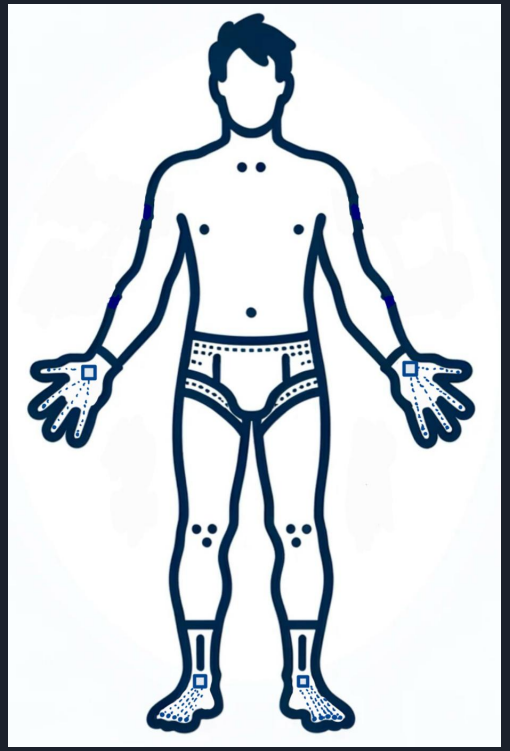
Microcontroller Processing on Each Hand and Foot

