SCIENTIFIC RESEARCH ON THE DEVELOPMENT OF A PAIR OF ROBOTIC ARMS FOR COMUNICATION WITH HEARING DEFICITS

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ABSTRACT: The development of a pair of robotic arms for communication with hearing-impaired people requires a multidisciplinary approach, namely robotics, signal processing, human-computer interaction. The first step in developing them would be to determine the specific needs and preferences of these people. The design and construction of these arms will be based on the 3D design of the component elements, the Arduino IDE software and the use of the Arduino UNO board to receive and execute commands for this robotic system.

Key-words: 3d design, Arduino IDE, Arduino UNO, robotic arms, Hearing-impaired individuals.

1. Introduction

Robotic arms are a mechanism composed of interconnected links, joined together by appropriate joints to achieve the required degrees of freedom and spatial movement for executing commands. The robotic manipulator can often be programmed for specific tasks. Due to its functional similarity to a human hand, it is also referred to as anthropomorphic [1].

The robotic hand is typically composed of a number of fingers, each having multiple independently controllable joints. Some robotic hands are designed to mimic the movement and capabilities of a human hand, while others are designed for specific tasks such as gripping and manipulating objects in manufacturing or surgical procedures. In general, robotic arms are highly versatile and can be customized for a wide range of applications, easily meeting the needs of all users.

Requirements analysis is the first step in defining the specific needs and preferences of individuals with hearing impairments. The analysis involves conducting user research to understand the communication issues faced by individuals with hearing disabilities and how a robotic arm can assist them. People with hearing impairments may experience social isolation, difficulties in finding employment, or participating in certain activities due to communication barriers. Based on the requirements analysis, the design of these robotic arms should be developed. The design includes the size and shape of the arm, the material used, the control system, and the sensors needed to detect and interpret sign language gestures. An important feature would be the incorporation of LED lights to provide visual cues corresponding to specific types of information. The pair of arms will also include the ability to adjust settings and commands to meet the user's needs.

Prototyping involves building the physical components, such as the arm structure, sensors, and integrating the control system. The prototype needs to be tested to ensure that it meets the requirements specified in the design phase. This includes testing the accuracy of the sign language recognition system, the reliability of the control system, and the ease of use for users. The robotic arms should cater to the needs of the target audience.

Comparative analysis with other competing products will help us obtain a pair of arms that are as efficient as possible, made of high-quality and durable materials. Through this analysis, we will make comparisons regarding dimensions, shape, weight, materials used, software control system, cost, and aesthetics.

2. Current stage

People with hearing impairments can have a variety of needs when it comes to robotic arms, depending on their specific communication preferences. Following the analysis of their needs, the most important ones are:

1.Sign language communication: Through robotic arms, users can easily communicate using sign language with individuals who are hard of hearing. With the help of the software used in the development of these arms, the message can be entered into a computer, and the arms will produce the necessary signs to convey the desired message.

2.Audio-visual feedback: Some individuals with hearing impairments can benefit from receiving audio or visual feedback from the robotic arms to help them understand spoken language or other sounds. The arms could provide visual cues or vibrations to indicate the presence and direction of a sound.

3.Environmental awareness: With the user's assistance, robotic arms can alert individuals to events in their surroundings that they may not be able to hear, such as fire alarms, earthquake alerts, natural disasters, or someone calling their name.

4.Announcement of important events: The arms can announce important events, upcoming appointments, or future changes to individuals.

5.Independence in communication: The advantage of using robotic arms is that they can transmit information regardless of the time without relying on others who know sign language.

6.Object manipulation difficulties: Robotic arms can provide guidance on the correct handling of objects.

7.Quality of life: Robotic arms can enable more efficient communication, thereby improving the quality of life by facilitating better social interaction and creating more opportunities.

8.Accident prevention: The arms can provide warnings regarding potential accidents.

9.Ensuring a pleasant atmosphere: The pair of robotic arms can determine the well-being of individuals with impairments, as their health status is crucial.

10.Reduced transmission time for information.

In general, understanding the specific needs of individuals with hearing impairments is crucial in designing a pair of robotic arms that are efficient, useful, and meet the requirements of the target audience. Conducting this research aids in the design and development process, ensuring that the final product is user-centered and addresses specific needs.

