HOME AUTOMATION TECHNICAL OVERVIEW

TECHNICAL DOCUMENTATION

NATIONAL AWARDS WINNING PROJECT

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I - GENERAL OVERLOOK

Abstract

This paper presents a home automation system that is tailored to the custom needs of its users. By offering personalization, efficiency, sustainability and cost-effectiveness, this custom solution provides a unique approach to creating a more comfortable home environment. The system combines hardware components with software features to create an automated system that can be easily customized for each user's individual needs. In addition, the system provides energy savings through its efficient use of resources and cost savings due to its low initial investment and long-term affordability. Finally, the paper discusses how this system can be used as an effective way to reduce energy consumption in homes while providing convenience and personalization for the user.

The proposed home automation system consists of several components that work together to provide a comprehensive and customized solution. The first component is a web-based user interface that allows users to customize their home environment, such as temperature, lighting, security settings and other preferences. This interface is linked to the hardware components of the system which include sensors, controllers and actuators. These components are connected to the user interface through a wireless network, allowing users to access the system remotely from any location.

The sensors and controllers are responsible for detecting changes in the environment such as motion or temperature changes, and then sending this data back to the user interface for further processing. The actuators then take action based on this data by performing tasks such as turning.

Objective

The objective of the proposed home automation system is to provide a comprehensive and customized solution for users to control their home environment. This will be achieved by implementing several components, including a web-based user interface, hardware components such as sensors, controllers, and actuators, and a wireless network connecting them. The system aims to offer a more cost-effective and efficient automation solution that reduces investment and saves time.

II - AWARDS

The robotic arm competed in eight different competitions, and these were its results ordered according to the grandeur of the competition:

- Medal INVENTICA - INVENTICA 2018
- Diploma of excellence - Euro INVENT 2018
- Second prize - RoSEF 2018
- Diploma Procopiu (first prize) - The creativity competition in physics and technologies "Ștefan Procopiu" (the county stage)
- Diploma Procopiu (first prize) - The creativity competition in physics and technologies "Ștefan Procopiu" (the national stage)
- Third prize - ICE-USV (Innovation and Creative Education University "Ștefan cel Mare" Suceava)
- First prize - The national competition of electronic constructions T.E.A.M. 2018
- Certificate of attendance - Euro INVENT 2018

III - History of automation

Brief history

The history of home and garage automation devices dates back to the early 20th century when the first **automatic garage door** opener was invented by **C.G. Johnson** in **1926**. However, it was not until the 1980s that home automation began to take off with the introduction of X10, a communication protocol for home automation devices and so, in the **1990s**, the concept of a "smart home" emerged.

Several companies began to develop home automation systems that integrated various technologies such as lighting, heating, and security systems. Unfortunately, these systems were often expensive and complex to install, limiting their adoption.

The **2000s** saw a rise of wireless communication technologies such as Wi-Fi and Bluetooth, which made it easier and more cost-effective to connect home automation devices. Companies such as **Nest** and **Philips** introduced smart thermostats and lighting systems that could be controlled using a smartphone, paving the way for widespread adoption of home automation.

In recent years, voice-activated assistants such as Amazon's Alexa and Google Assistant have become popular home automation devices, allowing users to control their home environment using voice commands. Additionally, the development of the Internet of Things (IoT) has enabled the integration of various devices and systems, allowing for more seamless and integrated automation.

In the garage, the development of automatic garage door openers has continued, with advancements in technology such as sensors that prevent the door from closing if an object is in its path. Additionally, smart garage door openers have been introduced that can be controlled using a smartphone, providing added convenience and security.

Overall, the history of home and garage automation devices has been characterized by advancements in technology and increasing affordability and accessibility, leading to widespread adoption and integration into everyday life.

Remarkable models

Smart Irrigation Systems: Smart irrigation systems use sensors and weather data to monitor soil moisture levels and adjust watering schedules accordingly. This results in more efficient water usage and healthier plants. These systems can be controlled remotely through a smartphone app, providing homeowners with real-time information and control over their irrigation systems.

The first prototype of a smart irrigation system was developed in the **1970s** by the **United States Department of Agriculture**. This system used soil moisture sensors to monitor and control irrigation in agricultural fields.

