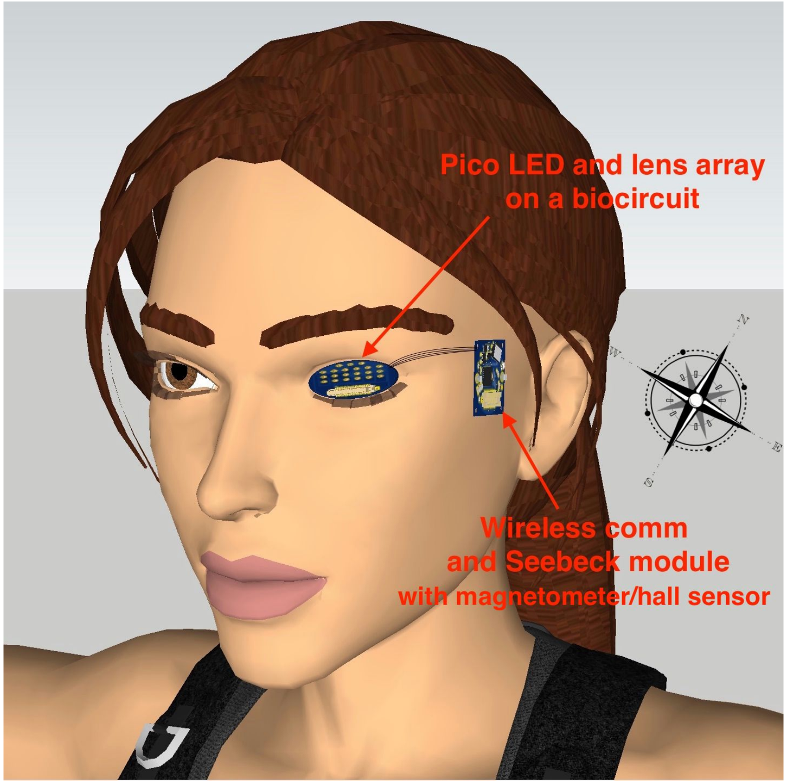
1. Magnetoreception based wearable interface



Robin Baker from the University of Manchester in 1980s set out to prove that humans could have a hidden ability to see magnetic fields through a protein present in our eye called cryptochrome. This protein in other animals gives them the ability of magnetoreception, i.e. the ability to see magnetic fields through their eyes. Baker spent 10 years trying to prove that humans are sensitive to magnetic fields, however was not able to prove it successfully.

My research idea is inspired by his work and to create a system that could sense and allow us to see or detect intensity of magnetic fields. This project is also inspired from the ability that Robins (birds) have to see magnetic fields through only one of their eyes. This in turn helps them in navigation while in flight.
Instead of embedding the concept onto augmented reality glasses, I wish to create a bio wearable that can give humans the innate ability to sense magnetic fields.

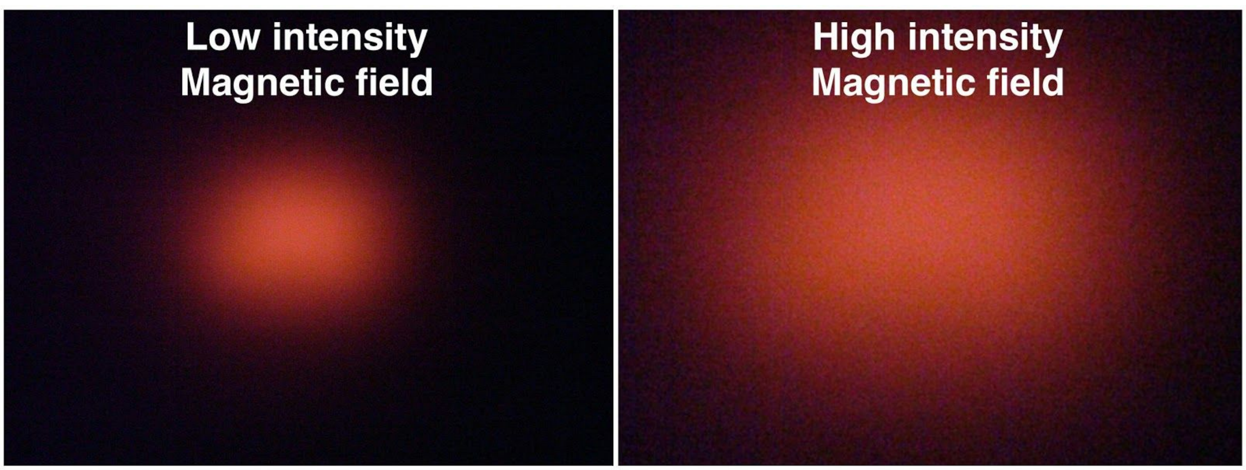
Here, I envision to create an epidermal electronics based interface with embedded pico LEDs that can focus light through the eyelids on to the eyes. Patterns and wavelengths used will be varied depending on the earth's magnetic direction the person is looking at. The concept of epidermal electronics is inspired from the work of John A Rogers from the University of Illinois, where he has successfully fabricated circuits on a thin layer of substrate (John A Rogers, Epidermal Electronics. *Science* **333**, 838 (2011)). An ATtiny microcontroller embedded to a magnetometer will serve as the controller for this project.