Comparative analysis of products.

Comparative analysis aims to objectively inform consumers about the quality characteristics of products, features that contribute to the overall quality of a product, and assist in the decision-making process of purchasing the desired and needed product. The purpose of this comparative analysis is to help consumers in acquiring products at a lower price, where the quality-to-price ratio is of importance [2]

Comparative analyses, despite their limitations, hold significant importance because through their conduction and consistent publication of the obtained results, they generate a remarkable influence on both consumers and producers. As a result of the analysis, consumers become more rational in their purchasing process [2].

Robotic arms are devices designed to perform a variety of tasks with precision and high accuracy, being utilized in a wide range of applications from manufacturing and assembly to healthcare and space exploration. In this comparative analysis, some of the most important aspects include the quality and durability of the materials used in their construction, cost-effectiveness, software used, arm weight,

component elements in their construction, time required for component printing and assembly, arm functionalities, and purchase price.

Pair of arms for individuals with hearing impairments.

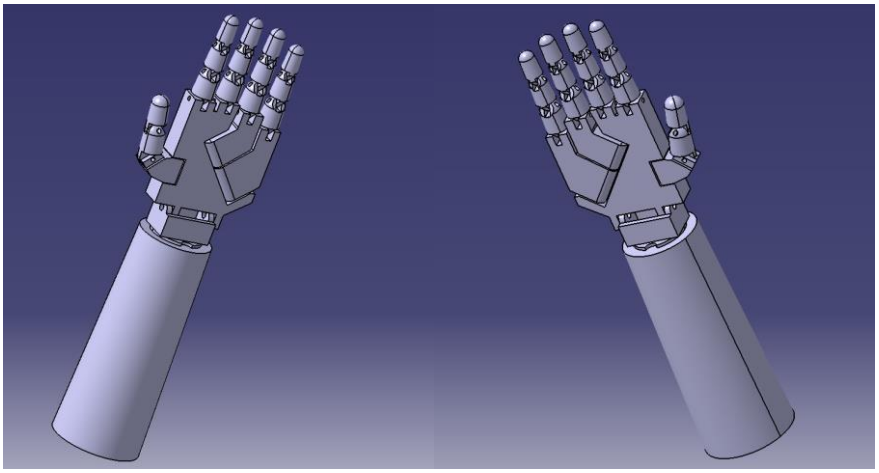

Fig. 2.1. The pair of arms

Competing products: ASLAN ROBOT

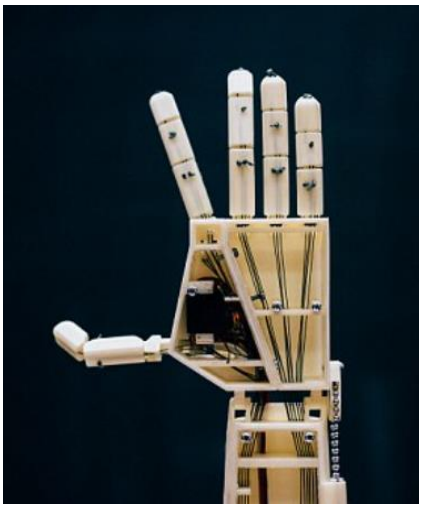

Fig. 2.2. ASLAN Robot [3].

ROBOT C

Fig 2.3. Robot C [4]

Comparative analysis regarding the materials used for constructing robotic arms.

Table 1. The materials used

Products	The materials used	Description of the materials used and consumed in their construction
ASLAN Robot	ABS Acrilontril-Butadien-Stiren	The main advantages of acquiring and using these robotic arms for individuals with hearing impairments are their low acquisition cost and high durability [5]. The quantity of material used for their construction is 4 kg.
Robot C	PLA FILAMENTS (Polylactic Acid)	The material used for this robotic arm is made from a corn starch-derived plastic called PLA (Polylactic Acid), which is known for being environmentally friendly and biodegradable [5]. The quantity of material consumed for the construction of this arm is 7 kg.
Pair of arms for individuals with hearing impairments	HIPS (High Impact Polystyrene)	HIPS (High Impact Polystyrene) is a dissolvable support material commonly used in conjunction with ABS (Acrylonitrile Butadiene Styrene) [8]. In the case of these arms, the quantity of material consumed for their construction is 5 kg.