- Inputs: Sensors from extremities (fingers, toes)
- Outputs: Heating Pads

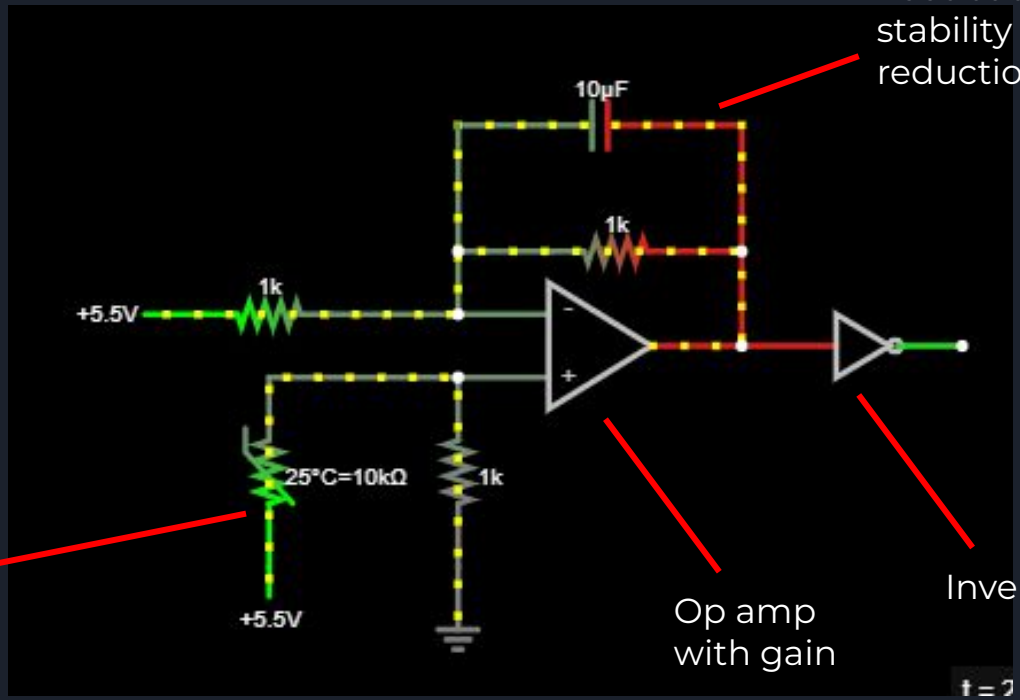
03

Heating Pads on Extremities with Low Temperature

- Based on MC, turn on or off



Part 1: Temperature Sensing Circuit for Extremities



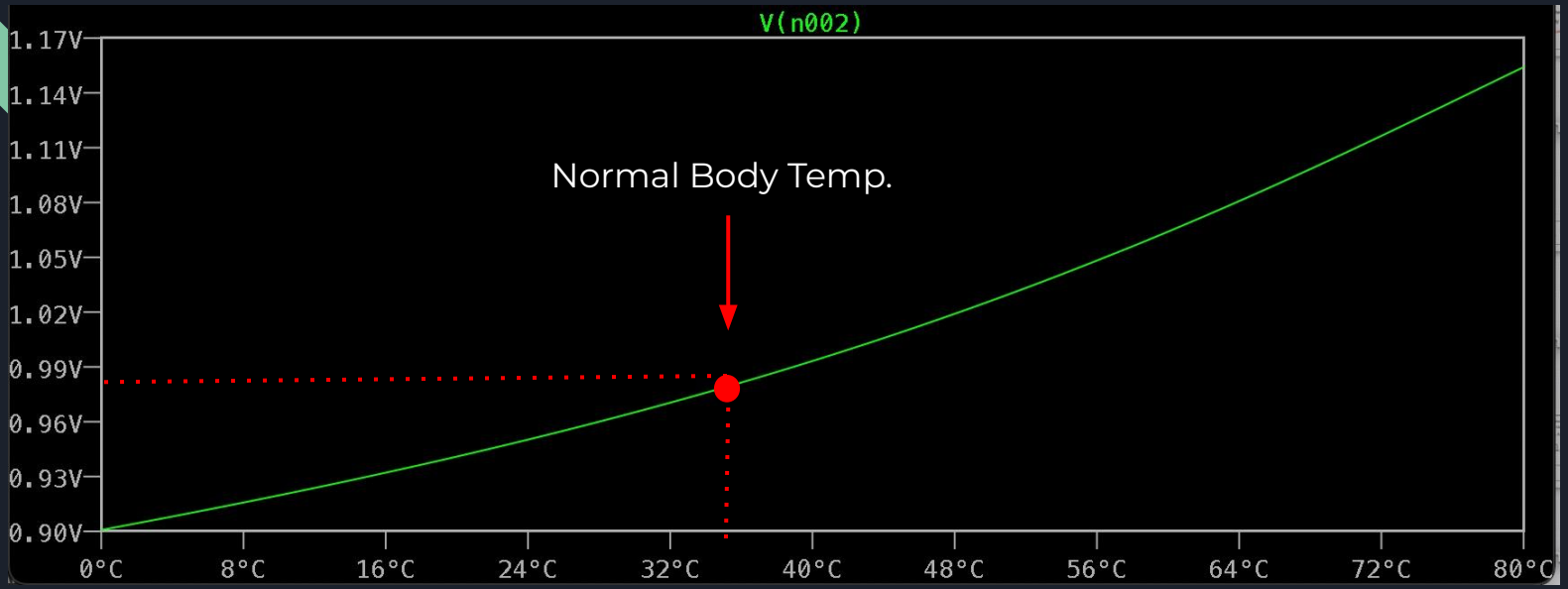
Feedback capacitor for stability and noise reduction

NTC Thermistor: as temperature increases, resistance decreases

Op amp with gain

Inverter

Preliminary Circuit Simulation: Vout vs Temperature



- Approximately linear relationship between Vout and temperature
- Microcontroller will keep pulling values from the sensor until it identifies the right threshold voltage/temp. associated with the red marker above that will force the heating pad to turn off because the body temperature is normal again

