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BIONIC UPPER LIMB PROSTHESES: COMPARATIVE ANALYSIS AND USE PROSPECTS

Isokova Sevara Abdumannonovna
Gulistan State University

Annotation

Already today there is the possibility of prosthetics of the upper limbs and part of its parts. The most common solution in Russia is cosmetic and traction prostheses. They will not take advantage of all the possibilities of the lost limb, because. Capabilities that have the most important functionality, such as the ability to pick up a pen, write text, play tennis, feel the resistance of an object when squeezed. Cases are also prostheses associated with pathological changes that do not only control increased force, as occurs in active mechanical prostheses, but are also sensitive to heat, pressure and more. This article is self-contained for detecting five calibers of prosthetic hands.

Keywords: bionic prostheses, hand prostheses, hand prosthesis control system.

Introduction

Advantages and subsequent cosmetic prostheses: appearance (there are models designed for patients that achieve an incredible resemblance to the original, both in appearance and in tactile sensations); reduced mass value due to the presence of any physical properties; easy to manufacture and operate (no need to take care of the battery); does not require large financial costs for maintenance, lack of attraction of the grip, as well as the need for pressure from the object placed in the prosthesis; limited functionality, high price for personal silicone accessories.

The traction prosthesis has a narrow range of functions that allow you to perform a practical task, for example, take a chicken egg in your hand and not break it. A mechanical prosthesis allows you to hold the object in your hand, which makes it possible to perform "fine" work.

To date, there are several manufacturers of data models, namely, open source on the e-nable site, open bionics and robohand, children's prosthesis with augmented reality "Kibi" from the company "Motorika", prosthesis BeBionic - kit from Touch Bionics, Vincent Systems, etc.

Advantages and durability of traction prostheses: reliable design; small weight and size parameters; acceptable price (the possibility of obtaining a prosthesis at the expense of financing by state structures); cheap maintenance; results to moisture, results of temperature jumps; lack of reaction delay, which gives any electronic device; ease of care; limited gripping force due to the installation of the structure; restrictions in degrees of freedom of movement; the traction system can be uncomfortable and restrict movement.

Another type of prosthesis that helps restore organs with loss of limb function is a bionic model that includes only one microprocessor and the remaining accompanying microprocessor bait.

In the preliminary section, several types of prostheses can be distinguished, different from each other according to the registration of the input signal from the user.

A prosthesis that copies the movement of an entire limb allows you to increase the naturalness of movements and debug the reaction rate. Copying occurs with the help of EMG studies, which allow determining the dependence of the level of excitation movements in the muscles and the reaction of the intact hand [2].

A neuroprosthesis based on the integration of the neurointerface and prosthetics, taking into account the need for invasive installation of sensors on the limbs and a variety of patient examination procedures and registrations of brain activity [3]. At the moment, active development is underway by the GalvaniBionix team from MIPT.

Myoelectric prostheses, in which the unequivocal advantages are: grip strength, increased comfort and freedom of movement, the ability to perform several gestures, the appearance of the model range. Prostheses use electromyogram (EMG) signals (electrical signals generated during muscle contraction) from residual limb muscles to control motorized hand joints [4]. Examples are OPRA Osseointegration, DARPA MPL, LifeHand 2, some types of models developed by the Russian company Motorika.

Turning to the types of prostheses, it should be noted that the variant described in [5] is one of the possible implementations of mechanical prostheses using a servo drive. Referring to the already indicated source, we note that at the moment the prostheses are controlled alternately.

Using feedback (closed loop example) involves analyzing input parameters that have changed after the signal has passed through the control system. At the moment, there are various technical implementations of feedback, for example, Extended physiological proprioception (EPP) - the idea of interaction between a person and the outside world through a prosthesis using phantom pain that appears when a limb is lost, which D. Simpson spoke about in 1972 (extended physiological proprioception).

The non-adaptive regulation discussed in [7] uses tactile sensing and ultrasound imaging, which have been tested on several volunteers who have experienced differences in performance and grip accuracy. This control method has a disadvantage

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in the absence of the possibility of correcting the grip force and predicting the parameters of the hand opening for a specific object.

At the moment, prosthesis control is most often implemented using externally powered myoelectric control due to ease of implementation and non-invasiveness [8]. A possible implementation of a neural network or integration of a prosthesis with a neural interface is the analysis of residual movements of a limb and control of the system according to the functions of the upper limbs that have already been established. Another option is a coordinated joint action, in which the process occurs intuitively, and the user's attention is directed to the action of the hand [9].

In addition to the problems associated with the discrepancy between the technical characteristics declared by the manufacturer and the actual parameters, there are 4 more factors [10] that disrupt the normal operation of a technical device: limb position factor, when muscle activity that maintains the desired position of the limb in space under the influence of gravitational forces is not the same in static and dynamic states; contraction intensity factor. Since the class of self-learning control methods is focused primarily on the "intuitive" signal given by the operator, subconsciously regulating the force of contraction, deviations in the input data (under different loads, but the same action) lead to a distortion of the expected patterns; coefficient of electrode shift relative to others, leading to distortion of signals from the muscle; precision elements and sensitive sensors, when removed and put on, as part of the prosthesis, noise and errors also occur.