Here, the Seebeck effect will be used to power the system and is based on the research and findings of Vladimir Leonov from IMEC, Belgium who corroborated that the human body can generate upto 10mW/cm² (Leonov, V. ; IMEC, Leuven ; Torfs, T. ; Fiorini, P. ; Van Hoof, C., "Thermoelectric Converters of Human Warmth for Self-Powered Wireless Sensor Nodes" in *Proc. IEEE Sensors* **7**, 650-657 (2007)).

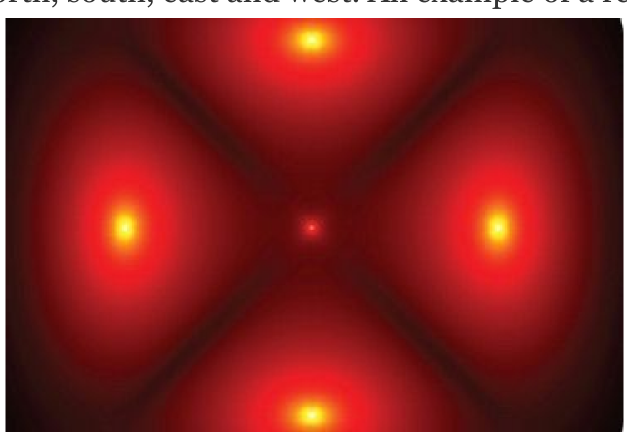
Moreover, I also wish to research to learn whether humans can process patterns of light in the form of characters or simple images while the eyes are closed. The array of pico LEDs can focus light through the eyelid and assist us in seeing information while our eyes are closed. This can also be used in lucid dreaming of controlled events or scenes.

Working: Here, while closing one of the eyes, the person will be able to detect the earth's magnetic field (magnetic north) through the embedded pico LEDs on the eyelid and the external magnetometer.
Moreover, the person can also visualise the magnetic fields of small magnets or electric wires by closing one of their eyes and bringing the object close to the face (hall effect sensor). The intensity at which the pico LEDs glow will be directly proportional to the strength of the object's magnetic field.

