HaptG:

Design of a Wearable Haptic Device For Intuitive Navigation

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SRA Track # 5 (Morphological Computation)
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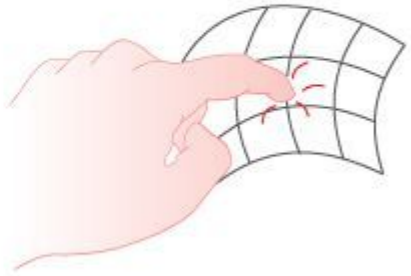
Table of Contents

Introduction



Haptic Feedback Devices

- Kinaesthetic and tactile feedback
- Intuitive translation of sensory input to command visualization (Machemehl et al., 2020)
- Non-visual and non-auditory interface w/ digital devices

Smithsonian Magazine, 28/12/2018

Problem

- Large uptick in bike use
  - **49 million** bikers in US as of 2019
- Prevalent smartphone use among bikers
  - **13.5%** Visual and **17.7%** Auditory

BicycleLawyer, 20/12/2018

Our Approach

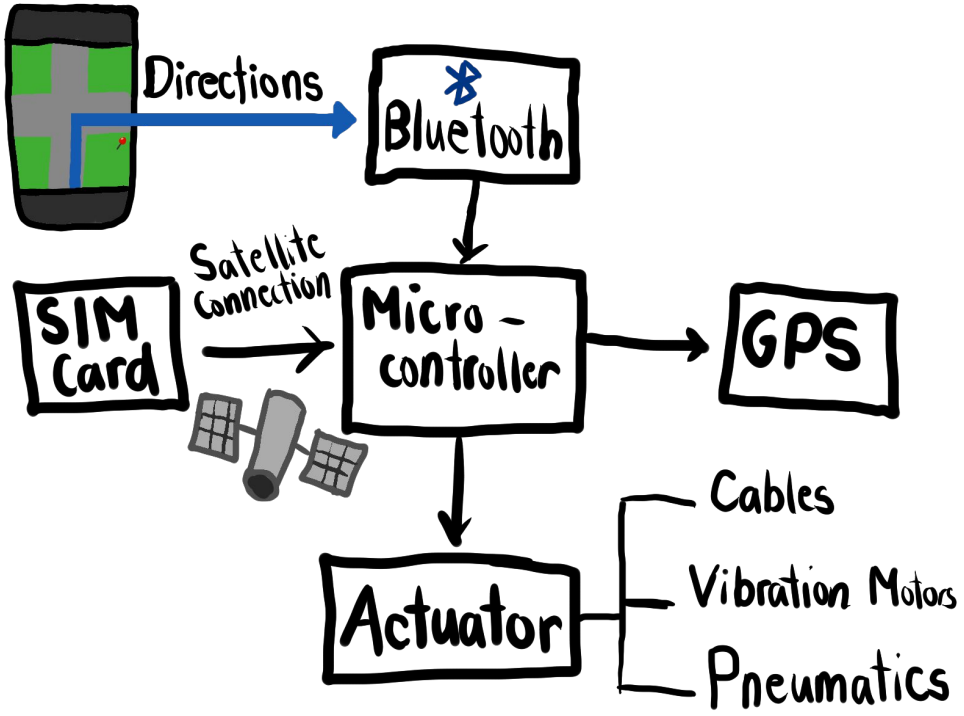
- How effective is haptic feedback as an augmentation for smart device based navigation?
- Solution:
  - Design a device to reduce distractions
  - Address the underutilized sense of touch

General Design

- Biking gloves that provide tactile sensation to indicate direction
- Features
  - Breathable, Waterproof, Haptic Feedback
- Inspiration
  - Bike wheels/treads
- Material
  - Polyester, Fleece, Polypropylene, PVC

