



Artificial Limbs



"All of us do not have equal talent, but all of us should have an equal opportunity to develop our talent.." - John F. Kennedy

1 Equal opportunity

There are many obstacles in today's life that affect our society. One of these issues are accidents that end with injuries to the human body or mind, some of which may unfortunately even lead to death. Such misfortunes can have many causes such as human inattentiveness or an equipment malfunction. None of us nor our inventions will ever be perfect, so preventing such unfortunate events from happening and effecting our health may not currently be in the realm of possibilities. However, with constant development in Cybernetics, scientists may be able to return body functionality to those affected by such injuries including the loss of limbs by enhancing human potential beyond its natural limit and giving these people a chance to have equal opportunities in life as everyone else once again, thanks to human augmentation. This essay will focus on Artificial limbs as a whole, including their different types, functionality, and potential hindrances in development.

2 Types of prosthetics

Artificial limbs in general require sensory feedback from the human body. This can be achieved by gathering information from the muscle system with surface EMG (electromyography) or from the nervous system with BCIs (brain computer interface) or peripheral nerve electrodes [2].

2.1 Muscle system

Skeletal muscle cells generate action potentials when they are electrically or neurologically activated, and these signals can be detected and recorded using electromyography. Each EMG signal provides valuable information about the biomechanics of human movement. This technology forms the basis of non-invasive, wearable prosthetics. Because these devices are relatively easy to implement, they have become common and widely used, even if they are not always the most advanced option available. Their effectiveness, however, depends heavily on the presence and condition of residual muscle tissue[2]. Wearable prosthetics also come with practical limitations: they are not the best in terms of recognizing the action potential in cells and they may struggle to maintain stable contact during physically demanding activities, such as sports, where sweat can interfere with adhesion.

2.2 Nervous system

The human nervous system is in touch with the world thanks to various sensory impulses that produce motor-controlled movement. BCIs are one way to connect the nervous system with technology. They are classified by their function: motor, sensory, sensorimotor and cognitive, and by level of invasiveness: invasive (BCIs with the need of a neurosurgery that places them inside the human skull) and noninvasive (placed on the head). Every BCI works on a principle of gathering specific brain signals, decoding and translating them into an action, which is then performed by the prosthetic. The most difficult part of this process is gathering and translating. Neurons in the brain create rapid, electrical impulses, that travel along the membrane, these are called the action potential. BCIs attempt to capture exactly this electrical activity, but because of the minute scale of these stimuli, competing signals both inside and outside of the body may create “noise”. By implementing artificial intelligence, researchers have not only been able to more effectively filter out unwanted noise, but also better recognize what certain wave lengths in the brain mean in connection with movement of the body. Thanks to that scientists were able to make BCIs more effective and thus prosthetic limbs of this type more reliable [1]. But even this great piece of technology has its drawbacks. Invasive BCIs are better at gathering signals than the noninvasive type and that creates two major issues. First is the difficulty of doing a neurosurgery without damaging the nervous system and second is finding an equilibrium between the effectiveness of a BCI and the size of one, because with greater size comes better functionality, but also the risk of interfering with the brain, therefore they are highly experimental. Nerve electrodes are becoming more common because they offer higher precision in movement due to being connected to the nervous system and are safer than BCIs. This type works by recognizing electrical activity of neurons, but not directly from the brain. One example are bone-anchored prosthetics [3], where an operation is needed to connect the artificial limb to the bone and set up electrodes to pick up signals. They perform better throughout activities, because sweat is not a problem with this type, and can also send a sort of sensory feedback back to the user due to the ability of creating vibrations that travel back through the bone [3].

3 Conclusion

In conclusion, non-invasive prosthetics that rely on EMG signals already offer a reliable and accessible way to restore function for people in need of artificial limbs. While invasive prosthetics are not yet suitable for widespread use due to the risks associated with their implementation, continued research and experimentation may eventually unlock their full potential and make them a viable option for the future.

Reference

- [1] Mikhail A Lebedev and Miguel AL Nicolelis. Brain-machine interfaces: from basic science to neuroprostheses and neurorehabilitation. *Physiological reviews*, 97(2):767–837, 2017.
- [2] Albert Manero, Viviana Rivera, Qiushi Fu, Jonathan D Schwartzman, Hannah Prock-Gibbs, Neel Shah, Deep Gandhi, Evan White, Kaitlyn E Crawford, and Melanie J Coathup. Emerging medical technologies and their use in bionic repair and human augmentation. *Bioengineering*, 11(7):695, 2024.
- [3] Max Ortiz-Catalan, Bo Håkansson, and Rickard Brånemark. An osseointegrated human-machine gateway for long-term sensory feedback and motor control of artificial limbs. *Science translational medicine*, 6(257):257re6–257re6, 2014.