Development of electric hand prothesis controlled by voice commands and muscle sensors

Desarrollo de prótesis de mano eléctrica controlada por comando de voz y sensores musculares

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Keywords

Electric hand prosthesis; voice commands; muscle sensors; prosthetic technology; limb loss; mobility; sophisticated devices; everyday tasks; amputees; electromyography.

Abstract

Prosthetic technology has advanced significantly in recent years, giving people who have lost limbs the chance to restore mobility and independence. Electric hand prosthesis controlled by voice instructions and muscle sensors represent one interesting area of advancement. This study focuses on the creation of an electric hand prosthesis that can be voice-controlled and muscle-sensing, with a focus on the usage of 3D-printed polylactic acid (PLA) and fiberglass reinforced with pineapple leaves. The goal of this project is to examine the viability and advantages of using these cutting-edge materials in the manufacture of prosthetic components. The project also seeks to investigate the possibilities of implantable myoelectric sensors in conjunction with voice instructions for natural prosthesis control. The inquiry is still in its early stages, with a focus on gathering real-time system values while it is in use. This research aims to advance prosthetic technology by shedding light on these developments, ultimately improving the lives of those who have lost limbs. And developing a prototype of the discoveries.

Palabras clave

Prótesis de mano eléctrica; comandos de voz; sensores musculares; tecnología de prótesis; pérdida de extremidades; movilidad; dispositivos sofisticados; tareas cotidianas; amputados; electromiografía.

Resumen

La tecnología de prótesis ha avanzado significativamente en los últimos años, brindando a las personas que han perdido extremidades la oportunidad de recuperar movilidad e independencia. Las prótesis de mano eléctrica controladas por instrucciones de voz y sensores musculares representan un área interesante de avance. Este estudio se centra en la creación de una prótesis de mano eléctrica que pueda ser controlada por voz y sensores musculares, con un enfoque en el uso de ácido poliláctico (PLA) impreso en 3D y fibra de vidrio reforzada con hojas de piña. El objetivo de este proyecto es examinar la viabilidad y las ventajas de utilizar estos materiales de vanguardia en la fabricación de componentes protésicos. El proyecto también busca investigar las posibilidades de sensores mioeléctricos implantables en conjunto con instrucciones de voz para el control natural de la prótesis. La investigación aún se encuentra en sus primeras etapas, con un enfoque en la recopilación de valores del sistema en tiempo real mientras está en uso. Esta investigación tiene como objetivo avanzar en la tecnología de prótesis al arrojar luz sobre estos desarrollos, mejorando en última instancia la vida de las personas que han perdido extremidades y desarrollando un prototipo de los hallazgos.

Introduction

Prosthetic technology has advanced significantly in recent years thanks to improvements in engineering methods and material science. These developments have opened the door for the creation of very complex devices that provide amputees with greater independence and mobility. Electric hand prosthesis, which may be operated via voice instructions and muscle sensors, represent one particularly innovative and promising field. This state-of-the-art technology has the power to drastically improve the lives of amputees by enabling them to carry out a variety of routine tasks with ease.

These prosthesis' capabilities are further increased using cutting-edge materials throughout the production process. Polylactic acid (PLA) in 3D printing and pineapple leaf reinforced fiberglass are two materials that have drawn attention. For complex and personalized prosthetic components, 3D printing increasingly uses PLA, a biodegradable and biocompatible thermoplastic.

Conversely, pineapple leaf reinforced fiberglass, which is made from used pineapple leaves, demonstrates outstanding strength and lightweight characteristics, making it a desirable option for building strong and effective prosthetic constructions.

In addition to using cutting-edge materials, electronic hand prosthetics use implantable myoelectric sensors that can recognize and decipher the electrical signals produced by the user's remaining muscles. These sensors record and convert muscle movements into precise commands, enabling intuitive control of the prosthesis. A further alternative control mechanism that enables users to communicate with their prostheses verbally is voice command technology. It is possible to create prosthetic devices that closely resemble real hands and offer a seamless user experience by combining implantable myoelectric sensors with voice instructions.

Methodology

The type of this investigation is an experimental investigation, this implies the development of a prototype or project of an electric hand prothesis. The investigation will take place in a specialized robotic and biomechanical laboratory, equipped with all the necessary resources for the development of the electric hand prothesis and testing.

