**Abstract:**

Devices that interact with virtual reality (VR) environments sit at the forefront of electrical engineering development. There currently exists few ways to provide accurate and precise force feedback to the human hand when interacting with objects in VR. This approach is unique because of its usage of tendon like structures located on a glove-like sleeve to provide varying tension feedback to the user’s fingers. The tension is provided by linear actuators located on the forearm or off body stepper motors that provide resistance to the user’s grip. When a user grabs an object in the VR environment, the force exerted on each of the fingers will be sent to a microcontroller which will dynamically update the stiffness of the tendons. This will provide the user with a genuine and precise experience of feeling an object that isn’t there. Accelerometers located on the fingers, palm, and forearm will allow for tracking of the entire human arm in 3D space. VR technology already has applications in medical fields, the gaming industry, and the military. The addition of a precise force feedback glove will allow for further advances in interactive VR experiences.``

**Previous work:**

Looking into previous and related work it is useful to draw insights and build upon haptic and force feedback wearable VR projects, but it is also useful to gather advice and information from studies which apply only on one specific aspect of our project.

Projects that fall into the first category are projects such as the:

1. Tesla Suit,<https://teslasuit.io>

2. Haptx Glove,<https://haptx.com>

3. Cyber Glove <http://www.cyberglovesystems.com/cybergrasp/>

**Tesla suit:**

Tesla suit is a full body suit that features motion capture, Transcutaneous haptic feedback and a temperature control system to produce an immersive VR experience. The haptic feedback on the suit is accomplished with Electrical Nerve Stimulation (TENS), Electrical Muscle Stimulation. Finally, the Teslasuit company has also developed APIs for *Unreal Studio* and *Unity* game engines for interface with their product.

**Haptx Glove:**

The Haptx glove is a wearable VR haptic accessory. It features haptic feedback which is mainly accomplished with what the Haptx company calls *Microfluidic smart textile*.

Our flexible, silicone-based smart textile contains an array of high-displacement pneumatic actuators and embedded microfluidic air channels. The actuators provide haptic feedback by pushing against the user’s skin, displacing it the same way a real object would when touched. High-performance, miniature valves accurately control the pressure of each actuator to create a virtually infinite variety of sensations—texture, size, shape, movement, and more. An optional second layer of microchannels can add temperature feedback by delivering variations of hot and cold water[[1]](#footnote-0)

The glove also features tracking and a “light exoskeleton”. Finally, API interface is available for VR development.

**Cyber Glove:**

Cyber Glove is a force feedback exoskeleton.

**Related Papers:**

Paper “Haptic Exoskeleton For Learning Piano” which is senior project report of 2018 by Cooper Union students Gordon Macshane, Kevin Wong, Zachary Xing, Stanley Zheng describes a project with some minor overlap with the project that we set out to do. Insights in exoskeleton design and ideas on force feedback application can be drawn from this project.

“Design of a Highly Biometric Anthropomorphic Robot Hand towards Artificial Limb Regeneration.” ,a paper published by Washington University features the design of Anthropomorphic robot hand. What would our team draw from this paper would be exoskeleton design tips as the paper goes into depth describing human hand joint movements and what worked best in their effort to mimic natural movement.

“BiRTH: Biomimetic Robotic Teleoperated Haptics” is another Cooper Union senior design project and as it goes through exoskeleton design and force feedback it may provide some useful information.

“Haptic Feedback in Robot-Assisted Minimally Invasive Surgery”[[2]](#footnote-1) is a study from which we can draw on haptic feedback. The study features the use of tactile display which in its most simple form is an array of pins that are individually actuated. Ways that a tactile display can be implemented is with micromotors, pneumatic systems or in an electrotactile form.

On Electrotactile arrays, papers “Electrotactile Arrays for Texture and Pressure Feedback During Robotic Teleoperation”[[3]](#footnote-2) and “The tongue display unit (TDU) for electrotactile spatiotemporal pattern presentation”[[4]](#footnote-3) are good resources to get familiar with said device.

**Plan:**

**Electrical:**

Roles:

Varouzan: Hardware and Controls

Luka: Hardware and Software

Joey: Software and Unity

Current Plan:

1. Implement tracking of a single accelerometer in unity working
2. Measure force response of touch in unity working
3. Implement multi-accelerometer in unity working
4. Measure force response of multiple touches in unity working
5. Translate individual forces on each join to lateral ligament force
6. Implement haptic motor feedback in real life
7. Expand mechanical CAD of glove to contain electronics
8. Develop mountable board with flexes containing all 15/16 accelerometers and 5 haptic motors
9. Implement custom board hand tracking working in VR
10. Develop control system for stepper motors
11. Translate touch in VR to real life haptic feedback

**Mechanical:**

Roles:

Jerry: Design and Manufacturing

Luka: Design and Manufacturing

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1. <https://haptx.com/technology> [↑](#footnote-ref-0)
2. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2701448/#R41> [↑](#footnote-ref-1)
3. <http://www.hizook.com/blog/2010/08/11/electrotactile-arrays-texture-and-pressure-feedback-during-robotic-teleoperation> [↑](#footnote-ref-2)
4. <https://www.sciencedirect.com/science/article/pii/S1026309811001702> [↑](#footnote-ref-3)