Robotic Lawn Mowers: Robotic lawn mowers are a revolutionary solution for lawn care automation. These devices use sensors and GPS to navigate lawns and cut grass autonomously. They can be programmed to operate on a schedule and return to their charging station when the job is complete. Robotic lawn mowers are quieter, more efficient, and require less maintenance than traditional gas-powered mowers.

The first robotic lawn mower was developed by the Swedish company **Husqvarna** in **1995**. Known as the "Automower," this device used sensors and boundary wires to navigate and mow lawns autonomously.

Smart Garage Door Openers: Smart garage door openers allow homeowners to control their garage doors remotely through a smartphone app. These devices provide added security features, such as real-time alerts when the garage door is opened or closed. Some smart garage door openers also include motion sensors and cameras, allowing homeowners to monitor their garage remotely. Additionally, these systems can be integrated with other smart home devices, such as Amazon Alexa or Google Assistant, for seamless automation control.

The first prototype of a smart garage door opener was developed by the company **Chamberlain** in the early **2000s**. Known as the "LiftMaster MyQ," this system used a wireless network to connect garage doors to a smartphone app, allowing homeowners to control their garage doors remotely.

Overall, these three revolutionary solutions demonstrate the potential of home garage and garden automation to improve efficiency, convenience, and sustainability. As technology continues to advance, we can expect to see even more innovative solutions emerge in this space.

IV - Current solutions

Types of automations

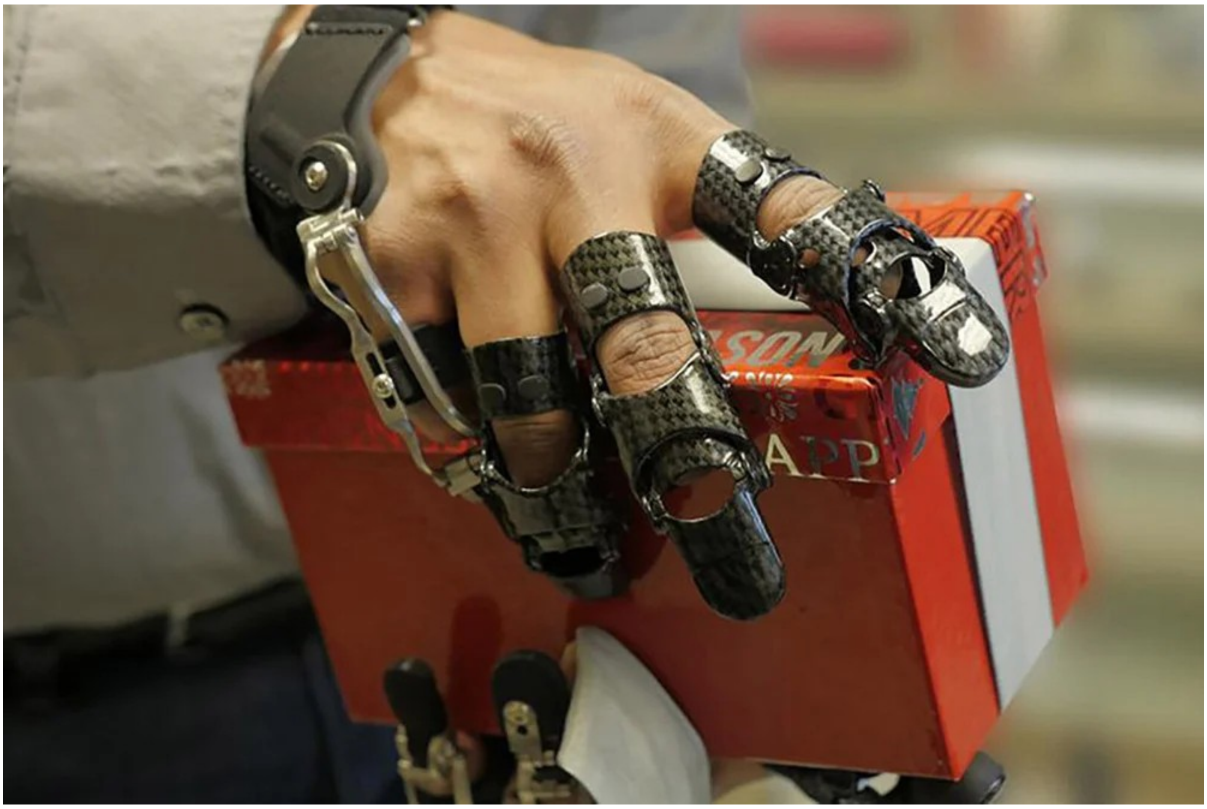
There are several types of automation that are currently being used across various industries, including:

