42. THE APPLICATION OF INFORMATION TECHNOLOGIES FOR LIMB PROSTHETICS

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The information about prostheses and their common types is presented. The main problems of prosthetic design are listed. The application of Python and C++, brain-computer interfaces and reinforcement learning for limb prosthetics is described.

Nowadays, many people face problems related to limb amputations. Modern society strives to provide such people with a full life without both physical and moral discomfort. Prosthetics are used to solve this problem.

There are generally two types of prostheses: exoskeletal and endoskeletal [1]. Exoskeletal prostheses have a strong plastic or metal frame that resembles a limb, providing durability and stability suitable for people engaged in physical labor or working in demanding environments. In contrast, endoskeletal prostheses have a flexible internal framework, that allows an amputee to adjust the position, but may be less durable. Typically, an endoskeletal design includes a covering of soft material and synthetic skin to mimic the appearance of a natural limb. These types, in turn, are subdivided into ankle, knee and foot prosthetic systems, passive prostheses, body-powered prostheses, myoelectric externally powered, hybrid prostheses and special prostheses for specific activities (for example, sports).

In terms of information technologies (IT), myoelectric externally powered endoskeletal prostheses are of greatest scientific interest. A developer who is about to design a prosthesis must solve two problems: formation of optimal sensitivity of the prosthesis and development of a personal approach to each amputee. Both of them are solved by IT.

The solution to the first problem is a brain-computer interface (BCI) [2]. BCIs establish a direct connection between the electrical signals in the brain and an external device, enabling individuals to translate their thoughts into actions. By capturing and transmitting electrophysiological signals between neurons in the brain, BCI sensors facilitate communication with external sources such as computers or robotic limbs, allowing users to control devices through mental commands. BCI's software is commonly written in Python or C++ because of Python's simplified syntax, out of the box tooling. C++ usually relates to speed and memory usage, because many time-critical functions can have lower-level bindings to increase speed and then use Python as their declarative interface [3]. BCI concept is used in Human Neural Prosthetics program of Pittsburgh University, its usage allows the amputee not only to control the robotic arm, but also to sense stimuli [4].

The solution to the second problem is provided by artificial intelligence (AI). Reinforcement learning (RL) is a branch of machine learning that enables an AI system (referred to as an agent) to learn by trial and error based on feedback from its actions. This feedback, either positive or negative, is given as a reward or punishment, with the goal of maximizing the reward function. RL learns from errors and aims to closely mimic natural intelligence with artificial intelligence. In order to develop an optimal strategy, the RL agent must balance exploring new states while increasing rewards. The focus is not on immediate rewards but on maximizing cumulative rewards over the training period. Policy iteration is an algorithm that helps find the optimal policy for given states and actions, which provides every amputee a personalized approach based on their preferences and peculiarities [4].

In conclusion, it is worth noting that the introduction of IT is becoming an increasingly common practice in limb prosthetics. It is believed that in the nearest future most prostheses will have the described functional, which will significantly improve amputees' standard of living.

References:

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