NOTE: Still working on simulation and getting desired voltages

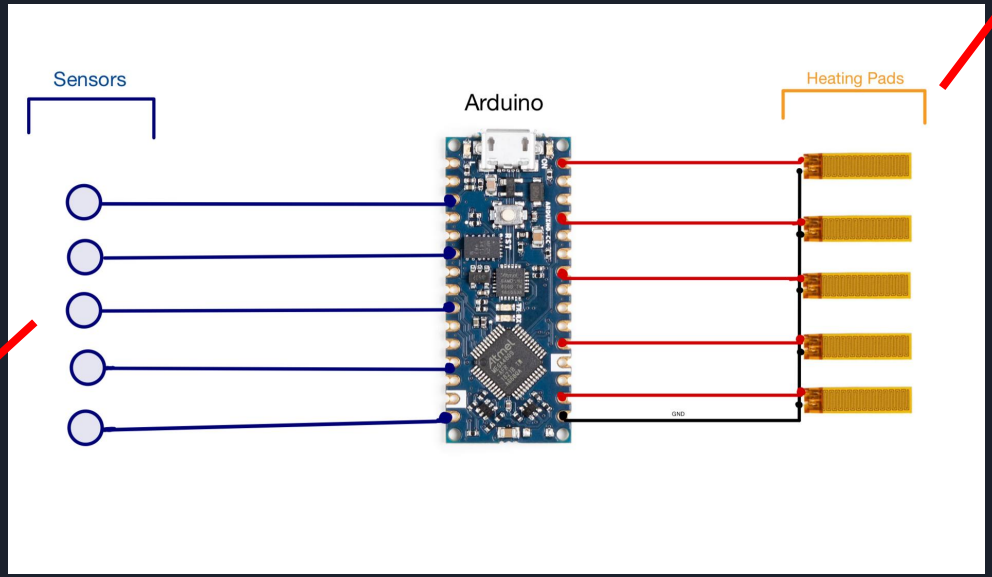
Part 2: Microcontroller Processing **Pseudo Code**

```
//Define Variables
  // Inputs Include 5 Temperature Sensors
  input1 = extremity(1);
  input2 = extremity(2);
  input3 = extremity(3);
  input4 = extremity(4);
  input5 = extremity(5);
  // Outputs for Each Indidvidual Heating Pad
  output1 = extremityPad(1);
  output2 = extremityPad(2);
  output3 = extremityPad(3);
  output4 = extremityPad(4);
  output5 = extremityPad(5);
  //Threshold for hypothermia - 35 C
  threshold  = 35;

//Check for each input X = {1, 2, 3, 4, 5)
for(int X = 1; X <= 5; X++){
  //If below threshold
  if(inputX < threshold)
  {
    //Heating Pad ON unitil temperature back to normal
    while(inputX < threshold){
      outputX = 1;
    }
    outputX = 0;
  }
  else{
    //Output should be 0 if conditions are not satified
    output = 0;
  }
}
```

Part 3: Heating Pads

Arduino sends a **ON/OFF** signal to heating pads



5 sensors inputs per finger/toe; each corresponds to its own heating pad

- Heating pads are turned ON/OFF based on the temperature sensor reading. If the value falls below 35 degrees celsius by a significant amount, the heading pad will be ON until the sensor outputs a temp value within a normal body temperature range (about 35 degrees celsius) => heating pads will be OFF.

Limitations

- Expenses
  - Heating and complex controls can be very expensive
- Electrical Noise
  - Physical movement or vibrations can cause disturbance in the sensors accuracy and cause heating to malfunction
- Pressure
  - High Pressure can decrease battery life as well as affect accuracy of sensors
- Battery Size
- Reliability
  - No backup/failsafe
- Safety
  - If sensors are not accurate fingers or toes may overheat

Advantages

- Versatility & Adaptability
  - Applications: work, extreme sports, cold living environments
  - Gloves and Socks allow easy application and removal
- Safety
  - Decreased risk of hypothermia
  - Constant body temperature monitoring
- Customization
  - Adjustable Temperature Thresholds
- Integration w/ Smart Devices
  - Wireless/Bluetooth, Smartphone Monitoring

Future Challenges

1. Implement back ups in case of:
   - Sensor malfunction
   - Microcontroller malfunction
   - Heating Pad malfunction
2. Consider battery usage
   - Powers Extended usage
   - Easy Recharge
3. Water/Waterproofing
   - Increases Adaptability/Applications
4. Heating Pad
   - Instead of ON/OFF, have a range(1-10)
5. Determining Spatial Thermal Profile
6. Shock Protection Circuit

} → Based on presentation feedback. Still figuring out how to incorporate in final version.

Conclusion

- Overall, Body Temperature Regulating Gloves and Socks provide hope to decrease cases of hypothermia amongst individuals. Though there are limitations, advanced sensors and microcontrols create effective heating. Individuals no longer have to worry about the risk of hypothermia and instead are able to stay cool and comfortable while enjoying their sports or activities.

- The Body Temperature Regulating Gloves and Socks use sensors which detect change in temperature at each finger and toe; the Arduino is then able to indicate when there is a decrease of temperature which can cause hypothermia; it triggers the heating pads to turn on. Once a normal temperature is maintained, the heating pad is turned off.

References

1. https://www.mayoclinic.org/diseases-conditions/hypothermia/symptoms-causes/syc-20352682
2. https://www.falstad.com/circuit/
3. https://store-usa.arduino.cc/products/arduino-nano?gad_source=1&gclid=Cj0KCQjw-r-vBhC-ARIsAGgUO2Dh9Yg9a0HyV6kJByhhSOyEV_rEQChMzmTSYB5-osuDK_NAp8xAj6caAik3EALw_wcB
4. https://www.cdc.gov/disasters/winter/staysafe/hypothermia.html

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