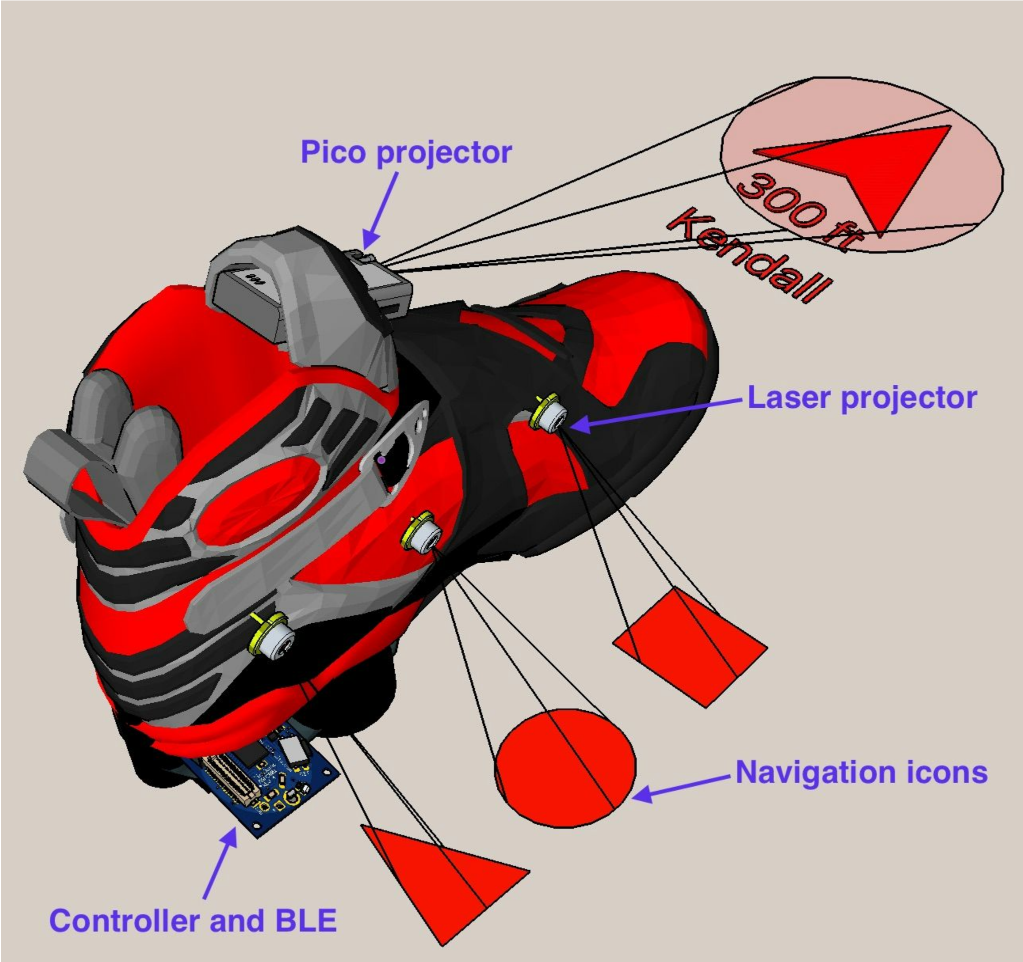
The intensity of light projecting on the eyelids will be proportional to the magnetic field of an object or conductor placed in front of the person and will appear as so:



Research will also be done to create patterns or even readable characters in the eyes to represent magnetic north, south, east and west. An example of a reproducable pattern:



