ADAPTIVE THERMAL HAPTICS

Peltier-Driven Thermal Haptics for Virtual Reality

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PROBLEM

Although modern day Virtual Reality systems are able to deliver incredible visual and auditory experiences, companies tend to neglect other senses, such as the sense of touch. We aimed to make VR applications slightly more immersive by allowing users to receive thermal feedback in a virtual environment. We focused on thermal feedback as it can be an excellent way to simulate how a real-world object may feel, however existing solutions are just too bulky, expensive, and often not compatible with many VR devices and accessories.

RELATED WORK

When it comes to simulating thermal cues, Peltier modules are the leading technology being used to achieve this. Over the last decade, there have been many prototypes made that attempted to solve this problem. Some of these include:

- **TouchDIVER**[1] - Commercial gloves that provided haptic, texture, and thermal feedback, but were extremely expensive.
- **Thermal Haptic HMD**[2] **-** Researcher focused on using Peltiers for directional hints and feedbacks, rather than thermal cues themselves.
- **Thermal Haptic Neck mount w/ Wind Accessory**[3] **-** Researcher focused on replicating ambient temperature of the virtual environment.
- **Thermo-haptic Gloves**[4] **-** Researcher focused on aiming to improve immersion by proving accurate thermal cues for objects in a virtual environment.

Fig. 3. Screenshot taken from the Unity scene.

ACKNOWLEDGMENTS

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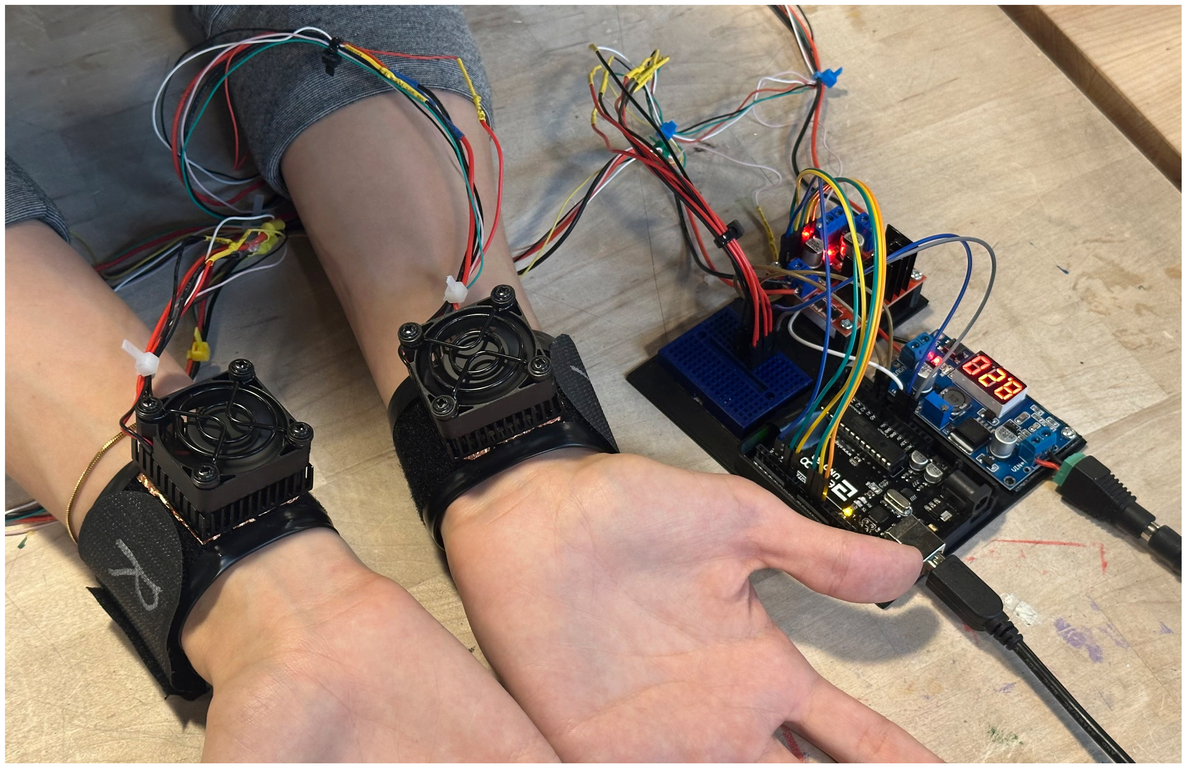

Fig. 1. The adaptive thermal wrist straps and electronics including Peltier cells, H-bridge, voltage regulator, power supply, temperature sensors, and Arduino.

METHOD

We prioritized several factors when designing, building, and coding our adaptive thermal wrist straps:

- **Affordability** - We aimed to minimize the cost of components that we needed so that the device would be accessible to the widest possible audience, including individuals who are new to VR.
- **Hand Movement** - We maximized freedom of the user's hands to use controllers as well as an unobstructed view for hand-tracking algorithms.
- **Independence** - We wanted our design to be an easy accessory to add to any setup, so its electronics are independent of other accessories.
- **Safety** - Safety is our first and foremost concern and all design choices were centered around it. Changing temperature comes with inherent risks and we implemented several redundant safety systems to maximize the safety of users.

OUR APPROACH

Our adaptive thermal wrist straps were built with easily accessible commercial components. Major components included:

- **5V 1A Peltier Module** - The Peltier module is the center of our wrist straps. It provides a temperature differential using electricity that is reversible.
- **L298 H-Bridge** - The H-Bridge is crucial for switching the polarity of the voltage to the Peltier module, allowing us to both heat and cool with the same module.
- **LM2596 Adjustable Voltage Regulator** - The voltage regulator steps down our 12V power supply to the 4.4V needed for the Peltier module.
- **Arduino Uno** - An Arduino Uno is the brain of our system. It controls the H-Bridge to supply the Peltier with the correct power. It receives commands over serial bus from the Unity scene and ensures safety using the temperature sensors.

RESULTS

Our adaptive thermal wrist straps performed very well in testing. Here are a few achievements that we are proud of:

- **Temperature Response Time** - The adaptive thermal wrist straps achieved 2.25 °F/s going from 40 to 80 °F. Since the operating temperature range is not as large as this test window, the user experiences a delay of only a few seconds.
- **Unity Integration** - We successfully integrated our thermal haptics system into Unity using the Ardity[5] package to communicate with the Arduino. It has real-time response and seamlessness resulting in increased immersion.
- **User Feedback** - Preliminary feedback during development yielded very positive results with comments on its rapid response and clear temperature differential.

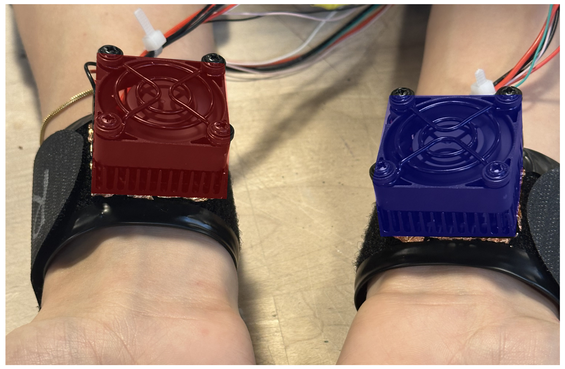

Fig. 4. Visual example of the Peltier modules heating and cooling.

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