An exoskeleton is an anthropomorphic, structural device that works in conjunction with the body’s natural architecture to aid in limb mobility. Exploiting biomimetic design, the device may be worn in close proximity to the body and transmits torques via powered revolute joints and structural limbs. Controllable, wireless robotic exoskeletons offer significant potential in restoring lost limb function, and enhancing natural human strength. Our team has designed and manufactured a powered, upper body exoskeleton for use in occupational lifting with applications in physical therapy.

38 metal components were custom designed and manufactured using either a full 3-axis automated Haas CNC Mini-Mill Vertical Milling Center or a Haas CNC Lathe. Non-load bearing components, including electronic mounts, were 3D printed using a photopolymer printer (Objet30).

Control is achieved using a master computer (BeagleBone) for high level processing and a low level microcontroller (M2). The exoskeleton is actuated using a remote control and Maxon motor encoder values. Joint angle data is generated from Hall Effect sensors mounted on all four exoskeletal revolute joints. The M2 receives the encoder and Hall Effect signals and sends them to the master computer over serial communication. The master computer runs the full position based PD control loop, updates the motor speed, and actuates the ratchet brake.

The system is powered using two 18.5V LiPo batteries, with a breaking strength of 2,200 lbs, which allows for a factor of safety of 6.5:1 when the suit is operating at maximum capacity.

A mechanical braking system is integrated to allow the user to hold a static load. This is accomplished by an actuated ratchet and pawl system which delivers unidirectional locking to the elbow joint. A 48-tooth ratchet allows for eighteen possible holding configurations within the arm’s range of motion. The braking system’s interlocking components are fabricated from 316 stainless steel in order to improve holding strength, prevent part wear, and reduce the size of the subsystem. The brake is engaged and disengaged upon command from the operator, and requires approximately 1.9 W to switch states.

Overall, the system weighs 20 pounds and can provide powered lifting achieved by a single cable drive-actuated joint local to the user’s elbow. The system is battery powered, which allows for untethered operation in a variety of environments. With a high ratio of usage to charge time (40 minutes to 2 hours), the device is an ideal candidate for workplace use. The exoskeleton is an ideal candidate for workplace use.