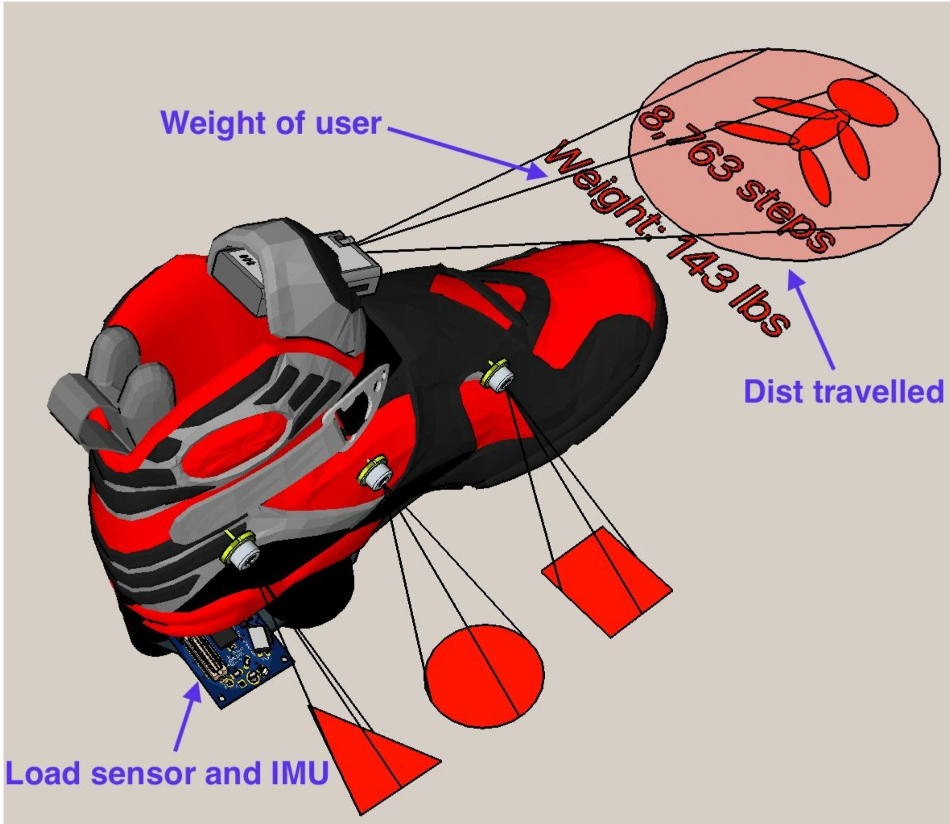
2.Shoe proprioception interface



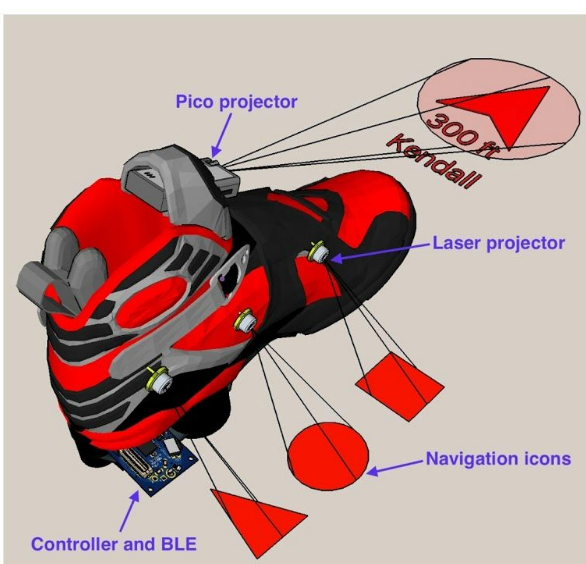
People are always reliant on navigation when they are in an unknown city, this causes them to use their smart devices for navigation and taking them around. The result is that people will have to take the phones from their pockets every five minutes or so to check if they are going in the right direction. Hence, I wanted to eliminate this and integrate navigation and other functionalities into something which we already use for walking and taking us places, our Shoes.

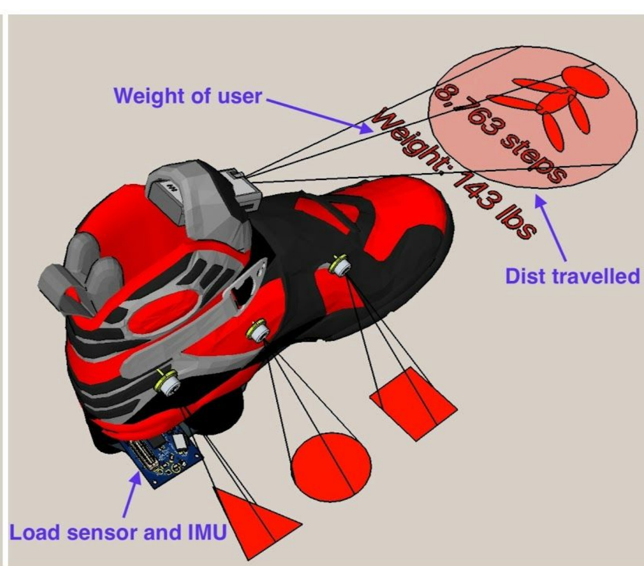
In this research project, I wish to integrate laser based projection interfaces in our shoes so that our shoes can lead the way. Here, the shoes shall project the way we should follow to reach our destination using simple icons and characters that are projected on the ground. Moreover, the gadget will also use proprioception for navigating through the interface and for displaying other data like: steps covered, names of places, direction (north/south) and much more.

Proprioception implies the ability to move parts of our body relative to each other. Here gestures like tapping the shoe with the other on the side, sweeping one shoe up and down, thumping, etc; can be performed in an eye-free manner with our body.

