FURTHER READING

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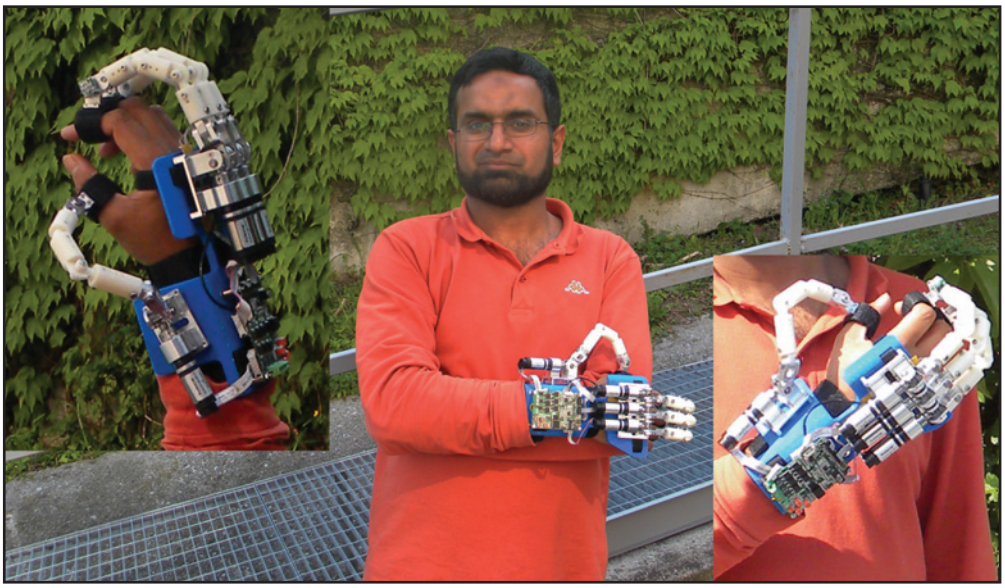
'Four-fingered light-weight exoskeleton robotic device accommodating different hand sizes', J. Iqbal, N.G. Tsagarakis and D.G. Caldwell

A lightweight, flexible, under-actuated exoskeleton hand with a wide range of potential applications from medicine to entertainment

a helping hand



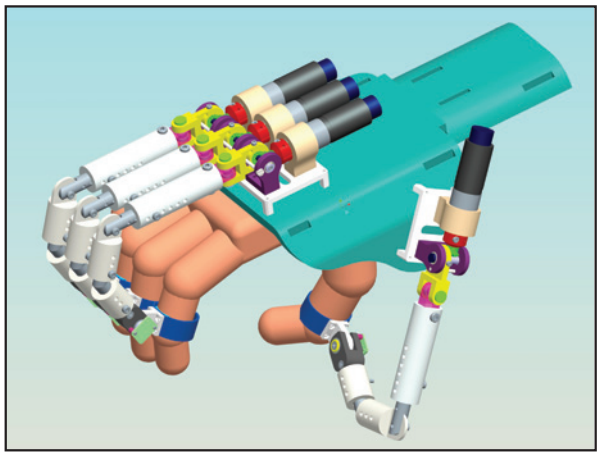
A lightweight, **flexible,** under-actuated exoskeleton hand has been created in work from the Italian Institute of Technology (IIT), Genova, Italy. Intended as a general purpose device, the four-finger design is now being explored as a medical rehabilitation aid but has wide potential from assisted living to virtual reality.

Assistance and augmentation

Robotic exoskeletons are designed to monitor and assist the movements of an operator. Dr Jamshed Iqbal, one of the IIT researchers, describes their role as "combining machine power and human intelligence to enhance a user's sensing and manipulation capabilities."

There are many potential assistive applications of this kind of technology from helping to restore a 'normal' level of strength or motion to allowing operators to exert forces in excess of their normal potential. There are also applications in remote operation of physical devices and interaction with virtual worlds – allowing a user to 'feel' them.

In the context of rehabilitation, a hand exoskeleton can be used to assist physiotherapists in managing a patient's recovery from a stroke or other hand injury. Exoskeletons, because of their wide range of sensory capabilities, are rapidly substituting traditional assessment of stroke patients. Therapies using robotic hand exoskeletons offer benefits in terms of accuracy, precision and repeatability over the manual methods and passive devices used previously. Exoskeleton-based therapies can also be integrated with virtual reality to transform monotonous rehabilitation exercises into engaging and appealing tasks like games.



TOP: The exoskeleton hand is compact and lightweight and compatible with a range of hand sizes
BOTTOM: A CAD model view of the complete mechanism

Power on hand

The hand exoskeleton presented in this issue of Electronics Letters, by a team from the IIT's Advanced Robotics Department, Genova, has an under-actuated four-finger design that is highly portable and can accommodate a range of hand sizes.

In creating it, the team has aimed to combine good features from previous designs to address the ergonomic and mechanicals challenges of the human hand. These spring mainly from the restricted space available and the multiple degrees of freedom (DOF) in our hands, combined with the need for a small and light device to make it practical and relatively comfortable in use.

These constraints have led to most previous designs being remotely actuated via cables, with actuators located on the forearm or off-body entirely. These cables introduce extra friction and also require continuous tension control.

In contrast, the Genova design has a directly-driven mechanism with actuators mounted directly on the back of the hand. Direct transmission also offers advantages in terms of force bandwidth and enhanced stiffness range. "Such a manipulator like configuration, composed of rigid links interconnected by joints can be designed to function like a human hand," Iqbal explained. "Moreover, we believe that the objectives of a hand exoskeleton cannot be achieved by solutions employing a large number of actuation units trying to power all or most of the finger phalanges. This will certainly result in uncomfortable, cumbersome and bulky devices not suitable for repetitive periods of operation. Our under-actuated mechanism reduces the required number of actuators and also permits passive adaptation of each finger according to the shape of a grasped object."

Home help

The team's aim has been to develop a general purpose device rather than concentrating on a specific application. The four-finger design, which attaches to the larger three fingers and thumb, is based on computational and experimental exploration of both the way a human hand moves and the possible designs for the mechanisms of the exoskeleton.

The rapid prototype of the proposed design is now being tested by a range of people and the team reports positive user feedback. Preliminary experimental trials confirm that their design can assist finger flexion and extension motions in a natural and coordinated way. Clinical trials are under-way to further access the device performance.

The team is working with rehabilitation professionals to develop VR-based rehabilitation strategies to test the exoskeleton with stroke patients. They also believe their design has great potential in motion assistance for activities of daily living (ADL) applications. "In the near future, the device will be integrated with an arm exoskeleton currently under development to create a complete upper-extremity exoskeleton system," said Iqbal.

When asked what the next ten years could hold in this area, the team talked about the possibility that lightweight, portable and even fashionable exoskeletons could be used by people to interact with technology in daily life, as commonplace as smart watches are now becoming. However, they see rehabilitation and motion assistance remaining the primary application, but with a move from clinics-based exoskeletons to modules at home, customised to a patient's exercise requirements.

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