A Compact Lockable Module for a Modular Wearable Robot System

Dongting Li and Dan Aukes
{dongting,danaukes}@asu.edu
School of Manufacturing Systems and Networks
Arizona State University

Background

Based on prior work on the effect of external load on the human trunk for obstacle avoidance tasks, and our previous origami-inspired wearable robot prototype, we have improved this concept by: 1) increasing force amplitude, 2) introducing local locking, and 3) reducing design complexity through a modular approach.

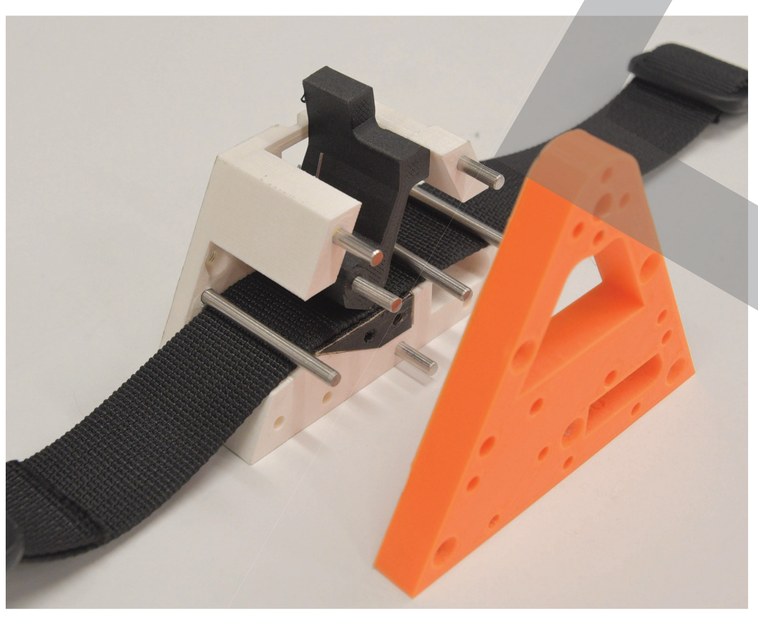
To provide external stiffness around the human trunk, our aim is to develop a compact, quick-response, low-power consumption, and high-force density locking solution. This solution is based on a single-sided self-locking mechanism, which we refer to as a "lockable module." Each module includes two brakes, a belt routing system and a motor.

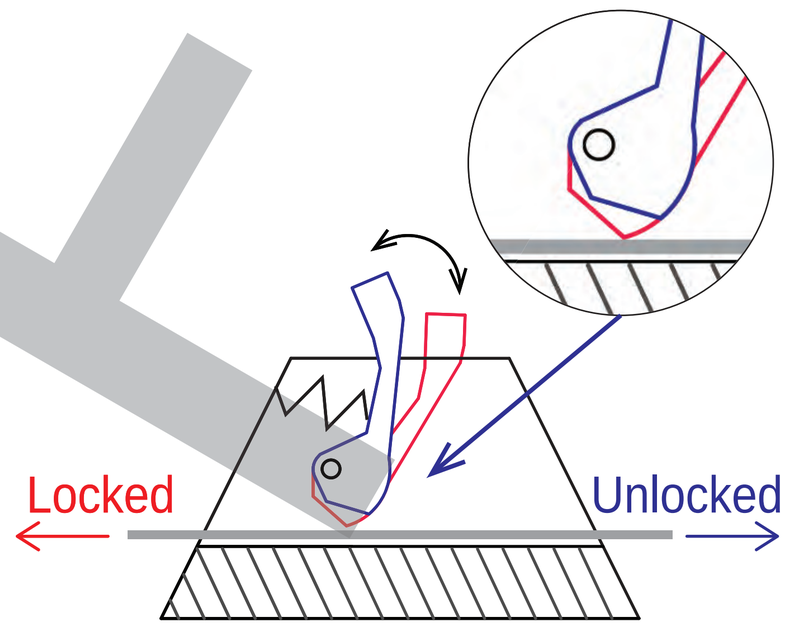
With this lockable module, we've integrated a modular connector that allows for a serial connection with other modules. These can include wearable interfaces, power units, and customized wearable devices that enable control over the number, orientation, and location of the external supporting force.

[1] D. Li, E. Q. Yumbla, A. Olivas, T. Sugar, H. B. Amor, H. Lee, W. Zhang, and D. M. Aukes, “Origami-inspired wearable robot for trunk support,” IEEE/ASME Transactions on Mechatronics, 2022.