Advantages and disadvantages of the materials used:
ABS (Acrylonitrile Butadiene Styrene) advantages:

- ABS material is inexpensive [6].
- It has excellent characteristics in terms of malleability, making it easily transformable into simple or complex shapes [6].
- It is very rigid, shock-resistant, and pressure-resistant [6].

Disadvantages:

- Made from petroleum, it is not an environmentally friendly solution [6].
- It is not resistant to certain solvents [6].
- It is not biodegradable [6].

PLA FILAMENTS (Polylactic Acid) advantages:

- Unlike other 3D filaments, PLA filaments are biodegradable [7].
- They have variable purchasing costs, depending on the quality offered by the respective product [7].
- It is a biodegradable material, which is one of its main advantages compared to other types of 3D filaments [7].

Disadvantages:

- It is not resistant to high temperatures and may discolor or deform when exposed to sunlight [7].
- It is not very durable over time, being a biodegradable material [7].
- It does not withstand prolonged use and may break or fracture [7].

HIPS (High Impact Polystyrene) advantages:

- Impact resistance [8].
- HIPS produces a smooth and uniform surface [8].
- It has good adhesion properties to the print bed and adheres easily [8].
- It can be used in combination with other materials [8].
- Easy to print [8].

Disadvantages:

- Sensitivity to moisture [8].
- May release harmful fumes [8].
- It can deform at very high temperatures [8].
- It can be more expensive than other materials [8].

Comparative analysis of weight and purchase price of the presented products.:

Table 2. Weight and purchase price

Products	Weight	Price
The pair of arms	7 kg	4000 USD
Robot C	10 kg	5000 USD
ASLAN Robot	8 kg	4500 USD

Comparative analysis of the software used in the design of the products

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Table 3. Software used

Products	Software used
The pair of arms	Arduino IDE
Robot C	Arduino IDE
ASLAN Robot	Arduino IDE

Comparative analysis of printing time, assembly time, and arm functions..

Table 4. Print time, assembly time, arm functions.

Products	Print time	Assambly type	Arms functions
The pair of arms	72 h	10 h	Sign language, LED alerts for messages.
Robot C	100 h	7 h	Sign language
ASLAN Robot	139 h	8 h	Sign language

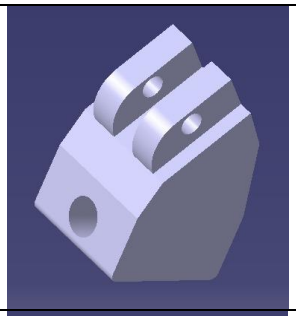
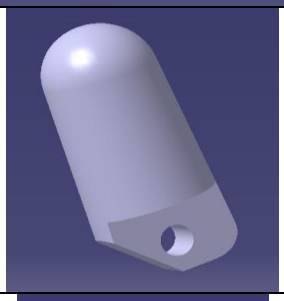
Comparative analysis of product components.