Receiving data. Typically, at the time of the prompts offered by the control protocol, muscle patterns from the user are recorded into the bipolar electrodes. The number of electrodes required by a particular user is determined by the movement class; the location is usually found by palpation, circumferential placement, or meshwork around the forearm. Data collection most often occurs once at the time of training;

Data set. The analysis is carried out using pre-recorded datasets that were obtained from healthy individuals;

Data preprocessing. In this section, we increase the signal-to-noise ratio (SNR) to improve the distinctive characteristics of the EMG signal (which is most often approximately ±5 mV);

Data segmentation. Since the signal received from the muscle is random for the control system, which violates the general assumption in the extraction method. Segmentation (windows) is used to identify stationarity. Windows are usually created using adjacent or overlapping segmentation and are enclosed in a time interval of approximately 300ms;

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Feature extraction. Features are needed to increase the density of useful information, at the expense of the main properties of the general population (all windows), in contrast to the analysis of the raw sample. Features are Time Domain (TD), Frequency Domain (FD), and Time Frequency Representation (TFR) parameters;
Dimension reduction. The very presence of myoelectric control functions requires: the inclusion of features that have high-quality discriminatory information, the exclusion of features that are very similar to each other, and the minimization of the number of included features to combat the "curse of dimensionality";
Classification is the process of assigning a class to an unknown observation using a predictive model trained on earlier observations. Classifiers are divided into 3 types: parametric, non-parametric, deep learning classifiers;
Evaluation of work efficiency. The assessment of myoelectrical systems can be performed at the stages of feature extraction, classification, or during the use of feedback. Evaluation of the feature extraction stage quantifies the available features.
The need for invasive methods in management is best explained by a specific example [11]. The most successful will be the ulnar disarticulation of the residual limb, which leaves a sufficient portion of the arm still alive, in contrast to transhumeral amputation, but wearing a conventional prosthesis with a non-invasive sensor has a number of inconveniences. For example, power supply from the body using an external loop makes the prosthesis cumbersome; it clings to various objects, including clothing [12].
Intuitive control methods, perhaps, have the greatest number of pluses, relative to all of the above. The operator does not need to adapt to the bionic prosthesis for a long time, since the intelligent system is aimed at learning, there are no sensors that need to be attached to the arm and worry about their displacement, errors caused by muscle fatigue, sweat, etc.
The methods listed are not the only solutions for implementing upper body control.
According to experts. There are yes main directions of development of bionic prostheses. The first is to give them sensitivity, that is, the organization of feedback, which will allow the owner of the device to receive information about the qualities of the object that he touches. The second is the implantation of all elements, including the frame and the sensor. Even the most modern dentures must be removed while sleeping or taking a bath. After the developers have made the prostheses match the original limbs in appearance and function, it remains to make them a permanent part of the human body that does not require additional care.

References

1. Kamalova K. R. Modern hand prostheses / K. R. Kamalova // Mavlyutov Readings: Sat. scientific tr. / Ufimsk. state aviation tech. un-t. - Ufa, 2021. - vol. 3. - pp. 73-79
2. Fleischer C. Application of EMG signals for controlling exoskeleton robots / C. Fleischer, A. Wege, K. Kondak et al. // Biomed Tech (Berl). 2006 Dec;51(5-6):314-9
3. Müller-Putz G.R. Temporal coding of brain patterns for direct limb control in humans / G.R. Müller-Putz, R. Scherer, G. Pfurtscheller et al. // Front Neurosci 2010 Jun 18;4. pii: 34.
4. Kuiken T.A. Targeted muscle reinnervation for real-time myoelectric control of multifunction artificial arms / A. Kuiken, G. Li, B.A. Lock et al. // JAMA. 2009 Feb 11;301(6):619-28.
5. Burov G.N. Determining the requirements for the sources of control signals of the control system for the forearm prosthesis / G.N. Burov, V.A. Bolshakov // Bulletin of the All-Russian Guild of Orthopedic Prosthetists. 2017. No. 2 (64). With. 36–40.
6. Gorohova N.M. Control methods for upper limb prostheses / N.M. Gorohova, M.A. Golovin, M.S. Chezhin // Scientific and technical bulletin of information technologies, mechanics and optics. 2019. V. 19. No. 2. S. 314–325. DOI: 17586/2226-1494-2019-19-2-314-325
7. Ortenzi V. Ultrasound imaging for hand prosthesis control: a comparative study of features and classification methods / V. Ortenzi et al. //Proc. 2015 IEEE Int. Conf. on Rehabilitation