- Industrial Automation: This includes the use of machines and robots to perform tasks in manufacturing and production facilities. Examples include automated assembly lines, robotic welding, and material handling systems.
- Home Automation: This refers to the automation of household tasks and appliances, such as controlling lighting, temperature, and security systems using smart devices.
- Process Automation: This involves the automation of business processes such as data entry, document processing, and customer service. Examples include automated email responses and chatbots.
- Robotic Process Automation (RPA): This is a type of process automation that involves the use of software robots to automate repetitive tasks such as data entry and processing.
- Artificial Intelligence (AI) Automation: This involves the use of machine learning and other AI technologies to automate complex decision-making processes, such as fraud detection and predictive maintenance.
- Cognitive Automation: This is a type of AI automation that involves the use of natural language processing (NLP) and other cognitive technologies to automate tasks that require human-like decision-making and reasoning.

On the following pages there are pictures showing the different types of automations mentioned above.

NO PROSTHESIS

PASSIVE PROSTHESIS



BODY-POWERED PROSTHESIS

ELECTRICALLY POWERED (MYOELECTRIC) PROSTHESIS

HYBRID PROSTHESIS

ACTIVITY-SPECIFIC PROSTHESIS

V - Design process

Electronics used

The parts used in this project were chosen based on their compatibility with other parts, ease of programming, and compactness.

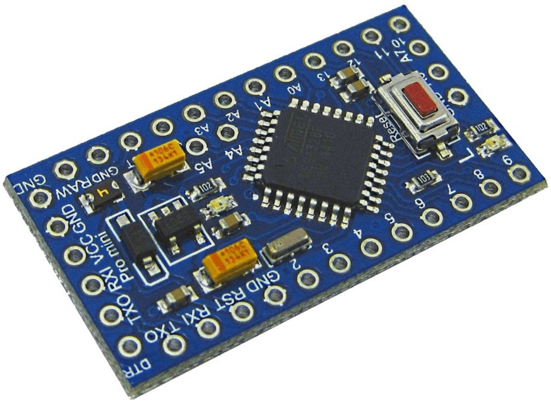
This project was built on the Arduino platform, using the Pro Mini model. This board is small and available in 3.3V and 5V versions, powered by the ATmega328P.

The motors were chosen based on their power development per occupied volume and the MG996R servomotors were an obvious choice. MG996R is an upgraded version of MG995 servo, and its PCB and IC control system makes it far more accurate. Its internal gearing and motor have also been upgraded to improve dead bandwidth and centering. It is generally a great choice for RC airplanes, helicopters, cars, and many more applications.

The prosthetic arm also has a SG90 servomotor used directly for the thumb movement. Being tiny, lightweight, and with a sufficiently high output power, it was an easy choice for the sensor.

EMG MyoWare is the sensor of choice for measuring muscle contraction signals and bringing it to an usable digital reading. Other passive components were used for the power supply part of the circuit.

On the following page are pictures of the components used.



ARDUINO PRO MINI

MG996R

SG90

EMG MyoWare

Programming

The main logic of the program is based on how the sensors react when the user tenses the forearm muscle. When the muscle is in a medium level of tension, the sensors provide a value that's greater than 100mV, but not greater than 200mV. This tells the program to run. When the muscle is relaxed, the sensors read lower than 70mV. This signals the program to make a change.

A servo library helps to program and control the robotic arm. In the source code can be found many functions that are specific to the Arduino board, which help with the limited amount of memory available. A good understanding of the C++ programming language is needed in order to make sure the program runs quickly on the microcontroller.

Main specifications of the microcontroller can be summed up by the clock frequency (16Mhz), storage (32KB ROM and 2KB RAM) and architecture (8-Bit AVR). More detailed information can be found in the datasheet of the chip (ATMega328P).

