

# Artificial intelligence makes gripping of prosthetic hands more intuitive

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Hand prostheses are the specialty of scientists Dr. Patricia Capsi-Morales (left), Prof. Cristina Piazza (center), and doctoral student Johanna Happold from the Technical University of Munich (TUM). Credit: Technical University Munich

Artificial hands can be operated via app or with sensors placed in the muscles of the forearm. New research from the Technical University of Munich (TUM) shows that a better understanding of muscle activity patterns in the forearm supports a more intuitive and natural control of

artificial limbs. This requires a network of 128 sensors and AI-based techniques.

Technological developments in recent decades have already led to advanced artificial hands. They can enable amputees who have lost a [hand](#) through accident or illness to regain some movement. Some of these modern prostheses allow independent finger movements and wrist rotation. These movements can be selected via a smartphone app or by using [muscle](#) signals from the forearm, typically detected by two sensors.

For instance, the activation of wrist flexor muscles can be used to close the fingers together to grip a pen. If the wrist extensor muscles are contracted, the fingers re-open and the hand releases the pen. The same approach makes it possible to control different finger movements that are selected with the simultaneous activation of both flexor and extensor muscle groups. "These are movements that the patient has to learn during rehabilitation," says Cristina Piazza, a professor of rehabilitation and assistive robotics at TUM.

Now, Prof. Piazza's research team has shown that [artificial intelligence](#) can enable patients to control advanced hand prostheses more intuitively by using the "synergy principle" and with the help of 128 sensors on the forearm. The work is [published](#) in the *2023 International Conference on Rehabilitation Robotics (ICORR)*.

## **The synergy principle: The brain activates a pool of muscle cells**

What is the synergy principle? "It is known from neuroscientific studies that repetitive patterns are observed in experimental sessions, both in kinematics and muscle activation," says Prof. Piazza. These patterns can be interpreted as the way in which the human brain copes with the

complexity of the biological system. That means that the brain activates a pool of muscle cells, also in the forearm.

"When we use our hands to grasp an object, for example a ball, we move our fingers in a synchronized way and adapt to the shape of the object when contact occurs," says Prof. Piazza. The researchers are now using this principle to design and control artificial hands by creating new learning algorithms.

This is necessary for intuitive movement: When controlling an artificial hand to grasp a pen, for example, multiple steps take place. First, the patient orients the artificial hand according to the grasping location, slowly moves the fingers together, and then grabs the pen. The goal is to make these movements more and more fluid, so that it is hardly noticeable that numerous separate movements make up an overall process.

"With the help of machine learning, we can understand the variations among subjects and improve the control adaptability over time and the learning process," concludes Patricia Capsi Morales, the senior scientist in Prof. Piazza's team.

## **Discovering patterns from 128 signal channels**

Experiments with the new approach already indicate that conventional control methods could soon be empowered by more advanced strategies. To study what is happening at the level of the central nervous system, the researchers are working with two films: one for the inside and one for the outside of the forearm. Each contains up to 64 sensors to detect muscle activation. The method also estimates which [electrical signals](#) the spinal motor neurons have transmitted.

"The more sensors we use, the better we can record information from

different muscle groups and find out which muscle activations are responsible for which hand movements," explains Prof. Piazza. Depending on whether a person intends to make a fist, grip a pen or open a jam jar, "characteristic features of muscle signals" result, according to Dr. Capsi Morales—a prerequisite for intuitive movements.

## **Wrist and hand movement: Eight out of ten people prefer the intuitive way**

Current research concentrates on the movement of the wrist and the whole hand. It shows that most people (eight out of ten) prefer the intuitive way of moving wrist and hand. This is also the more efficient way. But two of ten learn to handle the less intuitive way, becoming in the end even more precise. "Our goal is to investigate the learning effect and find the right solution for each patient," Dr. Capsi Morales explains.

"This is a step in the right direction," says Prof. Piazza, who emphasizes that each system consists of individual mechanics and properties of the hand, special training with patients, interpretation and analysis, and machine learning.

## **Current challenges of advanced control of artificial hands**

There are still some challenges to address: The learning algorithm, which is based on the information from the sensors, has to be retrained every time the film slips or is removed. In addition, the sensors must be prepared with a gel to guarantee the necessary conductivity to record the signals from the muscles precisely.

"We use signal processing techniques to filter out the noise and get usable signals," explains Dr. Capsi Morales. Every time a new patient

wears the cuff with the many sensors over their forearm, the algorithm must first identify the activation patterns for each [movement](#) sequence to later detect the user's intention and translate it into commands for the artificial hand.

**More information:** K. C. Tse et al, Exploring Muscle Synergies for Performance Enhancement and Learning in Myoelectric Control Maps, *2023 International Conference on Rehabilitation Robotics (ICORR)* (2023). [DOI: 10.1109/ICORR58425.2023.10304809](https://doi.org/10.1109/ICORR58425.2023.10304809)

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