

Lecture 2: Haptic feedback in extended reality, telemanipulation and prosthetics

Human Bionics

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1 Close the loop

We need to provide feedback to the user. It is not just about controlling the prosthesis, but also about providing feedback.

The problem with virtual reality, is the lack of feedback on other sensors than the visual receptors. A headset that has been developed to restore sensory feedback with fans, piezo element (heat and cooling) and smell. Multisensory add-ons.

The best thing to do is restore force feedback. This is called *kinesthetic feedback*. This can be done with a kinesthetic arm, which is an underactuated articulated manipulator, which records the movement of the end-effector. It does still however provide a 3degree of freedom force feedback. The samplingtime must be very high and compute the force by the physics simulation within 1 ms, and therefore reduce the lag as much as possible.

A way of providing feedback without having a grounded device, we could use an exoskeleton. This could however also be grounded, depending on the level of feedback. The full feedback wearable system must be able to provide full feedback and withstand the force provided by the human, and therefore be more powerful than the standard assistive exoskeleton.

In addition to just restore force, it is also important to restore tactile sensation regarding pressure on the hand. The superficial tactile receptors, are more spatially focussed, and therefore they are activated by touch withing a smaller area of superficial contact. Devices that restore tactile sensation, are very small and mounted on the fingertips. Some devices are made to restore skin stretching with a band underneath the finger, and some are made to change position and orientation of the contact point. Another type is UltraHaptics, by using ultrasound with beamforming (desktop device). Microfluidics is very small and provide nice feedback but it is very expensive.

1.0.1 Eccentric rotating mass (ERM)

Mass offset from axis of rotation of a small motor. 2 parameters of input (higher velocity results in higher intensity.)

1.0.2 Linear resonant actuators

uses magnets and springs, but it has a resonance frequency.

1.0.3 Vibrotactile vests

Haptic feedback on the torso.

1.1 Electrical stimulation

There are different receptors in the skin.

- Meissner corpuscle
- Pacinian corpuscle

- Merkel disks
- Rufini endings

You need at least two electrodes, one ground and one active electrode. Therefore most electrodes are co-centric. A single stimulator can provide multiple ways of tactile feedback. You can control the frequency, and the current by increasing the amplitude or width of the pulse. It is important to have negative pulses, else the tissue can be damaged, by change in PH value of the skin. It is important to retract the current out of the skin after it is injected. All the types of receptors are stimulated at once, which can feel unnatural.

1.1.1 Electrotactile stimulation

When using electrotactile stimulation in conjunction with EMG electrodes, the stimulating electrodes can effect the emg measurements with artifacts.

1.2 Human sense of touch