Research on sensors

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In this document, I will review a variety of sensors that we could use to get input for our prosthetic hand.

1 Muscle sensors

One possibility would be to use muscle sensors, also called electromyography (EMG), to record electrical activity produced by the muscles. Electrodes would be placed on one's upper arm or forearm. An EMG device would be used to detect the level of activation of certain muscles. [1]

A quick Internet search reveals that muscle sensors are relatively easy to acquire and interface with. Take the MyoWare Muscle Sensor for example. The only interfacing device required is an Arduino to read out the voltage levels.

Various studies have been done on using EMGs to capture finger movement. In one study, four electrodes were placed on the forearm after which various finger motions were performed. The data was fed into and EMG and after a 25 training sessions the finger motions could be precisely registered. The results are pretty stunning with a reported accuracy of 97.75%. [2]
The question is whether this will still work when the patient is missing his or her fingers.

2 Brainwave sensors

A brainwave sensor, also called electroencephalography (EEG) is a method of monitoring electrical brainwave activity. The idea is that electrodes are placed on one's skull after which the EEG device will record the various known brain waves. [3] Let's look at the various types of brainwaves to see if they're of any use to us.

EEG devices are relatively more expensive and not as easy to interface with as EMGs. [4]

2.1 Delta wave

First, we have the δ (delta) wave, which is commonly used to analyse one's sleep pattern. [5]

2.2 Theta wave

Then we have the θ (theta) wave, which can be linked to whether one is in an idle state or performing a certain task. It is also related to motor behavior as a result of sensory stimuli. [6]

2.3 Alpha wave

The α (alpha) wave, just like the Delta wave, is linked to sleep activity as well. It can also be weakly linked to the Visual cortex which is a part of the brain that processes visual information. [7]

2.4 Beta wave

The β (beta) wave is associated with various different state of consciousness like flow, relaxation, anxiety, and so on. [8] Furthermore, this brain wave is also associated with isotonic (static) muscle contractions, meaning the contraction of muscles without movement (like when performing pushups or lat pull-downs [9]). [10]

2.5 Gamma wave

No much is known about the γ (gamma) wave, other than that it is possibly related to consciousness. [11]

2.6 Mu wave

The final distinguishable brain wave is the μ (mu) wave. The Mu wave is most prominent in the Motor cortex, a part of the brain which controls coordinated movements. Besides actual motor movement, intention of movement can also be traced back to the Mu wave. This is especially of interest to people who are missing a certain body part. One would be able to visualize a movement and this could (with enough training) be registered as a Mu wave on an EEG device. [12]

2.7 Conclusion

The θ (theta) wave could possibly be of interest to us as it is related to motor movement. But the μ (mu) wave would probably be of greater interest to us as it can be strongly linked to motor activity and intention of motor activity regardless of stimuli. We could look for a pattern in both of these waves relating to the muscle movement in the hand or fingers.

3 Morphological chart

	EMG	EEG
Ease of use	★★★★☆	★★☆☆☆
Observability	★★★★☆	★★★☆☆
Intention observability	☆☆☆☆☆	★★★★☆
Research	★★★★☆	★★★☆☆
Interfacing	★★★★☆	★★★☆☆
Price	★★★★☆	★★☆☆☆

4 Conclusion

An advantage of using electroencephalography over electromyography is that the brainwaves for controlling a body part are always detectable even if a patient is missing that body part. The advantage of using an EMG is that they're easier to work with as less decoding is required and less noise is present. Furthermore, more research has been done on using EMGs for prosthetic applications. [1]

I would recommend we try the EMG first and only try using the EEG if we are unable to register movement in patients with missing fingers.

References

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[12] *Mu wave*. URL: https://en.wikipedia.org/wiki/Mu_wave.