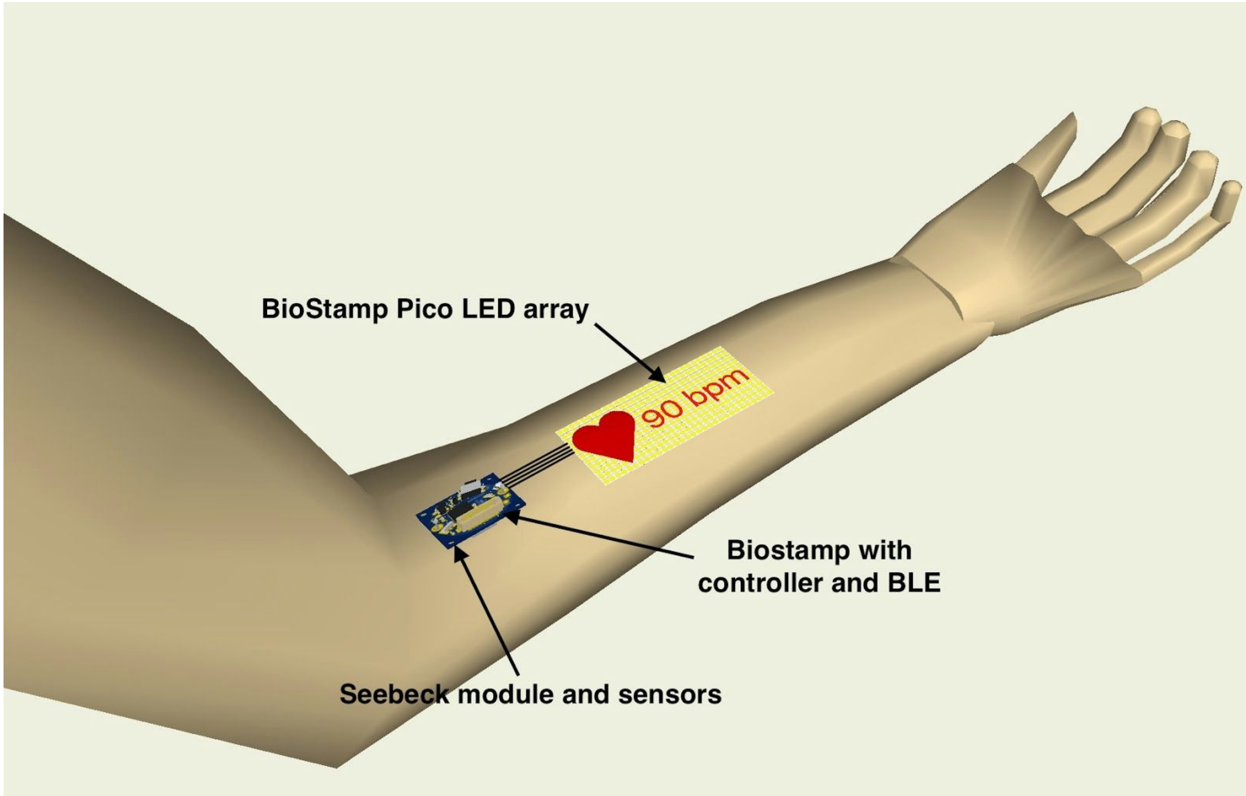


Working: The device will consist of a BLE based controller that can collect data from the smartphone and project it through a laser. It will also consist of pressure sensors and IMU to show data like: the weight of the person, steps covered, etc.
On tapping the navigation icons (projected through the laser) with our other foot (as shown in the figure), corresponding actions are triggered. Photodiodes will be used for detecting the selection.
Power for the system can be harvested through piezo effects or microfluidic devices from our steps. The research done by University of Wisconsin-Madison engineering researchers Tom Krupenkin and J. Ashley Taylor have corroborated that such energy harvesters can produce upto 20W and can be stored in batteries (Krupenkin, T. & Taylor, J.A. Reverse electrowetting as a new approach to high-power energy harvesting. *Nat. Commun.* 2:448 doi: 10.1038/ncomms1454 (2011)).





3.Epidermal display



In this concept, I would like to take advantage of the research work done by John A Rogers from the University of Illinois on epidermal electronics (John A Rogers, Epidermal Electronics. *Science* **333**, 838 (2011)). This project tries to experiment using our skin as a display interface through miniaturised electronics.
Here, I wish to research on solving the gap between epidermal electronics and using it as a display interface. Through this concept, the interface can be used as a fluid medium for human machine interaction. Information relating to human vitals can be collected through sensors and displayed in real time as an application.

