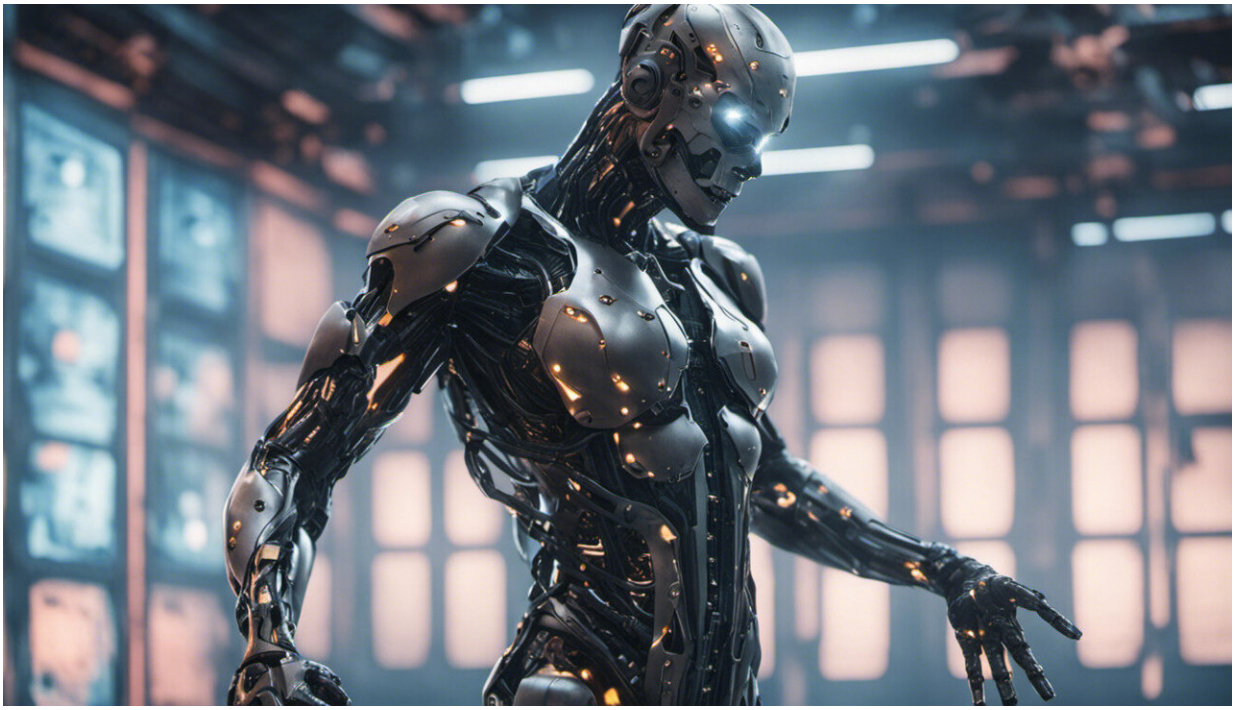
Moving exoskeletons from sci-fi into medical rehabilitation and therapy

July 14 2016, by Rana Soltani-Zarrin, Amin Zeiaee, And Reza Langari



Credit: AI-generated image (disclaimer)

Chances are, you've seen a person using a powered exoskeleton – what you might think of as a sort of bionic suit – but only in the movies. In the 2013 movie "Elysium," for example, Matt Damon's character has an exoskeleton that makes his body stronger and faster than it would otherwise be. Simply described, they are devices that can be externally

worn, resembling the skeleton of the body part they are attached to and able to provide support in many ways.

That technology isn't just in science fiction; it really exists and has even been commercialized. It supports devices that enhance human strength, assist disabled people and even provide rehabilitation after injuries. Our work focuses on helping stroke patients' recovery.

Every year, 15 million people worldwide suffer a stroke. More than 85 percent of them survive, but only 10 percent recover completely. The rest must deal with mobility impairment and cognitive disabilities.

Stroke victims can get help relearning skills they have lost or learn new ways of performing tasks to compensate for lost abilities. The most effective rehabilitation is specific to the skills the patient needs, and of sufficient intensity and duration to truly retrain the nerves and muscles involved. However, the number of trained human therapists who can provide this support is limited, while the demand is growing, particularly as populations age.