The objective population of this study are people with a hand amputation that can benefit from the electric hand prothesis controlled by muscular sensors and if necessary, voice commands. The size of the sample for this study is going to depend on the availability of the resources and the recruitment of participants. The sample size represents about 20 or 25 individuals with hand amputation that meet the inclusion criteria and are willing to participate in the study.

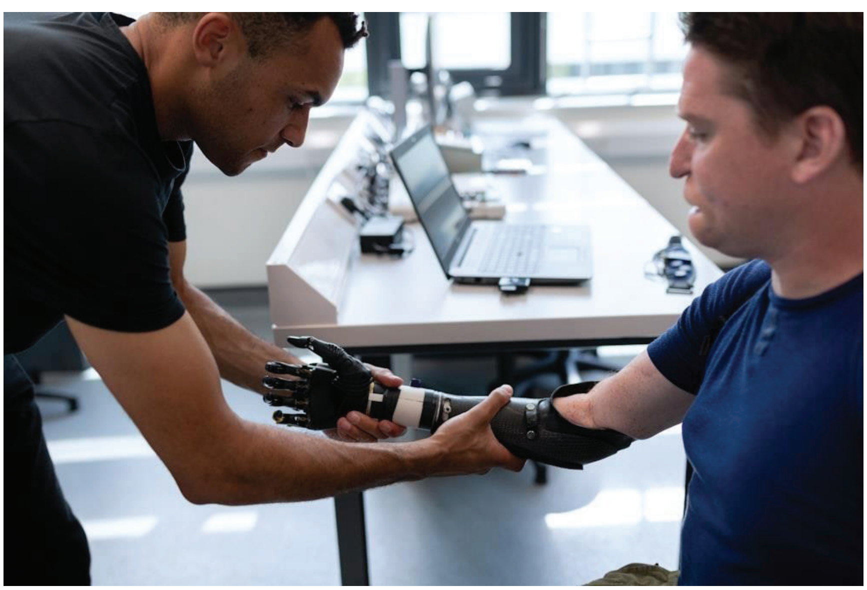

Figure 1. A prosthetic arm being placed for testing.

Control system design

For the design, it is proposed that a similar approach that P.F. Pasquina and collaborators.[1] It is planned to use an implantable myoelectric sensor (IMES) to detect wirelessly transmitting EMG signals to the prosthetic hand. It will also allow more natural control and offer more freedom. There will be processing algorithms to interpret the muscle signals and convert them into commands for the prothesis. Finally, an implementation of an extra feature will be made available that allows by using a interface that will recognize voice commands by using an artificial neural network, and depending on the command, a movement is developed, like the proposal of J.P. Angel and N. Arzola.[6]

The reasoning for combining both methods even though it is planned to keep the voice command as a secondary feature and therefore the amount of commands that it will recognize will be short, is to take advantage of the effectiveness of both methods normally used in prosthetics development, giving a more natural control sensation using IMES and keep the comfort and take advantage of the easy training process of the voice commands.

Material selection

For the prothesis material there are two possible options, the use of an open-source 3D printer upper limb prothesis. According to K. Wendo et all most studies of 3D printing prosthetics, used Polylactic Acid that is a hard-plastic 3D printing material to build their prothesis.[4] The use of this material with a production fee with a range cost of 449 dollars up to 862 dollars and the manufacturing ranging from 20 to 25 dollars.

The other alternative is the use of pineapple leaf reinforced fiber glass proposed by A. Kohli et all.[5] In their investigation they made physical and virtual testing to test if the material and the elastic properties, it was proven that is a good material for a prothesis, and its cost is halve as much as the material used till today Carbon 395.

Figure 2. Prosthetic arm.

Prototype construction

The following steps outline the expected following procedure:

Computer-Aided Design (CAD)

- Using specialist tools, a thorough CAD model of the electric hand prosthesis would be created.
- The design incorporated mechanical parts such finger joints, the structure of the palm, and housing for electrical parts.
- Ergonomics, functionality, and the integration of diverse pieces would all be taken into consideration.

Mechanical component production

- A 3D printer's machine-readable instructions would be created from the CAD model in case of choosing to use a 3D printing material.
- The material in the case of the 3D printer would be as mentioned before would be Polylactic Acid or the prosthetic hand would be manufactured with pineapple leaves reinforced fiber glass.

Integration of Electrical Components

- Motors, sensors, and control circuits were among the electrical parts that were chosen and will be prepared for integration.
- To help with assembly, wiring schematics and connection plans are going to be created.