Based on Moore's law, the size of controllers will become trivial in some years and it will result in more research in the field of bio display interfaces using femto (10^{-15}) size LEDs. Currently, pico (10^{-12}) LEDs can be used to form an array interface for displaying information. The prototyping can be done using conductive inks and adhesives to create the circuitry on top of low density polyethylene sheets of 12.5 μm thickness. The components used will be mainly pico LEDs and 0402 SMT based components.

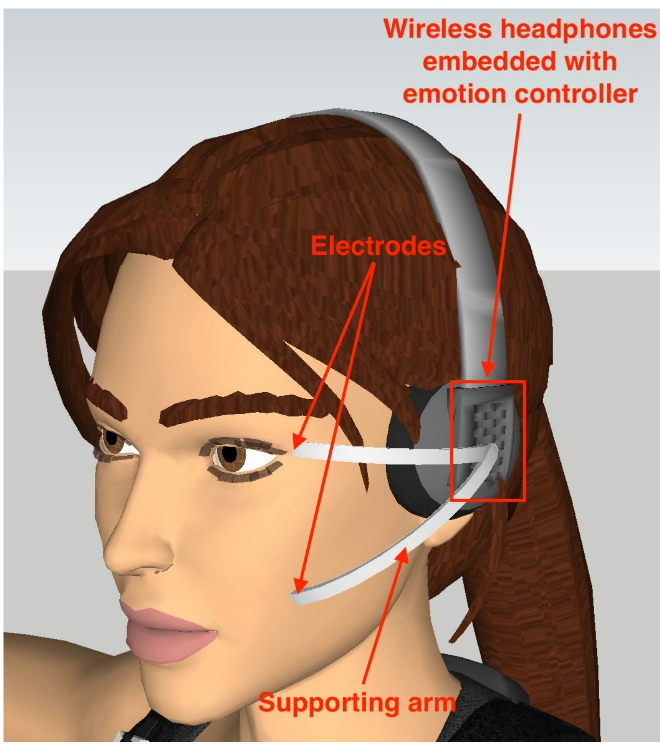
Working: The thin polyethylene layer hosts an array of pico LEDs that uses the concept of charlieplexing to interface it with microcontrollers. Capacitive nodes at various points on the layer allow a touch based control interface that shall assist in navigation.

Moreover, the same concept can be used on vinyl stickers to create LED based display stickers that can be attached to any object.

4. Wearable emotion interface - Control emotions by neuro electrical stimulation of facial muscles

My research idea got inspired by the work done by Dr.Paul Ekman (Pioneer American Psychologist) in terms of mapping and characterising the entire set of facial expressions that a person can make. In his research he has identified universal facial expressions that are used by people all around the world and has also worked on identifying micro expressions that can reveal our inner emotions. The concept which triggered my idea is thus based on his experiment where a person can trigger a genuine emotion by voluntarily recreating the facial expression associated with it, as proved in his work: *Voluntary smiling changes regional brain activity Psychological Science, Vol. 4, No. 5. (1993), pp. 342-345 by Paul Ekman, Richard J. Davidson.*

My idea is to create a wearable gadget that can be used to share a person's emotion with another remotely. This wearable emotion interface will be capable of activating the muscles involved in natural smiling as per the Duchenne marker (Duchenne de Boulogne GB. In: The Mechanism of Human Facial Expression. Cuthbertson RA, translator and editor. New York: Cambridge University Press; 1990), which states that the facial muscles: Zygomatic Major and Orbicularis Oculi are involved in our natural smile. On stimulating these facial muscles through electric currents, corresponding emotions have the potential to be recreated in the individual. Prior research had been done to figure out if facial muscle stimulation can trigger emotions through this paper: Zariffa, J., Hitzig, S. L. and Popovic, M. R. (2014), Neuromodulation of Emotion Using Functional Electrical Stimulation Applied to Facial Muscles. Neuromodulation: Technology at the Neural Interface, 17: 85–92. doi: 10.1111/ner.12056. According to which, researchers found out that emotions such as: daring, concentration and determination were brought out in individuals.



