A Lightweight Soft Exosuit for Gait Assistance

Conor J. Walsh
Wyss Institute for Biologicaly Inspired Engineering, Harvard University, Cambridge, MA, School of Engineering and Applied Sciences. Harvard University, Cambridge, MA
walsh@seas.harvard.edu

Exoskeleton and exosuit technology has the potential to assist with many military and non-military applications. Over the last two decades, a number of lower extremity robotic exoskeletal systems have been developed to augment warfighter performance [1-2]. Many of these systems have demonstrated the ability to augment strength and reduce the level of loading experienced by the wearer. However, typically locomotion and mobility with these systems has been compromised by the exoskeleton's rigid architecture and high inertia. In particular, these effects disrupt the natural human gait dynamics, require high power actuators to achieve the augmented performance, and limit the degrees of freedom, requiring further deviations from the normal gait kinematics [3]. Recently at Harvard, we have been pioneering new exoskeleton architectures by completely removing the rigid elements, which permits motion assistance while maintaining the body's natural degrees of freedom [4].

The figure below shows an early pneumatically actuated suit we developed where the orange elements are McKibben actuators that have load sensors attached in series so as to measure force as a function of the gait cycle. The data shows the force generated passively (i.e. when the actuator is not powered) and actively (i.e. with actuator turned on). The timing for this actuation was selected based on observing the subjects' minimum metabolic effort over a number of actuation turn on times. From the passive and active plots below it is clear that before the large force from the actuator in the active condition, the suit is being passively stretched during controlled dorsiflexion (up to about 35% of gait cycle).

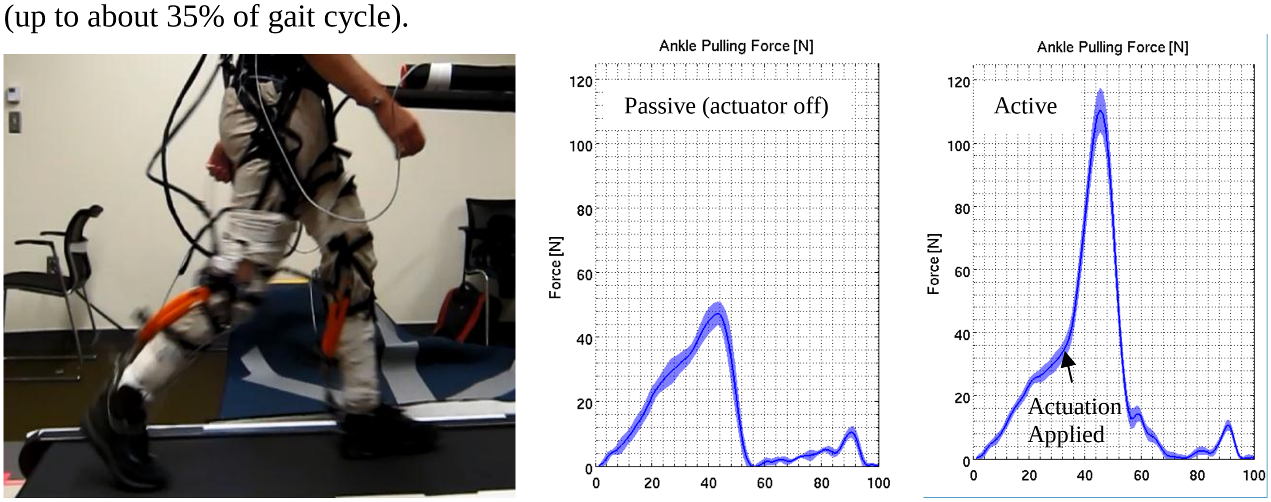

Fig. 1: Left, Early prototype of a soft pneumatically driven exosuit with orange McKibben actuators with load cells placed in series to measure force. Middle, force generated at the ankle due to the passive stretching of the suit during controlled dorsiflexion. Right, force generated at the ankle due to combined passive stretching and active energy input.

References

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