Wearable Robots for Worker Assistance – 17464

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ABSTRACT

Wearable Robots is a fast growing field with exoskeleton devices focused on augmenting, enhancing, and assisting human movement and strength. Devices have been designed for people with spinal cord injuries, stroke survivors, medical rehabilitation, assistance to the elderly, and recreation to aid in sports. For manufacturing and industry, devices are quickly being developed that allow the human and the robot to interact in a synergistic fashion to accomplish a task.

INTRODUCTION

Wearable robots are being designed to enhance the safety and productivity of workers in manufacturing and industry. Systems are being designed that use passive structures as compared to active systems that increase strength and can add force or speed to the user. Some systems use a rigid structure to transfer the load to the ground while other systems use soft, flexible structures. The goals of these systems are to reduce loads felt by the user, improve productivity, minimize fatigue, and enhance safety.

PASSIVE SYSTEMS

Passive exoskeleton devices use no external power to relieve stress and fatigue. Some devices transfer the load carried by the operator to the ground. Devices include the Lockheed Fortis, Ekso Works Industrial Exoskeleton, and the British Aerospace OLAD device (Orthotic Load Assistance Device), see Figure 1. These devices allow someone to hold a heavy object with reduced fatigue by canceling the gravitational force. The devices usually consist of a gravity balancing arm connected to a leg structure that transfers the load to the ground through the sole of the shoe. As the user manipulates the tool in their workspace, an upward force is created by the arm to eliminate the need to resist the gravitational force.

Other passive ergo-exoskeletons include devices that do not transfer the load all the way down to the ground, see Figure 2. Some devices transfer the load to the back or to the legs such as the Laevo device and the StrongArm device that use springs or cords to help to lift objects. The Laevo device uses springs at the waist to assist when leaning over. The reaction forces are felt at the upper chest and against the front of the thighs.

A new class of device includes the chairless-chair that helps a user to sit or squat in place with reduced fatigue in the back and legs. These devices hold the user in place when squatting but snap out of place into free motion when walking around, see Figure 3.



Figure 1: Passive Exoskeletons assist when holding large tools, (a) Lockheed Fortis device, courtesy, Lockheed Martin (b) Ekso Works Industrial Exoskeleton, courtesy, Ekso Bionics, (c) Orthotic Load Assistance Device, courtesy, British Aerospace Engineering.

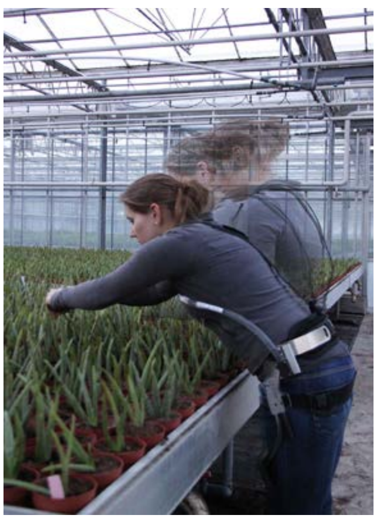


Figure 2: Devices assist the lower back when holding or carrying objects: (a) Laevo device uses springs at the waist to assist the body when leaning over, courtesy, Laevo, (b) Ergo-skeleton uses a clutch and cords to assist when lifting, courtesy, StrongArm.

ACTIVE SYSTEMS

Active exoskeletons can use motors, hydraulics, or pneumatics to supply an assistive force to help the operator. The current challenges include the bulk of the device and seamless interaction with the user. Many devices are heavy and metabolic cost is greatly increased. However, new devices are augmenting the metabolic cost and making it easy to carry loads or walk faster [1-5]. One must build devices that pay for their weight penalty.

Figure 3: Devices make squatting easier, courtesy, Noonee.

Legged hip exoskeletons are being designed to help operators lift objects by Cyberdyne, Honda, Pansonic Activelink, Innophys, SpringActive and others, see Figure 4. The hip devices can sense the user's motion and apply an assistive torque. Arm devices are being created that also help a user to lift objects or hold a tool above their head. Research includes work by the RoboMate Group and the Arm Exoskeleton from the Stuttgart, Fraunhofer Institute, see Figure 5.

CONCLUSIONS

In the near future, passive exoskeleton devices will be used to assist users in lifting and holding tasks. Quickly, active exoskeleton devices will allow for human-robot cooperation with the environment. These devices will allow operators to hold objects overhead, palletize objects, and lift objects. The current goal is to not create super-human strength but to reduce fatigue and make the task easier. These systems will not replace the human but will rely on human experience and knowledge to complete and finish a complex task while supplying an assistive force.

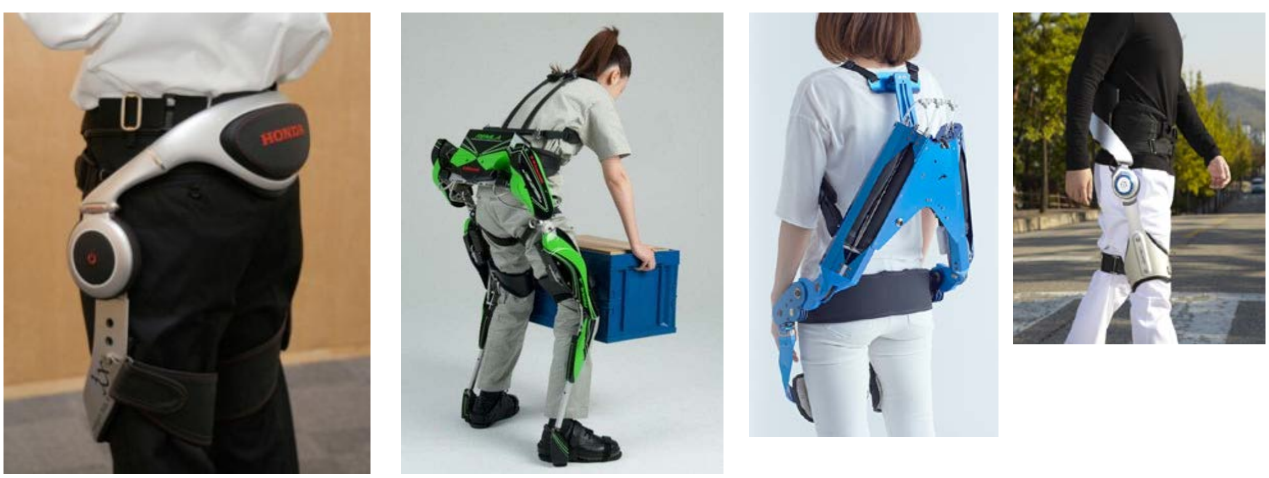

Figure 4: Active exoskeletons assist when lifting objects and aid walking. From left to right, and top to bottom: a) Honda Stride Assist exoskeleton, courtesy Honda, b) Kawasaki Exoskeleton for Multi-Labor Assistance, courtesy Kawasaki, c) Innophys hip exoskeleton, courtesy Innophys, d) Hexar hip exoskeleton, [6] e) Cyberdyne Lumbar exoskeleton, courtesy Cyberdyne, f) Panasonic Activelink hip exoseketon, courtesy Panasonic, g) HeSA, hip exoskeleton for superior performance [7].

Figure 5: Exoskeletons aid lifting objects: a) Robomate system [8], b) Fraunhofer arm exoskeleton [9]

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