Theme name	Development of Metal Myoelectric Hand Prothesis with Lightweight and Robust Optimal Design generated by Generative Design
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Technical field	Manufacturing, Medical and Industrial Collaboration / Life Sciences, IT

Overview

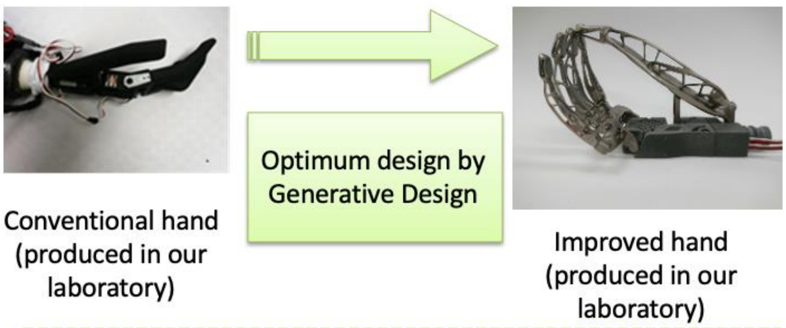
We have developed a lightweight and robust metal myoelectric prosthetic hand using an optimization design tool called Generative Design. As a result, we were able to achieve the lightest weight while maintaining the robustness required for myoelectric prosthetic hands. Furthermore, by introducing a torsion spring with moving parts only in the gripping direction at the joins of the four-finger bases, the necessary pinch force (force to grasp an object) is ensured while receiving an unexpected external force.

We looking forward to hearing from those who are willing to utilize this technology.

Schematic Image

Entire image of the myoelectric prosthesis

Myoelectric hand prosthesis



Improved Points

- The composition of hand changed from resin to metal
- Lightweight design achieved while maintaining necessary strength using Generative Design
- The necessary pinch force (force to grab an object) retained while receiving external force by introducing a spring mechanism to the joints of four fingers

Background

A myoelectric hand prosthesis is a type of prosthetic hand that supports the life of the people with upper limb defects by moving the hands based on reading the electrical potential difference generated when a muscle contracts. In our laboratory, we have developed a small, lightweight, and inexpensive myoelectric hand prothesis that can perform the necessary functions in daily life. The myoelectric hand prosthesis developed by our laboratory consists of three parts: the robot hand, the forearm socket, and the upper arm fixing part. However, the robot hand of the conventional myoelectric prosthesis manufactured in this laboratory is made of resin produced by a 3D printer that there remains a problem in robustness when used in daily life.

In order to solve this problem, we conducted joint research with a glasses manufacturer called Sharman in Sabae City, Fukui Prefecture, adopted an optimization design tool called Generative Design, and developed a metal myoelectric prosthetic hand that achieves both weight reduction and the strength required for hands. In addition, we have succeeded in obtaining the pinch force (force to grasp an object) required for the hand by utilizing Sharman’s manufacturing technology for glasses frames, improving the joint parts, and using the spring structure.

We welcome those who are interested in this technology and those who are willing to utilize and collaborate.

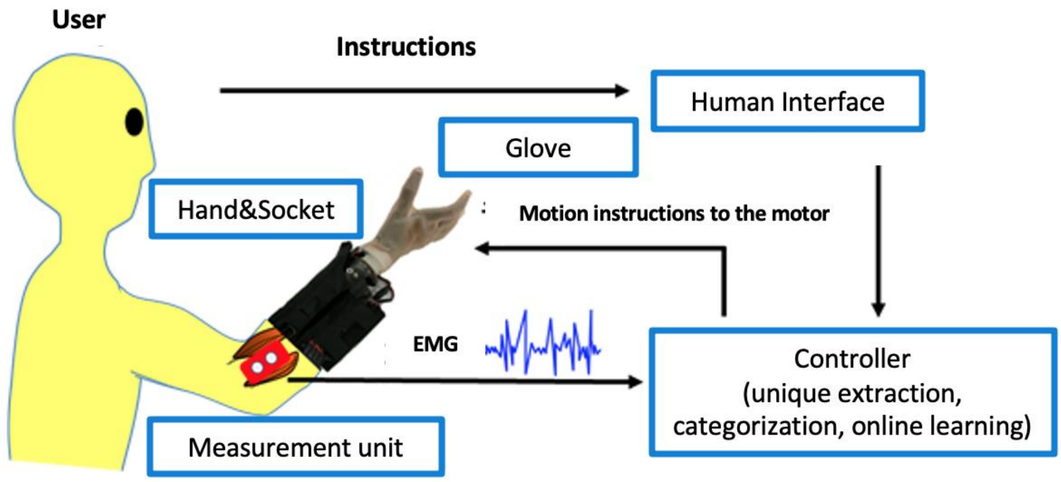
Technical content

[Outline of the myoelectric hand prosthesis]

The external view of the system is as follows.

- The system is divided into 3 types: robot hand, forearm socket, and upper arm fixing part.
- The robot hand has a built-in motor.
- The forearm sock has a controller, a battery, and on/off signal.
- The upper arm fixing part has an interface for reading surface electromyogram.
- The product weighs only a few hundred grams and is compact.