3D Design

Three-dimensional (3D) printing is an additive manufacturing process that creates a physical object from a digital design. The process works by laying down thin layers of material in the form of liquid or powdered plastic, metal or cement, and then fusing the layers together. 3D printing is a very fast and easy way to get prototypes from a digital format in physical form. The main advantages are as following:

- Cost effectiveness
- Flexibility and speed
- Reliability

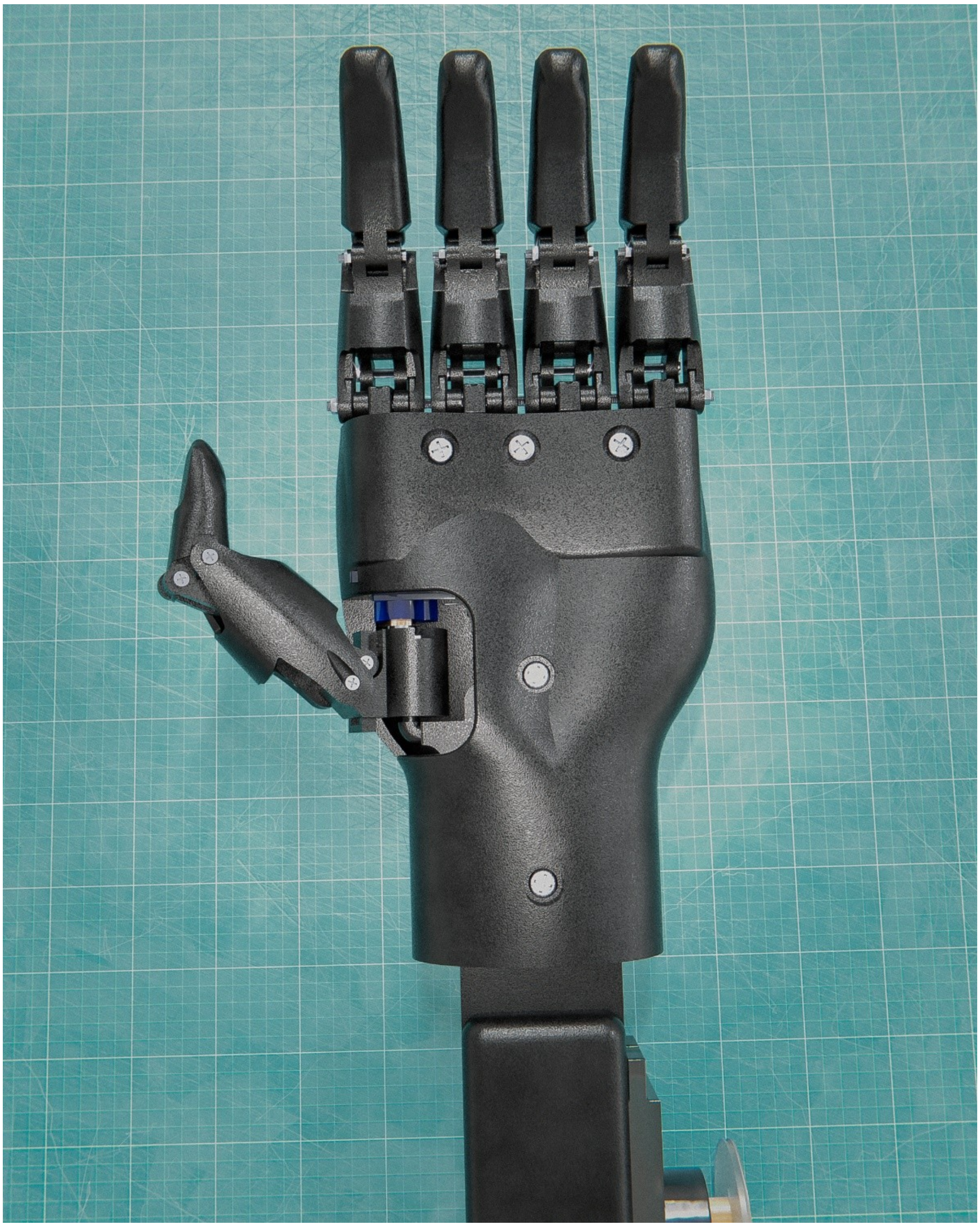
As a single-step manufacturing process, 3D printing saves time and costs associated with using different machines for manufacturing as it uses only the amount of material needed for the part itself with little or no waste. 3D printing allows for more complex designs without the design restrictions of traditional manufacturing processes. It speeds up prototyping by manufacturing parts within hours and is cheaper and quicker than machining. Design modifications can be completed at a more efficient rate and the printer can work without constant supervision.

