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The Ultimate Question of Muscles, Bionics and Everything

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Imagine the first prototypes of mobile phones and then pay attention to what advanced devices exist nowadays. This is how recent artificial limbs look in comparison with their potential designs. It is quite obvious that prosthetic medicine needs fresh ideas and hopefully the progress does not stand still.

Figure 1. The bionic prosthesis

Bionics is a word from biology and technology. Bionics can be characterized as an attempt of developing technical solutions on the example of nature. The bionic prosthesis works by reading the electric potential generated by the tension of the remaining muscle tissues of the arm with special myo-sensors [1] (Figure 1).

The myo-sensors, which ensure the correct reading of the electrical potential, consist of sensing electrodes. They transmit the readout signal to the microprocessor, which processes the information received using computer algorithms. The microprocessor generates commands and sends them to the motors, which drive the active parts of the prosthesis.

Multi-pivot arm prostheses, which now perform a wide variety of gripping patterns and individual finger movements, require simultaneous or multimodal control. Coded synergies are stored in the CNS, which can be called up and combined for specific tasks so that the corresponding contraction models fulfill the kinematic task of the hand. It requires an initial learning phase in which the classifier uses machine learning algorithms to correlate various positions and movements of the prosthesis with myoelectric activation patterns [2].

However, intuitive operation using pattern recognition algorithms becomes impossible in cases, when necessary muscles are lost. The Targeted Muscle Reinnervation method is now an important step forward: with a surgical procedure, the motor neurons of the lost muscles are transferred to the remaining muscles. These muscles generate action potentials as a result of motor commands from the transmitted neurons and thus function as their amplifiers for receiving EMG signals.

Although artificial limb sometimes can even surpass the functionality it’s still perceived as something unfamiliar. It is believed there are to key factors, that prevent robotic part wholly replace the lost limb: the limited motion and lack of sensibility.

The most advanced and functional prototypes of prostheses are still based on servomotors. Servos are cheap and easy to work with however they are not able to imitate motions of human body clearly. That is why the idea of synthesizing artificial muscles seems to be one of the most perspective branch of prosthetics.

Artificial muscle fibers are needed for diverse applications, ranging from humanoid robots to comfort-adjusting clothing and miniature actuators. Recent advances in nanomaterial fabrication and characterization, specifically carbon nanotubes and nanowires have had major contributions in the development of the sphere. Recently developed muscles include highly oriented semicrystalline polymer fibers, nanocomposite actuators, twisted nanofiber yarns, oil-driven actuators, thermally activated shape memory alloys, ionic polymer and metal composites, dielectric elastomer actuators, conducting polymers, stimuli responsive gels, piezoelectric, electrostrictive, magnetostrictive actuators and even origami-inspired prototypes (Figure 2).

Figure 2. Fluid-driven origami-inspired artificial muscle

However, performance, scalability and cost problems make modern designs inappropriate to use in medicine.

In its minimal form, an artificial somatosensory system consists of three components: a tactile sensor, an interface system, and a stimulator. For many years, engineers at the University of Glasgow have been developing "electronic skin" for hand prostheses that is sensitive to touch without being too expensive to manufacture. The skin presented had the ability to sense pressure, temperature, and texture through an array of neural sensors.

The age of so-called cyborgs shown in fictional stories is rapidly coming. Soon the progress will bring us to the point when exchanging the part of the human body has become as usual as tooth filling.

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