The user sends an intention to the controller that he or she wants to “move the hand like this” and also sends a myoelectric signal from the measuring unit to the controller. After the controller learns the correlation between the myoelectric signal and the intention, the intention of the movement is estimated from the myoelectric signal, and the instructions are sent to the motor in the robot hand to realize the hand motion.

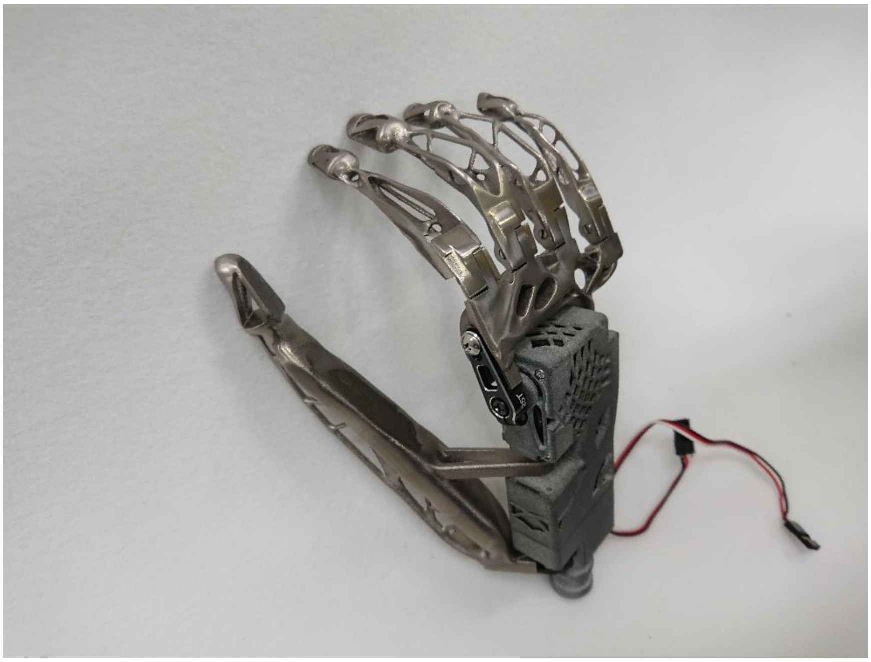


[Improved hand part]

Assuming that the myoelectric prosthetic hand is freely used in daily life, it is necessary to have the one that does not get damaged in any motion, is lightweight and comfortable to use.

For this reason, the robot hand part of the myoelectric prosthesis has been optimally designed by Generative Design to achieve both the required strength and weight reduction.

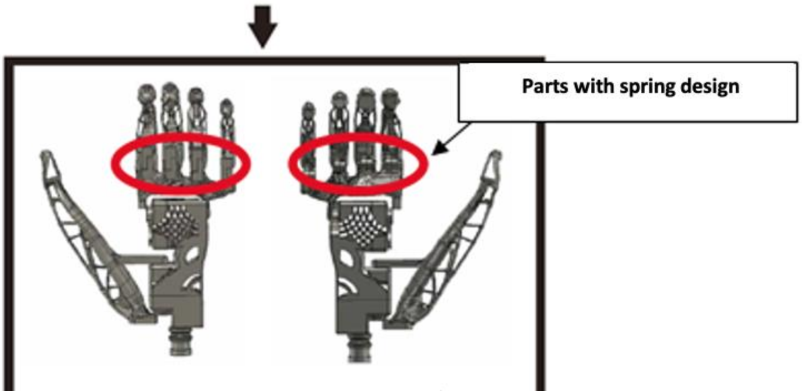
Generative Design automatically designs part geometry based on load cases and various requirements. The Generative Design was used to optimize the design by conducting simulations with multiple parameters. As a result, we succeeded in producing a lightweight hand part that has the strength required for myoelectric prosthetic hands.



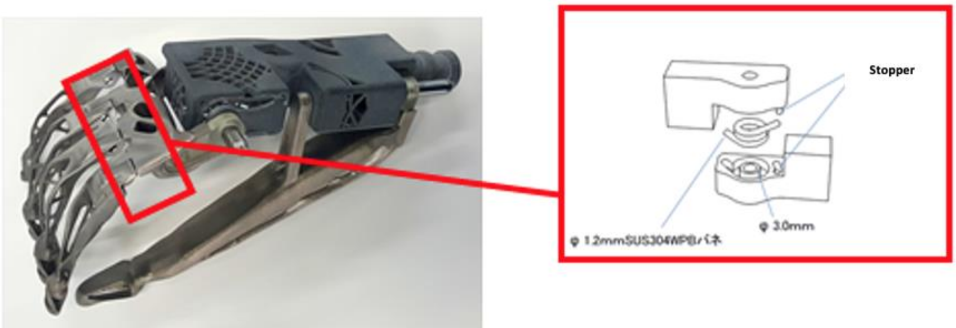
Furthermore, by applying the glasses frame manufacturing technology of a glasses manufacturer in Sabae City, we have devised a structure to obtain the pinch force (force to grasp an object) necessary for the hand. We also examined the design that can release external force by utilizing the features of metal springs in the joints of the hand part.
After verifying the springs used for the joints, we decided to use torsion springs (a type of coil spring) for the following reasons.