Dakine Cross-X Gloves

Block Diagram



Design #1 - Cable-Driven

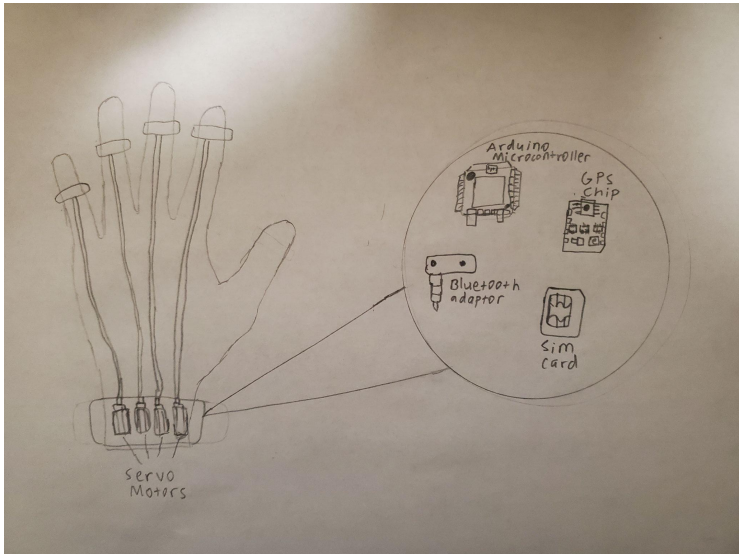


Figure 1. Sketch of cable design

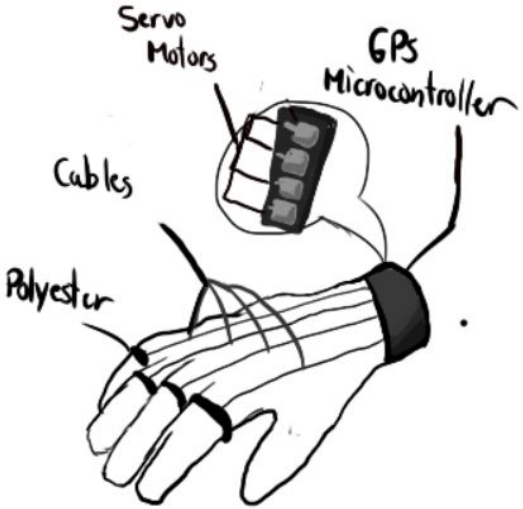


Figure 2 . Drawing of Cable design

Design Cont'd

Pros:

- Effective at notifying biker
- Easy integration
- Integrates aesthetics

Cons:

- No hand protection
- Potentially distracting
- Limited room for added functionality
- Potentially lower user appeal

