Compliant Motor Driven Linear Bi-Layer Actuators

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***Abstract*— Exoskeletons require complaint compact linear actuators that can be drive by motors. Current designs such as cable drives and handed shearing auxetics are limited or too large. We demonstrate a new design based on the scissor mechanism which can produce significant forces (10N) and large extension ratio (10X) while remaining compliant. We believe this will be a useful tool for electrically driven soft robotic exoskeletons**

I. INTRODUCTION

Applications such as exoskeletons push the capability set for soft robotics. Exoskeletons need actuators with compliance that are low profile, energy efficient, and electric. Cable drives are commonly found in exoskeletons [1], [2] but are severely limited because they can only generate contractile forces[1], [2]. HSA actuators can generate both, but must be used in pairs to prevent torsion and cannot produce low profile surfaces of actuation [3]. A distributed compliant actuator is low profile and directly driven by a motor would have great utility in exoskeletons. This extended abstract describes a novel linear bi-layer actuator based on the traditional scissor mechanisms to fill that need.

II. DESIGN OF ACTUATOR

Scissor mechanisms are common in devices such as lifts, reach extenders, and marking tools[4]. These are typically produced from rigid links designed to resist lateral loading and are often driven by a linear actuator which changes the length between nodes to control extension . This effectively makes the scissor mechanisms a distance amplification device.

The mechanism can be thought of as having links on two layers, where the angle between the links controls the extension of the framework.By changing the source of actuation from distances between nodes to angles between links we produced an actuator which is directly motor driven. By connecting the motor frame to one link and the output to the other, the torque generated by the motor is converted into a torque between the layers, changing the angle of the links. By replacing traditionally rigid elements with compliant spring steel links, we generate a structure which can change maintain the distances between points while allowing bending.

III. FABRICATION AND TESTING

We produced a demonstration system using a simple DWSDF Servo motor, 0.254 mm thick spring steel, and M3 screws and 5 sections. The layers were separated by 6mm and held apart by standoffs at nodes of the mechanism. The resulting device can be seen in the closed state and open state in Figure 1A and B. It is 39mm long when closed and 88mm long when open, for an extension ratio of 2.25X.

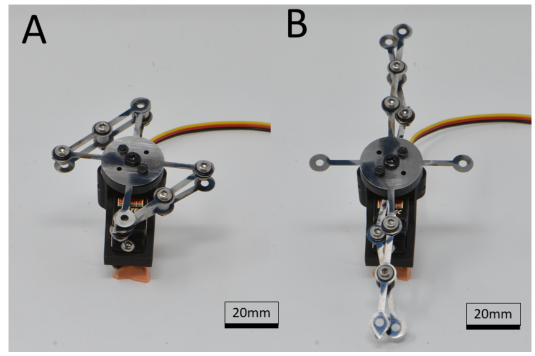

Fig. 1. A Bi-layer compliant linear actuator in a closed(A) and extended state(B)

We measured the drives blocked force in the closed state, and the contractile force by at full extension. We also performed a three-point bend test on the primary axes orthogonal to the extension direction at the fully extended and the servo engaged. The result is the actuator can push with 10 N of force, and pull with -10 N of force and had a Flexural modulus of 3.8MPa when fully compressed and 39.4MPa when fully extended. This is equivalent to the range of material properties consistnent with Silicones typically used in soft robotics.

IV. CONCLUSION

We have demonstrated a new type of compliant linear actuator based on the scissor mechanism. Its low profile and high contractile and extension forces make it ideally suited for exoskeleton applications. We believe that in the future networks of such actuators can be used to produce exoskeletons and other soft robotic devices.

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