Circuitry and Control System

- To accommodate the control system, circuit boards will be created and made.
- The vocal commands, the motors, and the signals from the muscle sensors will all be handled by microcontrollers or other programmable logic devices.
- The necessary capabilities, such as user interface and signal processing techniques, would be implemented using software programming.

Methods of evaluating and testing

It is planned to perform evaluations and testing that will be performed once the prosthetic hand is functional. To evaluate the performance and functionality of

the hand prothesis, it is planned to enlist 20 to 25 people with hand amputation. They will receive detailed instructions on the voice commands and muscle sensors to operate the prothesis. To make sure the system is customized to each person's specific traits, calibration tests will be carried out.

Several tests are planned to be conducted to gauge the prosthetic's control abilities. Specific hand motions, such as grasping, realizing, manipulating items of various shapes and sizes, are going to be required of the participants. Precision, quickness and smoothness are going to be examined in the movements. At the end, a questionnaire will be taken by the participants to receive feedback to measure comfort and usability.

Figure 3 Prothesis getting ready for testing.

The information gathered throughout the evaluation and testing phase will then be thoroughly examined. Statistical techniques are planned to be used to find any significant variations in user groups and task performance. The results of this evaluation are expected to provide insightful comments for the prosthetic design and control system's continued improvement.

Results

The inquiry is still in its early stages, and its intended results center on gathering real-time system values while it is in use.

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Introduction

Prosthetic technology has advanced greatly due to improvements in engineering and material science. This has led to the development of complex electric hand prostheses that can be controlled through voice instructions and muscle sensors. These cutting-edge prosthetics, made with innovative materials like PLA and pineapple leaf reinforced fiberglass, offer enhanced strength, lightweight characteristics, and personalized components. Additionally, implantable myoelectric sensors and voice command technology enable intuitive control and seamless user experiences. Overall, these advancements in prosthetic technology greatly improve the lives of amputees by providing greater independence and the ability to perform everyday tasks with ease.

Materials and Methods

Material selection for the prosthetic includes two options: Polylactic Acid (PLA) in 3D printing or pineapple leaf reinforced fiberglass. PLA is commonly used due to its biodegradability and biocompatibility, while pineapple leaf reinforced fiberglass offers cost advantages over traditional materials like Carbon 395.

The construction process involves creating a detailed CAD model of the electric hand prosthesis, incorporating mechanical components and considering ergonomics and functionality. Mechanical parts can be 3D printed using PLA or pineapple leaf reinforced fiberglass.

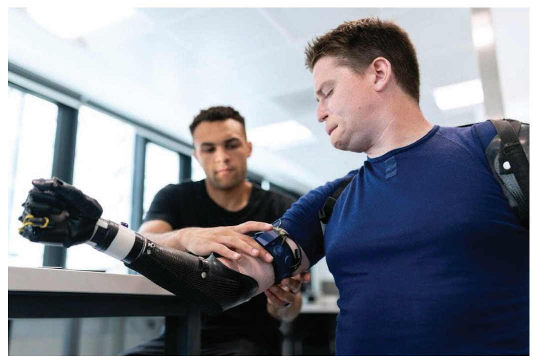
Electrical components like motors, sensors, and control circuits are integrated, with wiring schematics and connection plans created. Circuit boards are developed to accommodate the control system, which includes handling vocal commands, motor control, and signals from muscle sensors through microcontrollers or programmable logic devices. Software programming is used for user interface and signal processing.

Evaluation and testing involve recruiting amputees to assess performance and functionality. Calibration tests ensure customization, and various tasks are performed to evaluate control abilities. Precision, speed, and smoothness of movements are examined, and user feedback on comfort and usability is collected through questionnaires.

Gathered data is analyzed using statistical techniques to identify variations and provide insights for further improvement of the prosthetic design and control system.

Results and Discussion

The inquiry is still in its early stages, and its intended results center on gathering real-time system values while it is in use.



Conclusions / Next Steps

The process of material selection for prosthetics includes options such as the use of Polylactic Acid (PLA) in 3D printing or pineapple leaf reinforced fiberglass. Both materials offer advantages in terms of biodegradability, biocompatibility, and costs. The construction of the prosthesis involves creating a detailed CAD model, integrating mechanical and electrical components, and programming software for system control. Evaluations and tests are planned with amputees to assess the performance and functionality of the prosthesis and use the results to continuously improve the design and control system. Overall, the use of 3D printing technology and advanced materials is driving significant advancements in prosthetic manufacturing, providing greater independence and quality of life for amputated individuals.

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