Figure 3. Sketch of cable design

Figure 4. Rhino 3D rendering of cable design

Design #2 - Vibrotactile

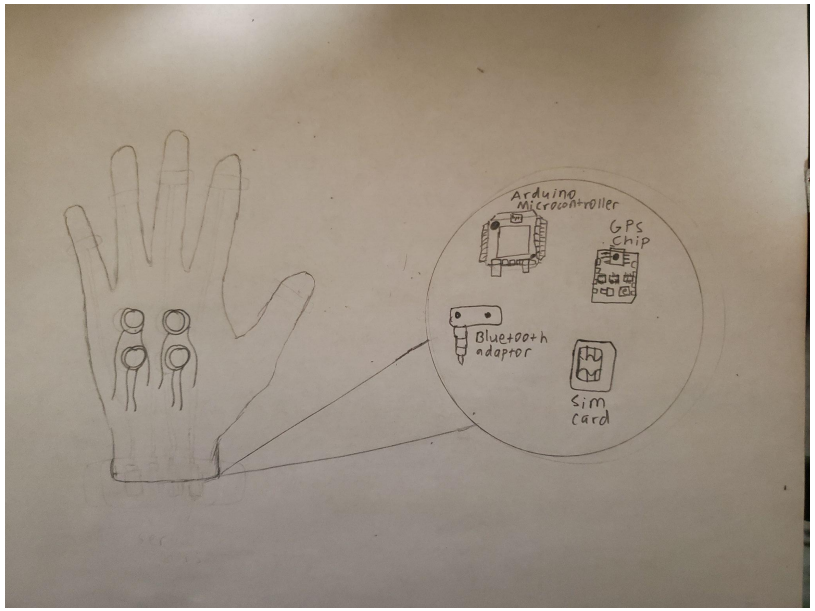


Figure 5. Sketch of vibrotactile design

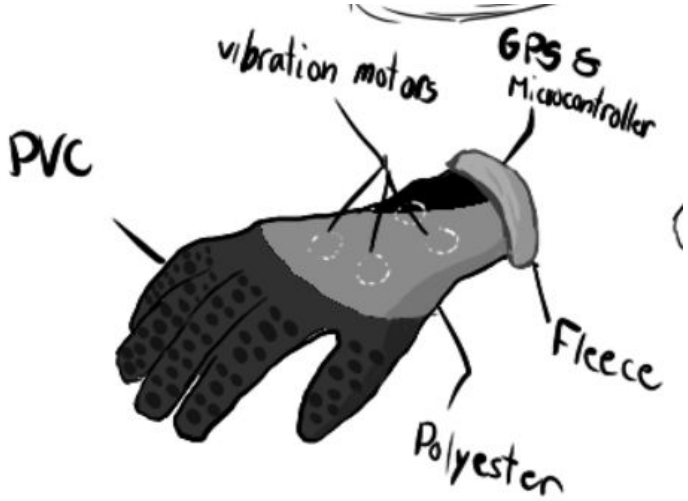


Figure 6. Drawing of Vibration Design

Design Cont'd

Pros:

- Easy to integrate
- Allows for more fashionable glove design
- Ability to add more functions to glove

Cons:

- Concerns with notifying biker (especially on bumpy roads)
- Potentially difficult to increase information density

Figure 7. Sketch of vibration design

Figure 8. Rhino 3D rendering of vibration design

Design #3 - Pneumatic

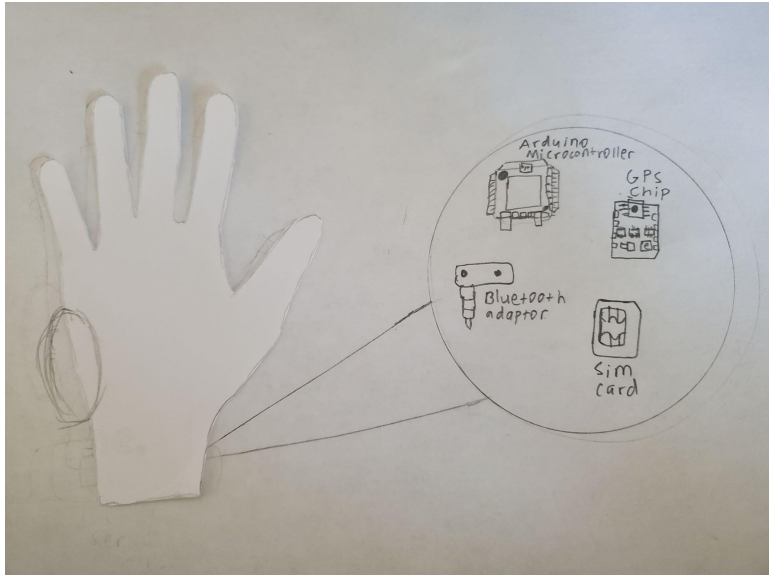


Figure 9. Sketch of pneumatically actuated design

Figure 10. Sketch of pneumatically actuated design

Design Cont'd

Pros:

- Effective at navigation
- Potential to integrate as a hand airbag
- Low complexity

Cons:

- Difficult to make fully portable
- Potentially large volume

Figure 12. Rhino 3D rendering of pneumatic design

User Study #1 - Cable Driven

Servo Motor Degrees

	5°	10°	15°	20°
Participant 1	1	2	3	5
Participant 2	1	1	3	5
Participant 3	1	2	4	4
Participant 4	1	2	3	5
Participant 5	1	1	3	4
Participant 6	1	2	4	4

TABLE 1. Participants' rating on a scale of 1-5 regarding the power of the servo motors at 5 degree intervals.

User Study #2 - VibroTactile

Vibration Frequency

	50 hz	100 hz	150 hz	200 hz
Participant 1	1	1	3	5
Participant 2	1	2	4	5
Participant 3	1	1	3	4
Participant 4	1	2	3	4
Participant 5	1	2	4	5
Participant 6	1	1	3	5

TABLE 2. Participants' rating on a scale of 1-5 regarding the power of vibration motors operating at different frequencies.