We at the Laboratory for Control, Robotics and Automation (LCRA) at Texas A&M University are working to help solve this problem by developing an intelligent robotic device that can provide therapy services in hospitals and clinics as an enhancement to conventional therapy methods. Our device will be connected to a patient's upper arm and back during therapy sessions, providing individualized movement assistance to increase strength and flexibility. Such a device benefits therapists by reducing the physical load of their jobs, and patients by providing affordable and widely available therapy opportunities.

A growing need

The number of elderly people worldwide is growing, as life expectancies

increase. The U.S. Census Bureau estimates that the number of Americans age 65 or over will double by 2050. Research suggests that people in that age group have an increased risk of suffering a stroke. We expect the number of stroke survivors who need rehabilitation services to rise significantly in the near future.

According to the U.S. Bureau of Labor Statistics, the number of occupational therapy and physical therapy jobs is expected to increase 27 percent and 34 percent, respectively, by 2020. Though interest in the field is growing, the American Academy of Physical Medicine and Rehabilitation projects the current physical therapist shortage will increase significantly in the upcoming decades. Efforts to keep rehabilitation at its current service quality could result in a shortage of as many as 26,000 physical therapists by 2020; improving service or updating it to reflect ongoing research will require even more people.

Initial development of the exoskeleton was at the Laboratory for Control, Robotics and Automation at Texas A&M University. Author provided

Robots for rehabilitation

While there remain a number of things that only human therapists can do , many rehab exercises are highly repetitive. This is where robotic systems excel: They can perform the same task countless times, with precision and accuracy without fatigue or loss of attention.

Many researchers around the world have developed robotic devices for rehabilitation purposes. These devices are typically designed specifically to work on patients' paralyzed arms or legs. Many clinical studies

confirm the effectiveness of automated therapy; in some cases it is even better than conventional therapy. However, there is still a long way to go.

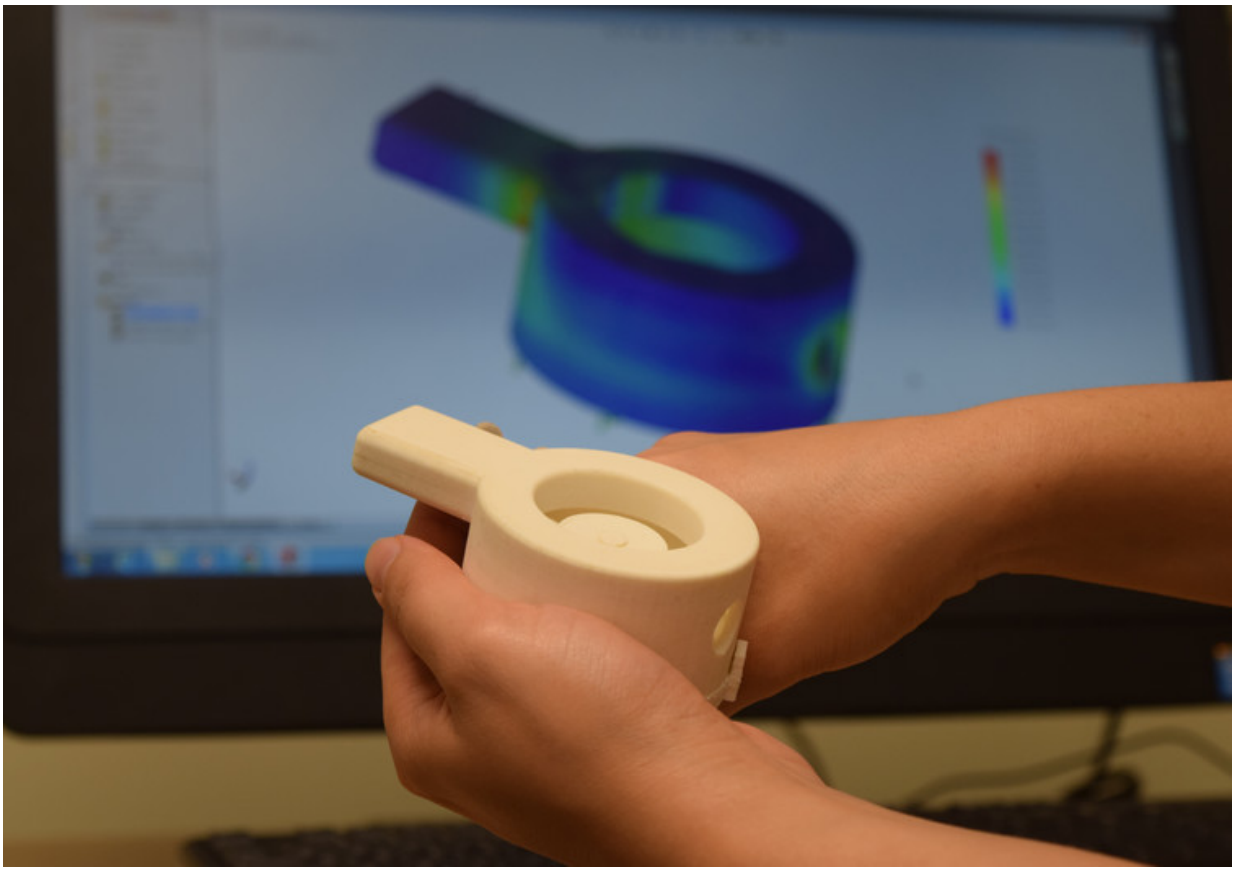
Challenges of automated therapy

Despite the many benefits robotic based rehabilitation can offer to society, not many clinics are equipped with such devices. Rehabilitation exoskeletons often require very complicated design and control processes, which usually result in bulky, heavy and expensive devices. In addition, patient trust or comfort with a therapist might be reduced when interacting with a robot.

These challenges limit the usage of robotic devices to research centers and a few rehabilitation centers. Considering the significant role of exoskeletons in the future of rehabilitation, it is time to address these challenges.

How our robot solves these challenges

Our work is focused on developing a lighter, more compact robotic exoskeleton device that can help stroke patients recover strength and motion in their arms. To this end, we have done detailed analysis of even the simplest device components.



Performing a close analysis of device components. Author provided

While development is ongoing, we are using new technologies and have adopted the most recent findings of rehabilitation science research to build a device that better prepare patients for activities of daily living. In addition to helping stroke patients, this device can also be used for rehabilitation of other patients with arm disabilities or injuries.

The technical evaluations of the device will be completed on the Texas A&M campus in College Station early next year. Once the safety of device is guaranteed, we will test it on real stroke patients in Hamad Medical Center in Doha, Qatar by fall 2017.

Looking to the future

Our final goal is to develop home-based exoskeletons. Currently portability, high costs and limitations on the performance of the available systems are the main barriers for using rehab exoskeletons in patients' homes. Home-based rehabilitation could dramatically improve the intensity and effectiveness of therapy patients receive. Robots could, for example, allow patients to start therapy in the very early stages of recovery, without having to deal with the hassles of frequent and long visits to clinics. In the comfort of their own homes, people could get specific training at the appropriate level of intensity, overseen and monitored by a human therapist over the internet.

Maximizing therapy robots' ability to help patients depends on deepening the human-robot interaction. This sort of connection is the subject of significant research of late, and not just for patient treatment. In most cases where people are working with robots, though, the human takes the lead role; in therapy, the robot must closely observe the patient and decide when to provide corrective input.

Virtual reality is another technology that has proven to be an effective tool for rehabilitation purposes. Virtual reality devices and the recently developed augmented reality systems can be adapted to use with rehab exoskeletons. Although linking the real and virtual worlds within these systems is a challenging task, an exoskeleton equipped with a high fidelity virtual- or augmented-reality device could offer unique benefits.

These opportunities are challenging to be realized. But if we manage to develop such systems, it could open a world of fantastic opportunities. Imagine automated rehabilitation gyms, with devices specific to different motions of different body parts, available for anyone who needed them. But there are even more miraculous possibilities: Would no one need a wheelchair anymore?

These devices can also help reduce the social isolation many stroke patients experience. With the aid of augmented reality tools, therapy robots can help patients interact with each other, as in a virtual exercise group. This sort of connection can make rehabilitation a pleasant experience in patients' daily lives, one they look forward to and enjoy, which will also promote their recovery.

This technology could have everyday uses for healthy individuals, too. Perhaps people would one day own an exoskeleton for help with labor-intensive tasks at home or in the garden. Factory workers could work harder and faster, but with less fatigue and risk of injury. The research is really just beginning.

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