The main material for 3D printing is plastic, although some metals can also be used for 3D printing. However, plastics have advantages because they are lighter than their metal equivalents. Not only can the fabrication of a part be time-saving with 3D printing, but the design process can also be very fast with the creation of print-ready STL or CAD files. Parts are produced using only the materials needed for the part itself, with little or no wastage compared to alternative methods that are cut from large pieces of non-recyclable materials.

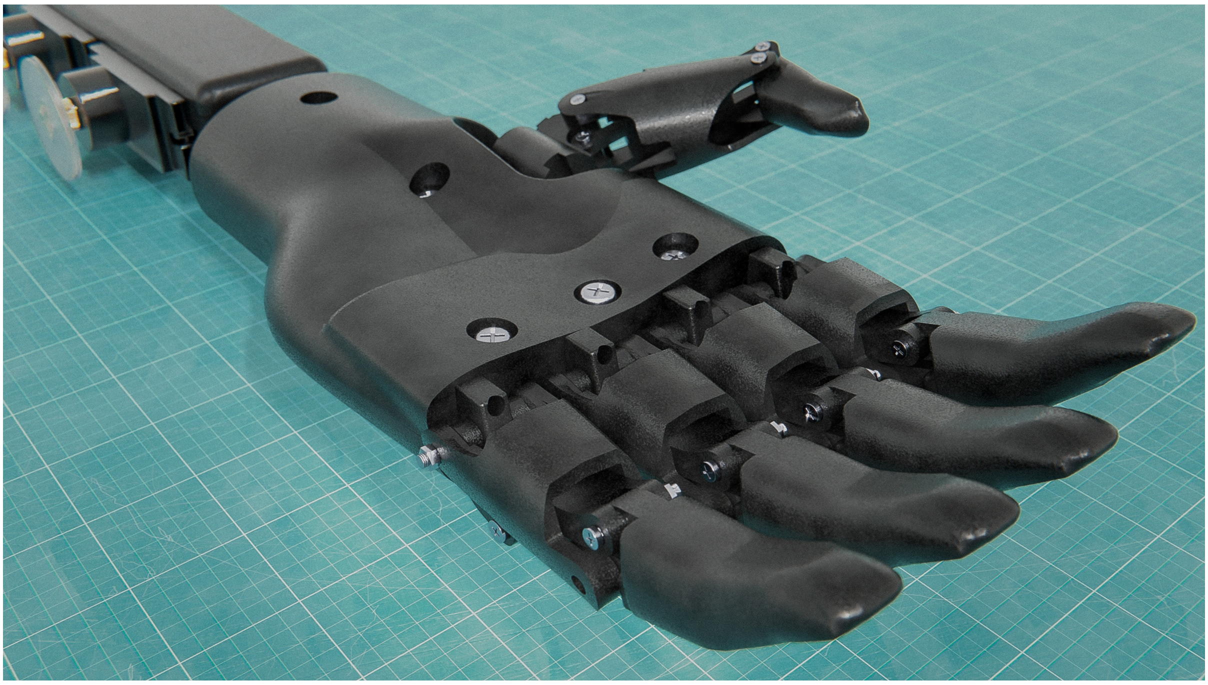
Upgrades

The biggest improvement in bionic prostheses is from the point of view of the materials used in their structures. The next biggest improvement is in methods of controlling the motors. One solution I propose is using flex sensors to copy the movements of the user's organic hand. Structurally, materials such as carbon fiber or steel can be used in place of plastic. A fine balance between cost and resistance is set by the usage purpose of the auxiliary arm.