Table 5. Product components

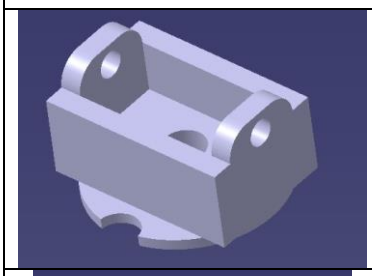
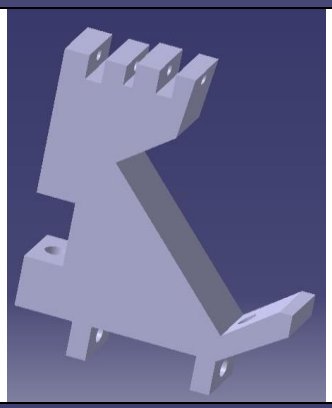
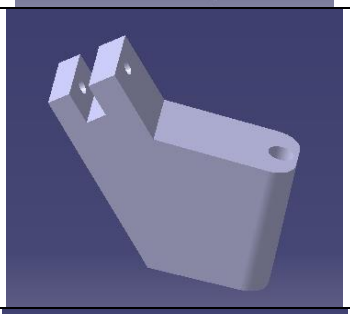
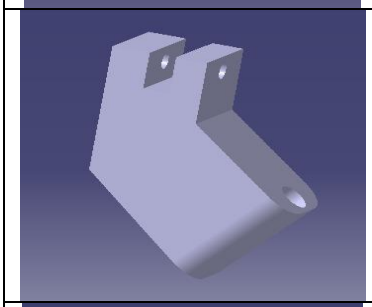
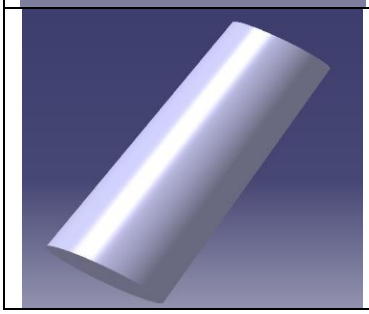
Products	Elemente componete
The pair of arms	10 servo motors 360 degrees, wheels that attach to the motors to wrap the threads for finger extension and contraction, Arduino UNO, connection wires, USB cable, power supply, 3 LEDs, HIPS material, 20 pieces per arm without additional fastening elements, 12V power source, finger stretching system.
Robot C	Arduino UNO, 5 servo motors, rubber bands, servo extension cables, and Arduino cables.
ASLAN Robot	25 3D-printed plastic parts, 16 servo motors, 3 motor controllers, an Arduino Due microcomputer, connecting wires, and ABS material.

Components of pair of arms

Table 6. Components

Robotic arms	Name of the element	Number of pieces	Element description
	Thumb support	2	The thumb support ensures the connection between its subassembly and the palm.
	Phalange 1	10	Phalange 1 ensures the connection with phalange 2 and 4 to the rest of the assembly.
	Phalange 2	8	Phalange 2 ensures the connection with phalange 1 and 3 to the rest of the assembly.
	Phalange 3	8	Phalange 3 being the tip of the fingers ensures the connections with the rest of the components in the finger.
	Phalange 4	2	Phalange 4 being the tip of the thumb ensures assembly with the rest of the components in the finger.

Continued of Table 6

	Wrist joints	2	The wrist joint has the role of connecting the other components of the assembly with the robotic arms.
	The palm of the arms	2	The palm ensures the connection between the fingers and the wrist supports of the arms.
	Support for the little finger	2	The support ensures the assembly between the phalanges and the palm.
	Ring finger support	2	The support ensures the assembly between the phalanges and the palm.
	Arm	2	The arm supports all the components of the assembly and is the most important part.

3. Conclusions

In conclusion, based on the analysis of needs, the most important needs of potential customers have been identified, and the pair of robotic arms is highly suitable for meeting and satisfying these needs. One of the most significant needs is the need for communication with individuals who are hearing loss. In many cases, these individuals feel marginalized because they cannot hear, which can lead to further health problems, depression, and anxiety. Communication with this group of people can contribute to improving their well-being. The comparative analysis of competing products with our product highlighted the importance of assembly, additive manufacturing, weight**,** and design. The comparative analysis aimed to assist potential customers in choosing the right product.
The comparative analysis emphasizes the most important aspects of our product as well as those of competing products. The results are as follows:
-All the presented products use the same type of software.
-The difference in materials used is significant, with HIPS material being of higher quality compared to the others, albeit at a higher price.
-Regarding component manufacturing, all are produced using additive manufacturing on 3D printers.
-The cost of acquisition varies, with Robot C being the most expensive and our product being the most affordable.
-The functions of competing products are similar, focusing on sign language communication, while our pair of arms also includes information conveyed through the color of illuminated LEDs.
-The weight differs among the products, with Robot C being the heaviest and the pair of arms being the lightest.
-In terms of material quantity used in the manufacturing process and assembly time, the pair of arms can be constructed and assembled in the shortest time.
-The component elements are relatively similar among the products, with minor differences. However, the pair of arms utilizes more elements that contribute to their correct and reliable functionality.
Nevertheless, robotic arms are not a substitute for human interaction and communication. They are tools that can assist individuals with hearing impairments in various ways. Human connections and social interactions remain vital for mental and emotional well-being. Robotic arms designed for individuals with hearing impairments can be a useful tool for communication and interaction.

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