Physical Prototype - Cable-Driven

Figure 14.B

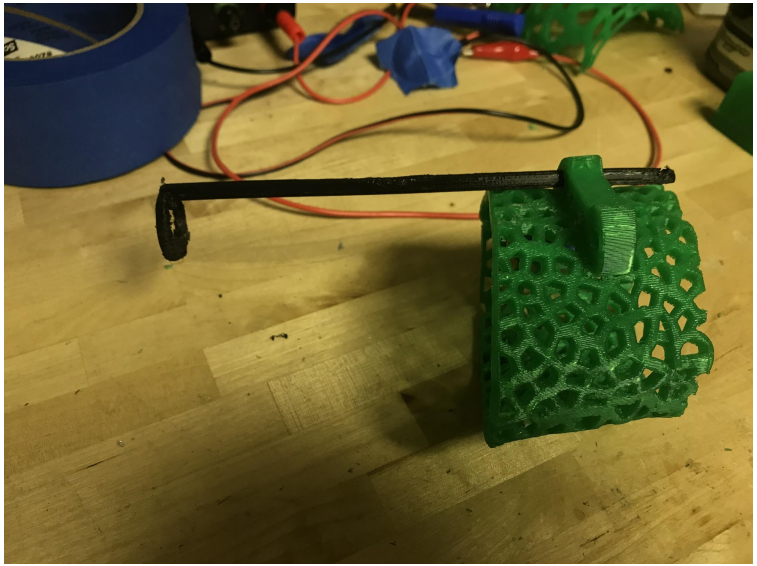


Figure 14. Cable design prototype

Figure 14.A

Physical Prototype - VibroTactile

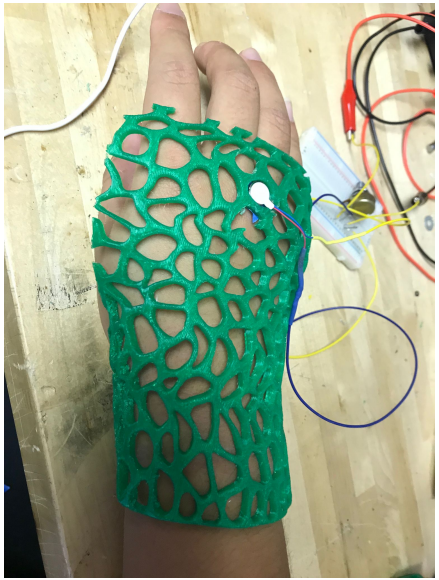


Figure 13.A

Figure 13. Vibration design prototype

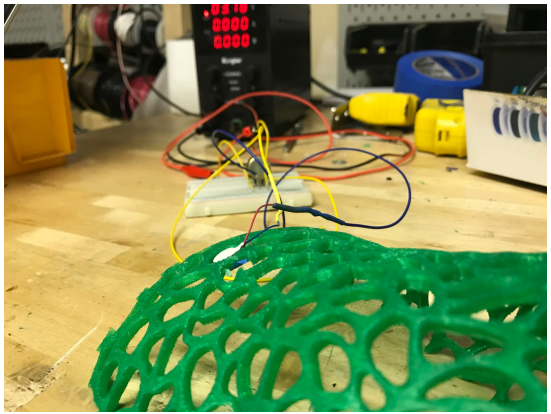
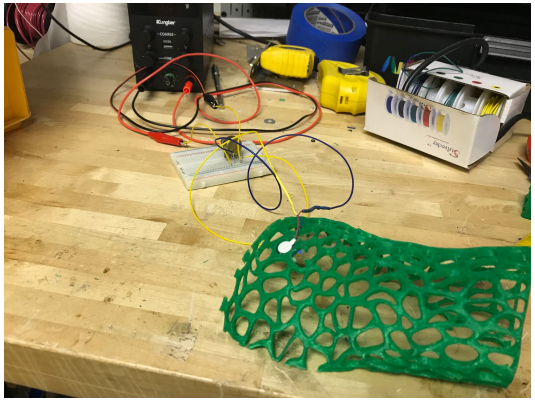
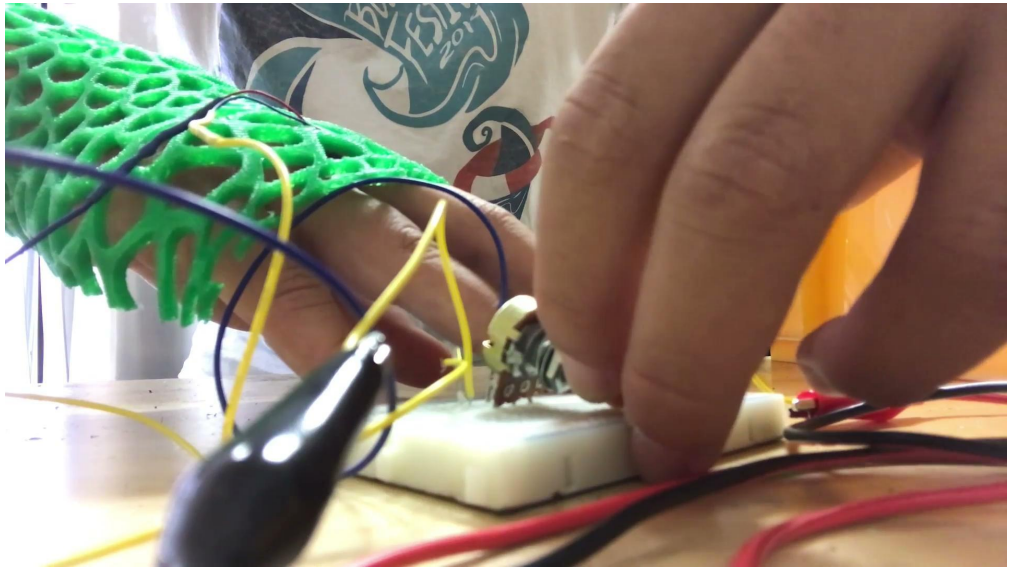


Figure 13.B

Figure 13.C



Physical Prototypes - Videos



Conclusion

- Helps mitigate visual and auditory distractions
- Reduce accidents