Self-locking inspired brake design

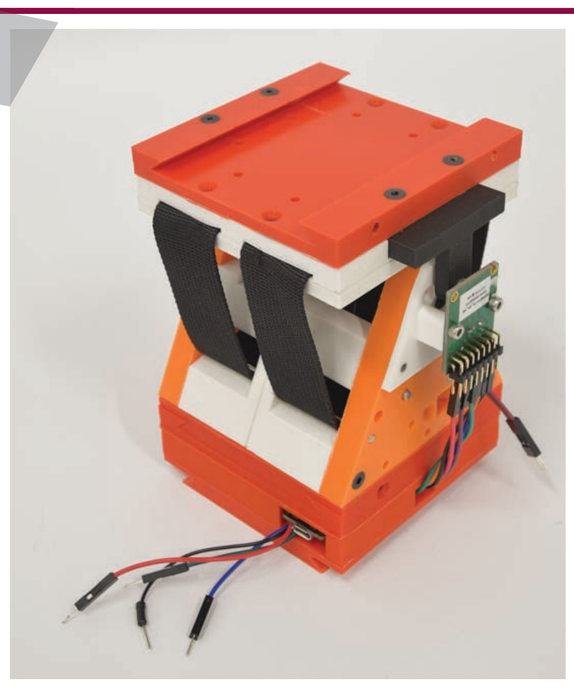
This brake self-locks in one direction. We use a belt to transmit the locking force and emphasize the geometry. Based on tensile testing, this brake can resist up to 250 N.



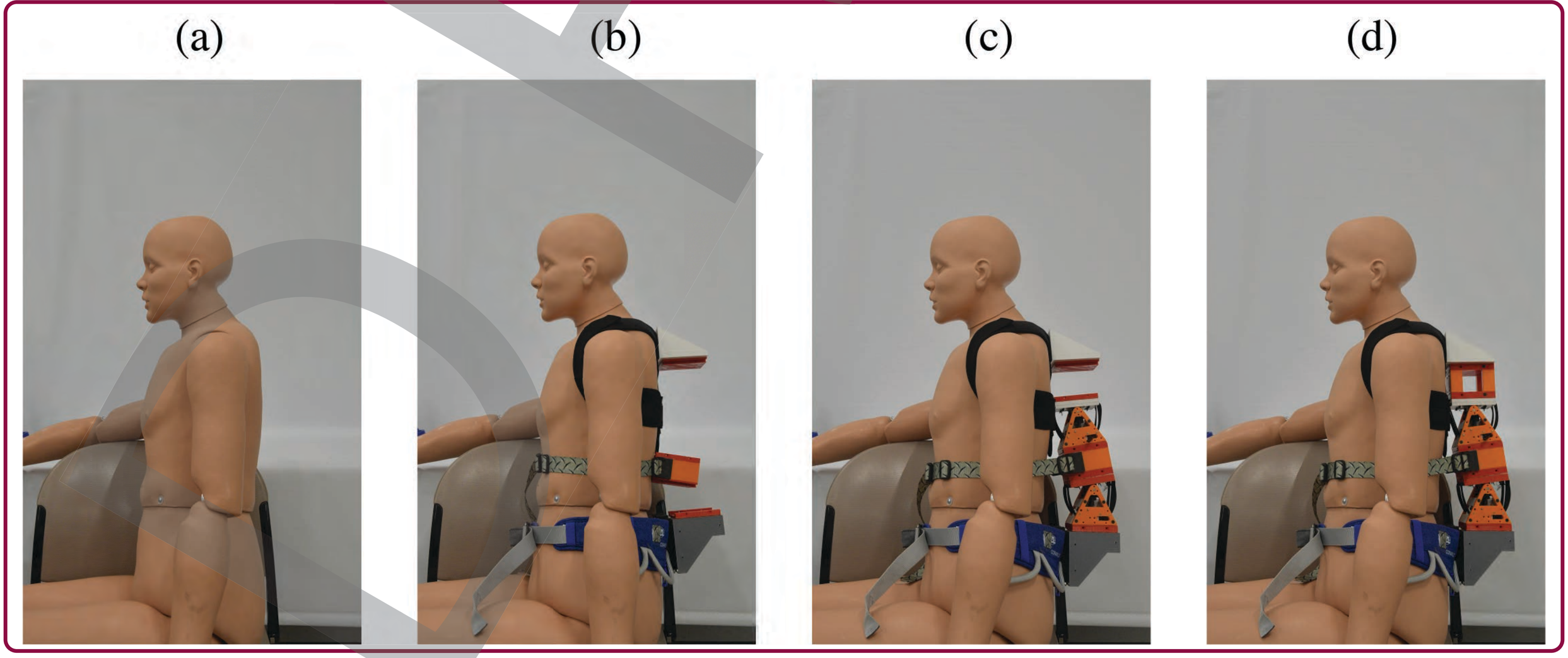


Lockable module with two brakes

By positioning two brakes in a circular pattern to control each direction, we can manage the full degrees of freedom (DOF) of the lockable module. Preliminary experiments have shown that the brakes provide a resistive torque of 10Nm in just 0.1 seconds. Subsequently, we added a modular connector for serial connection to other modules and created a wearable interface for user comfort and ease of wear.



Wearing sequence and customization



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