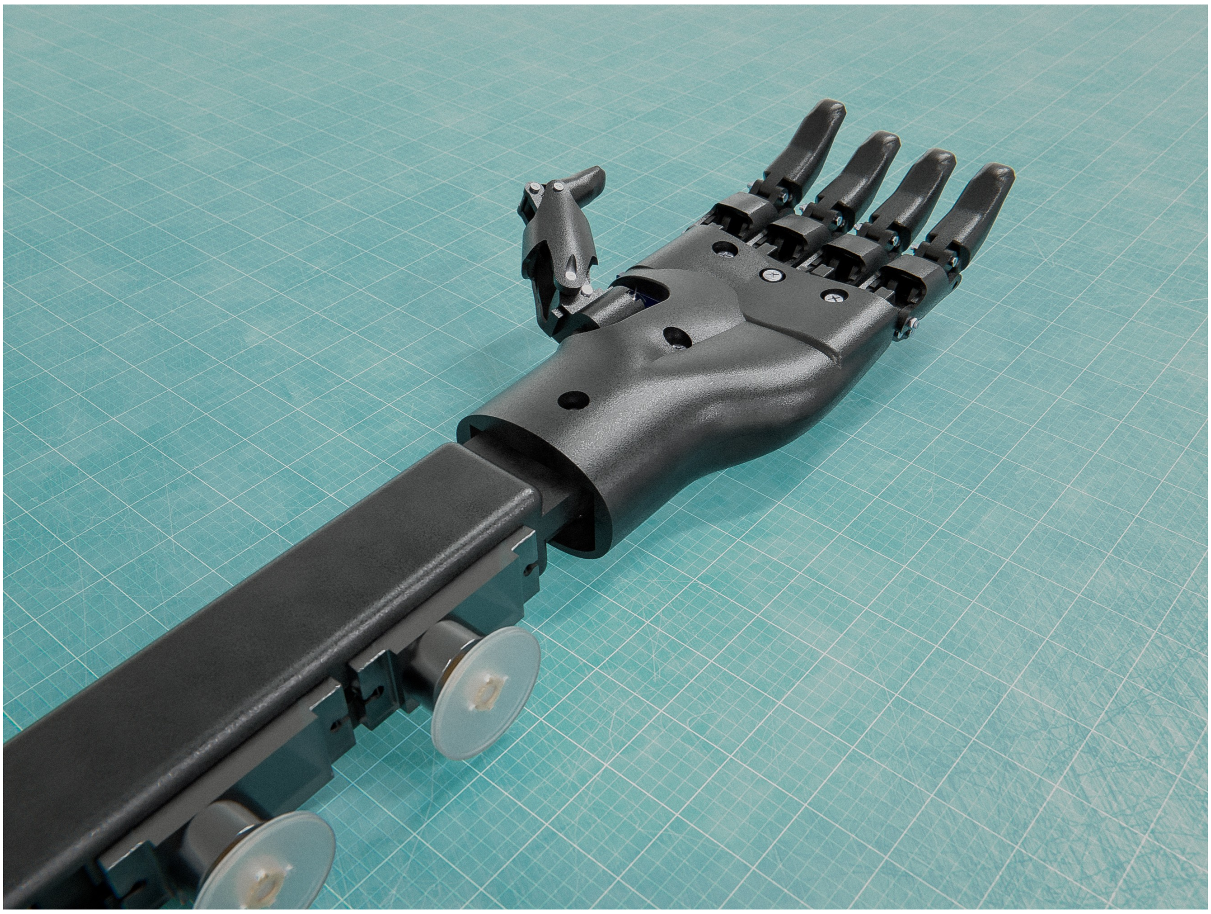
On the following pages there will be pictures of the actual 3D printed robotic arm.



