

## **An Improved Smart Ankle Foot Orthosis Design Using Dual Fluid Power Cylinders**

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To design a smart ankle-foot orthosis (SAFO) that improves upon current ankle-foot orthoses used to treat steppage gait. Current ankle-foot orthoses are subjected to significant stresses on the ankle region of the structure, causing discomfort and the possible failure of the AFO. Although these AFOs have a constant stiffness, they do not reduce the occurrence of slap foot, where the foot slaps on the ground rather than gradually lowering it. The SAFO is an active ankle-foot orthosis that allows the user's foot to follow a normal gait cycle. It is designed to reduce stress at the ankle by allowing for movement of the foot beyond a 90 deg angle for plantarflexion. The hinged ankle-foot orthosis is incorporated with a novel dual hydraulic-cylinder system, two tension springs, and force sensitive resistors. The force sensors are placed at the hallux, first metatarsal head, fifth metatarsal base, and heel. The foot movement actuation follows the force applied to the

plantar surface of the foot during gait. The sensor outputs are fed to a signal processor and control interface to coordinate the motor actuation with the forces exerted by the user. The motor turns the screw attached to the hydraulic cylinders, which, thereby, control the orifice size by moving a plate in the cylinder, thus, changing the resistance. The cylinder filled with air will be pressurized during the lean phase, as the orifices will be closed and will provide power just as a spring would during the heel-off phase. After the heel strike, the resistance of the fluid-filled cylinder is decreased to slowly lower the foot. Once the foot is flat, the resistance of the fluid-filled cylinder is increased to keep the foot in a position to allow for toe clearance. During the heel-off event, the air-filled cylinder will assist the user with the power to push off. When toe-off occurs, the fluid-filled cylinder will decrease the resistance to allow the tension springs to bring the foot back to neutral position. To power the motor and sensors, a rechargeable battery pack is placed in a waist bag. The SAFO's flexible design uses a novel combination of hydraulic-pneumatic cylinders to prevent foot drop, and restore the user's sense of normalcy by providing late stance plantarflexion and a return to neutral position in early swing phase.

## **Exo-Leg: An Active Single-Leg External Walking Assist Device**

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Lower extremity weakness is a serious problem afflicting people all over the world. Until recently, the mobility options for people with this condition have been confining and limit the individual's functionality. Walking assist devices are presently in development to restore hands-free walking to people with lower extremity weakness. These devices provide the necessary support and power to enable the individual to restore normal ambulation. The proposed design of exoleg, a single leg external walking assist device, addresses the demographic of people with lower extremity weakness. The design includes replication of the gait cycle utilizing mechanical links and user control interface with emphasis on safety. The design couples the actuation of the knee and hip

through the use of linkages connected to a single motor. The actuation of the hip is controlled by a 4 bars crank-rocker linkage system while the knee is actuated by corresponding linkages (designed in WORKING MODEL 2D, a commercial simulation software) that generates the knee kinematic profile. The angular profiles of the knee and hip actuations are compared with the actual knee and hip angular trajectories. The frame of the device incorporates a passive ankle stabilization system to compensate for the effects of foot drop. The system utilizes feedback from trigger points from pressure sensors on the foot and goniometers at the hip and knee joints to measure the angulations in gait to keep the device in synchronization with natural ambulation. An on-board microprocessor receives the feedback from the trigger points and sends the actuation signal to the motor. A conceptual design of electrostatic actuator motor is also proposed to keep the device light weight and compact.