Today, while people are communicating with each other from remote places in ways other than video calling, they rely on smileys and literal words to derive the emotions of another person. Here, I wish to thus create a new interface that allows an individual to feel the emotion of another person by the neuro electrical stimulation of facial muscles. Thus connecting two people with each other and allowing a real time emotion sharing system. Applications include:

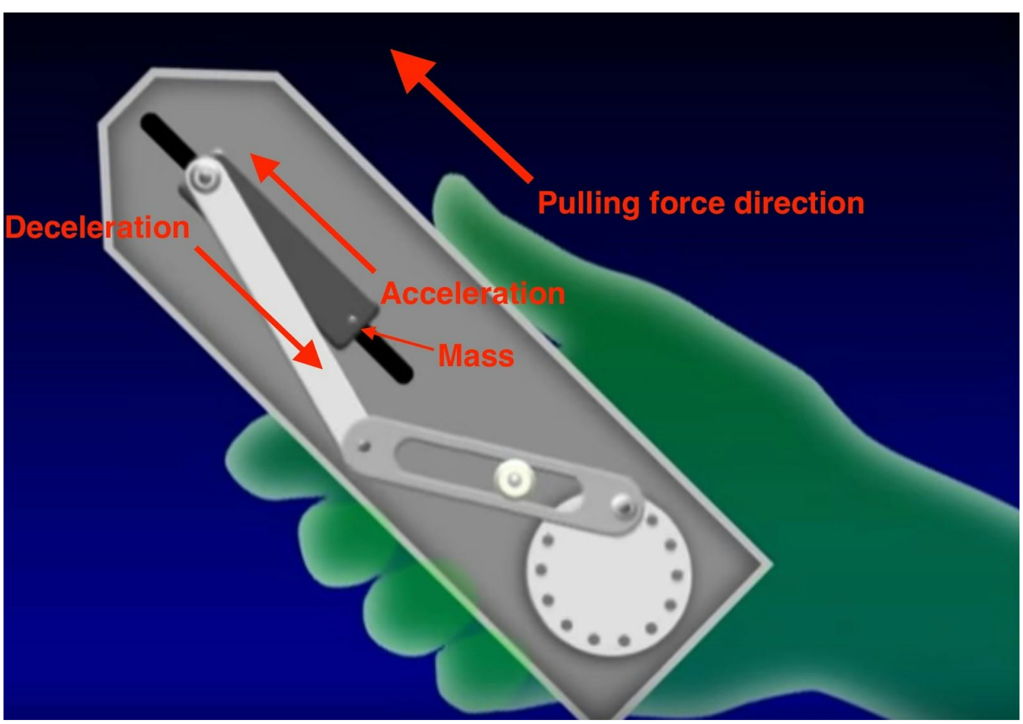
1. Remote transfer of emotions between individuals.
2. Real time emotion experience while listening to media.
3. Obtain feedback through current emotions for media content.

Some interesting reads that provokes the need for this project:
http://www.theverge.com/2015/6/30/8873819/mark-zuckerberg-facebook-sending-emotions-soon
http://www.popsci.com/forget-text-messages-and-send-emotions-over-air

5. Haptic lego bricks for the visually impaired

Here, I would like to propose the concept of creating a haptics based building interface for the visually impaired. The primary objective is to enable them to create physical structures from design files on the computer. Thus allowing them to create atoms from bits without having to be dependent on a visual display interface.

The system consists of an intelligent base platform whose each node is equipped with sensors (pressure/conductance) that can detect a lego brick when placed on top of it. Here, each node can be identified individually through their location and this platform inturn communicates via BLE to the individual lego bricks and navigates it to the correct location on the base. The independent lego bricks internally consists of a haptic interface that can create the illusion of pulling and pushing forces in three dimensions by taking advantage of the sensory illusion phenomena in humans:



This concept is based on the research done by T. Amemiya, H. Gomi, "Buru-Navi3: Behavioral Navigations Using Illusory Pulled Sensation Created by Thumb-sized Vibrator", In Proc. of ACM SIGGRAPH 2014 Emerging Technologies, Vancouver, Canada, August 2014. According to this, if an object is accelerating linearly in one direction faster than the other, then a sensation of a pulling or pushing force is created.

The brick then guides the user to insert the lego brick in the correct position by haptic pulling interfaces by communicating with the base platform through its embedded BLE unit. A rough structure of the embedded system inside the Lego brick and base array: