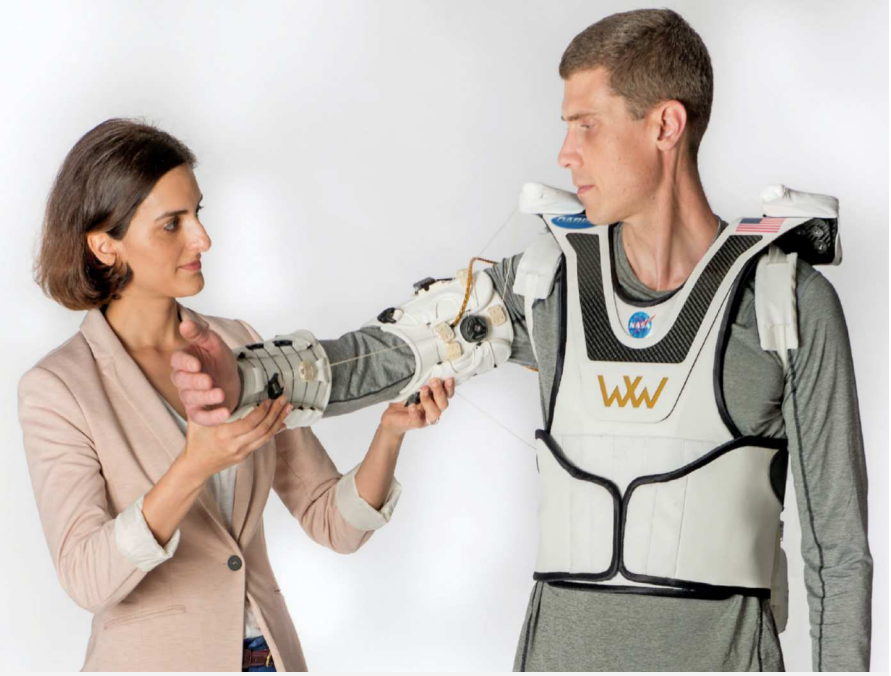

National Aeronautics and Space Administration

Robotics, Automation and Control

Upper Body Robotic Exoskeleton

A Lightweight, Portable Garment for Active Shoulder and Elbow Positioning

Innovators at the NASA Johnson Space Center (JSC) have developed a soft, wearable, robotic upper limb exoskeleton garment designed to actively control the shoulder and elbow, both positioning the limb in specific orientations and commanding the limb through desired motions. The invention was developed to provide effective upper extremity motor rehabilitation for patients with neurological impairments (e.g., traumatic brain injury, stroke). Due to its portable, battery-compatible design, NASA's garment allows for task-specific and intensive motor practice, an important part of rehabilitation for such patients, to be performed outside clinical environments (including in the home). In addition to upper extremity motor rehabilitation, the technology may also find applications in human performance augmentation, including in future spacesuit designs.

BENEFITS

- *Shoulder and elbow positioning:* Positions the limb as programmed (e.g., for rehabilitation exercises), capable of isolating shoulder and elbow degrees of freedom
- *Portability:* Unlike ground-based wearable robotics, the garment can be used outside the clinic, enabling task-oriented therapy (performing functional tasks as opposed to simple prescribed motions)
- *Comfort:* The soft design utilizes rigid components only when necessary, effectively distributes loads around the torso to eliminate pressure points, and is easy to don and doff
- *Multiple control modes:* Operators can select how much resistance is applied at the joint and set the device in different modes

technology solution

THE TECHNOLOGY

NASA's soft, portable, wearable robotic device is "plug and play" - it includes all necessary electronics, actuation, software, and sensors required to achieve augmented limb movement. The garment is designed such that the human-robot interface distributes load across the torso, maximizing user comfort. Donning and doffing is simple, as the device lowers over the head, straps to the torso via Velcro, and possesses adjustable custom arm cuffs. Actuators are housed in the back of the garment, which pull custom conduit-tendon-based systems attached to the limb at optimized locations, causing the joint of interest to move to the specified orientation. Force sensing is employed to enable optimal control of the limb, measuring user-applied force to maintain commanded joint orientations. Integrated electronics and software provide power distribution, safety monitoring, data transfer and data logging.

NASA's garment has multiple modes of operation. In active assist mode, shoulder abduction and flexion, and elbow flexion, may be commanded either simultaneously via coordinated control or individually while holding position/orientation of the other joints. In passive assist mode, the user can freely move the limb while the system provides minimal torque to the shoulder and elbow.

The upper body robotic exoskeleton is at a TRL 6 (system/subsystem prototype demonstration in a relevant environment) and it is now available for your company to license and develop into a commercial product. Please note that NASA does not manufacture products itself for commercial sale.

Weight (without battery):	**18.5 lbs.**
Voltage input:	**48 VDC**
Peak tendon force:	**100+ lbs.**
Minimum joint speeds:	**30+°/s**

APPLICATIONS

The technology has several potential applications:

- Upper-limb motor rehabilitation
- Assistance with upper-limb activities of daily living
- Human performance augmentation: enhancing human strength and reducing muscle fatigue for industrial and military applications
- Spacesuit designs: providing astronauts with additional strength to accomplish safer, more efficient spacewalks

PUBLICATIONS

Patent Pending

"On the Efficacy of Isolating Shoulder and Elbow Movements with a Soft, Portable, and Wearable Robotic Device," Kadivar Z., Beck C.E., Rovekamp R.N., O'Malley M.K., Joyce C.A. (2017) https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20160007499.pdf

More Information

National Aeronautics and Space Administration

JSC Licensing Manager

Johnson Space Center

2101 NASA Parkway
Houston, TX 77058
281-483-3809
jsc-techtran@mail.jsc.nasa.gov

http://technology.nasa.gov/

www.nasa.gov

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