1) Safety against coil breakage
2) Easy to replace with different spring pressures.
3) No discomfort in appearance.
4) Can suppress the lateral movement of fingers due to the hinged structure.

Hand design (the University of Electro-communications)



Final CAD Model
Fingers design (Sharman Co., Ltd)



Parts with spring design and the spring structure

The difference between the hand weight and the pinch force (force to grasp an object)

Hand type	UEC e-Hand For adults/Resin-made (Conventional Hand)	UEC e-Hand Titanium Version For adults/Titanium-made (CAD calculations)	New hand For adults/Titanium-made (by Generative Design)
Weight (g)	120	423g	274
Pinch force (N)	About 7	About 7	About 13

The ideal weight of the adult hand prosthesis is 370g or less. However, the new hand can be well below this weight, and the pinch force (force to grasp objects) is approximately two times as large as that of the UEC e-hand (the conventional hand.)

Strengths of the technology and know-how (novelty, superiority, usefulness)

(1) Can perform Activities of Living (ADL)

The developed myoelectric hand prothesis can perform the minimum activities of daily living (ADL) required by humans.

The human hand has 25 degrees of freedom in movement, including the movement of hand and wrist, and there are various possible postures. To achieve these functions with a myoelectric prosthetic hand, it is necessary to have the same degree of freedom as human hands. For this reason, most of the research on electric prosthesis aims at realizing more complex movements by increasing the number of degrees of freedom so that they are closer to the movements and functions of human hands. However, a myoelectric prosthesis using an electric prosthesis that can be controlled in multiple degrees of freedom has not been put into practical use. The main reasons are size and weight. Since the number of actuators corresponding to the degree of freedom is required, the multiplicity of the electric prosthesis has a trade-off relationship with the weight. Thus, a multi-degree prosthesis is larger and heavier than a low-degree prosthesis, which is difficult to support with one hand.

The prosthetic hand developed in our laboratory is compact and lightweight while satisfying the functions necessary for performing daily activities.

(2) Robust metal, compact and lightweight

<u>Due to the optimization of Generative Design, the prosthetic hand developed in this study is compact and lightweight while being made of robust metals</u>

Image of Partner Companies

We welcome inquiries from those who are interested in this myoelectric prosthetic hand, as well as the companies, such as nursing care and rehabilitation equipment manufacturers that are willing to commercialize and distribute the product.

Utilization of the technology and know-how (image)

1) We aim to realize the necessary hand movements in daily life for the people with upper limb defects by wearing this myoelectric hand prosthesis. The following are required for performing the minimum activities of daily living (ADL) that people need: (a) grip force; (b) precise grip; (c) side grip; (d) hook force; (e) three-sided grip; (f) pointing; (g) gesture. Also, of the ADL, 35% is grip force, 30% is precise grip, and 20% is side grip. These three types of grip postures enable 85% of ADL.
   An electric prosthetic hand that meets the minimum degree of freedom to perform the necessary hand functions is lightweight and suitable for daily use correspondingly.
2) The device can be used for rehabilitation of those with paralyzed hands and arms. Usually, when the arm is paralyzed, the muscles become still when the hand is clasped.

Flow of the utilization of the technology and know-how

Please feel free to contact us if you are interested in utilizing this technology.

Explanation of technical terms

[Myoelectric prosthesis]

Myoelectric hand prosthesis is a kind of artificial hand. Muscles contract when the receptors receive acetylcholine, which is realized by nerves that recognize weak electrical impulses from the brain. Although the electric potential generated at this time is weak, it can be detected even on the body surface. This is called “surface myoelectric potential,” and it serves as a switch to move the myoelectric prosthetic arm.

The operation method differs depending on the user, but in many cases, the muscle that moves the severed part is used as a switch. For example, when the wrist is severed, certain rules on the method of generating the surface potential are set for the movement of the artificial hand, such as setting the surface potential generated when the write bends to the palm side as “grasping” and that generated when the wrist bands to the backside as “releasing.”

In this way, the myoelectric prosthetic hand is operated by sensing the surface potential and turning the switch on and off when the output exceeds a certain threshold. The built-in motor makes it possible to grasp and release objects, and reproduces the hand that moves by the person's own will.

[Generative Design]

Generative Design is a method to generate various designs in a short time based on a basic design of the computer, by setting conditions that constrain the design such as the type, weight, and cost of materials. The product is characterized by its novel design that does not refer to the traditions and customs that are unconsciously performed by humans.

[Pinch force]

Pinch force if the power to hold something with the fingertips. For example, is it the force required when a person twists or opens the faucet.

Activities of Living (ADL)

It refers to the minimum motions necessary for people to live their daily lives. Specifically, it refers to the actions of standing up, climbing, moving, eating, dressing, excreting, bathing, and grooming. It is used as an index at nursing care sites to measure the physical ability and daily life level of elderly people and the disabled.