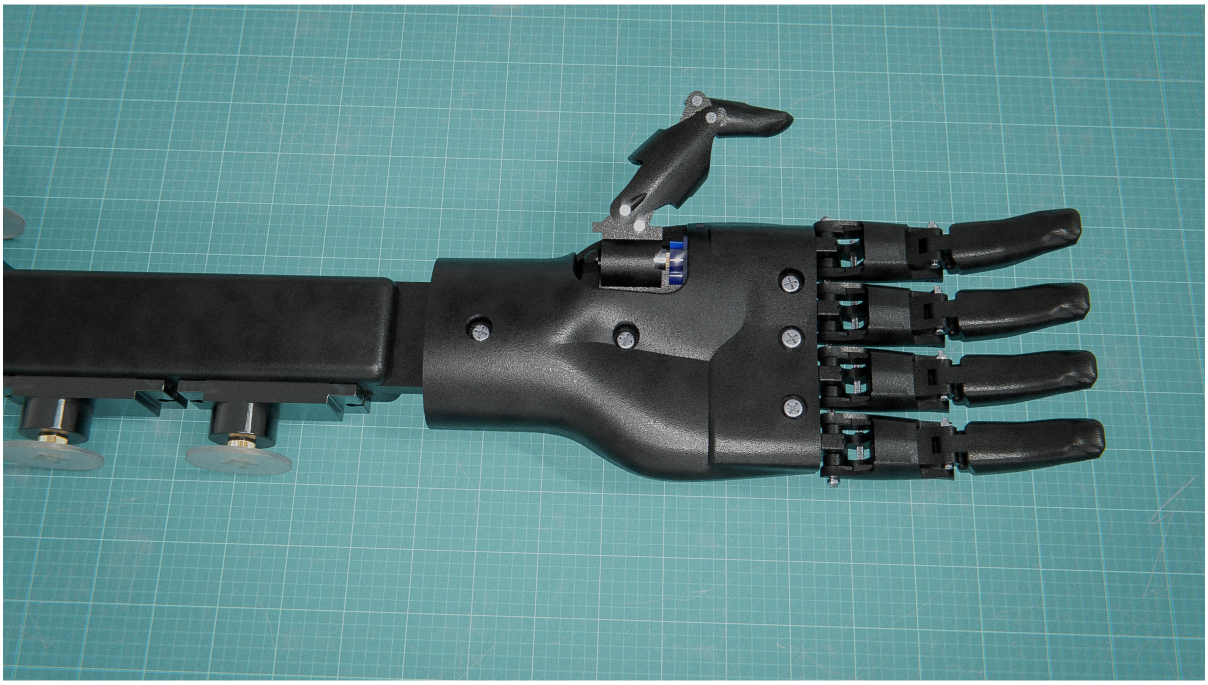
1 - TOP VIEW OF THE PALM



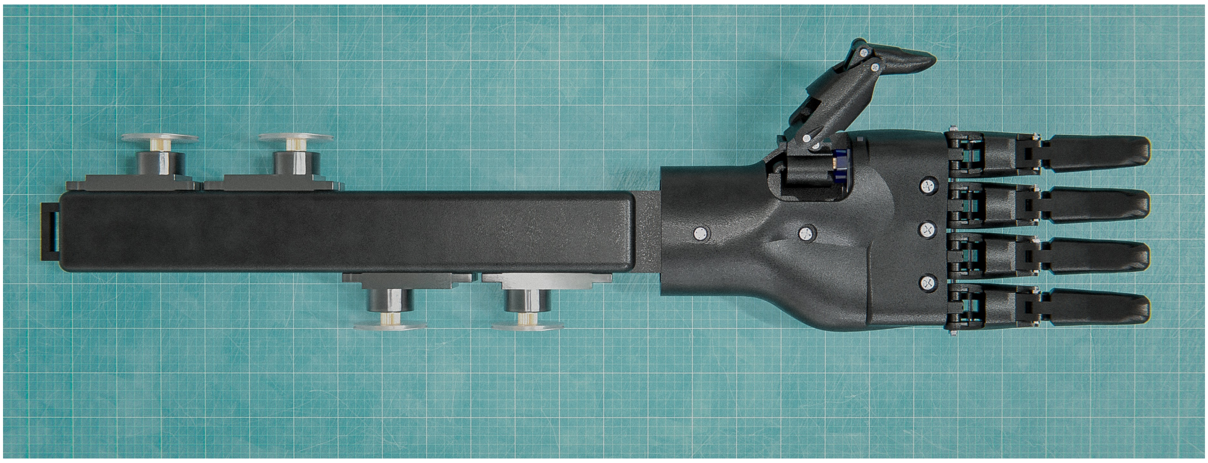
2 - FINGERS CLOSEUP



3 - WRIST AND FOREARM



4 - PALM AND FOREARM



5 - THE ROBOTIC ARM IN ITS ENTIRETY

VI - SOURCES

1. Datasheets on the component's manufacturer's site
2. armdynamics.com/our-care/prosthetic-options
3. twi-global.com/technical-knowledge/faqs/what-is-3d-printing/pros-and-cons
4. wikipedia.org/wiki/3D_printing
5. ncbi.nlm.nih.gov/pmc/articles/PMC4128433/