- Can also be used by first responders working in elevated mental effort condition

Future Work

- Immediate goals:
  - Test new plastics for a combination of pliability and structural support
  - Develop a tethered inflation-based prototype
  - Integrate photogrammetry in design flow

- Future goals:
  - Convert HaptG into an adaptable skeleton
  - Develop skin-conforming actuators

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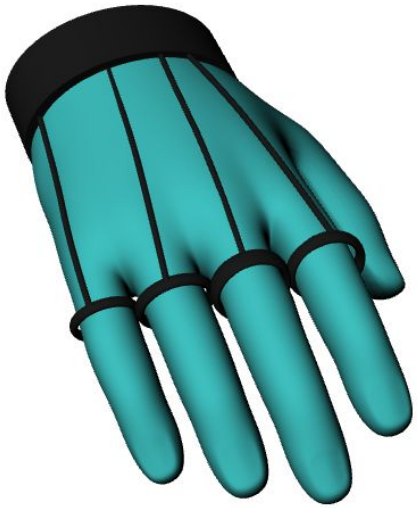

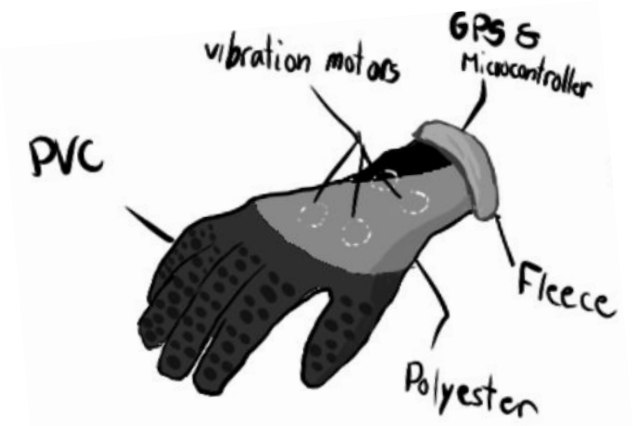

Thank You

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