Variable Stiffness Linear Actuator Robot

Zachary M. Hammond, Nathan S. Usevitch, Elliot W. Hawkes, and Sean Follmer

***Abstract*—Linear Actuator Robots (LARs) are frameworks of high-extension linear actuators that can change shape through the coordinated actuation of their members. Variably compliant LARs have interesting applications in energetic tasks and human-robot cooperation. We have developed a novel high-extension, variably compliant actuator for linear actuator robots called the Pneumatic Reel Actuator (PRA). We have developed a model describing the actuator and have conducted experiments characterizing the actuator's performance in regards to force, length, and pressure.**

I. Introduction

Linear actuator robotics (LARs) is an interesting class of shape-changing robotic systems that change shape through the coordinated deformation of a fixed topology of linear actuators. While traditional robots are often designed with a specific form to accomplish a specific task, a LAR can change its shape for the task at hand. Two significant challenges that currently hinder LARs are a lack of high-extension actuation and a lack of durability. In previous work, LARs were constructed with rigid electromechanical actuators with extension of no more than 5:1 [2]. This limited extension ratio limits the robot's shape-change, mobility, and range of possible tasks. Additionally, without a mechanism to absorb and dissipate energy, these rigid electromechanical actuators break or jam after exposure to high impact forces.

Variable stiffness structures offer several advantages over both rigid and single stiffness robotic interfaces. The ability of compliant structures to store and subsequently release energy allows them to achieve higher peak power than standard electromechanical systems. A variety of devices have exploited variable compliance to optimize the performance of highly dynamic tasks like throwing or striking [3]. Variably compliant structures are also desirable when working with or in close proximity to humans. Obviously, there are safety benefits from compliant structures, but there are also interesting performance advantages in this space as well. Manipulation of interaction impedance can improve performance of human-robot cooperation [4]. Given a human safety constraint, a variable stiffness actuator will have higher performance than single stiffness actuators and that the performance gain increases with the range of achievable stiffnesses [1].

II. Actuator Design and Modeling

Given the interesting prospects of variable stiffness structures, we have developed a high-extension, variable compliant actuator called the Pneumatic Reel Actuator (PRA). The PRA is constructed with inexpensive, flexible but not stretchable materials so it remains compliant but is able to support compression and tensile loads. The actuator has internally antagonistic elements such that its impedance can be varied. We have developed a model describing the actuator and have conducted experiments characterizing the actuator's performance in regards to force, length, and pressure.

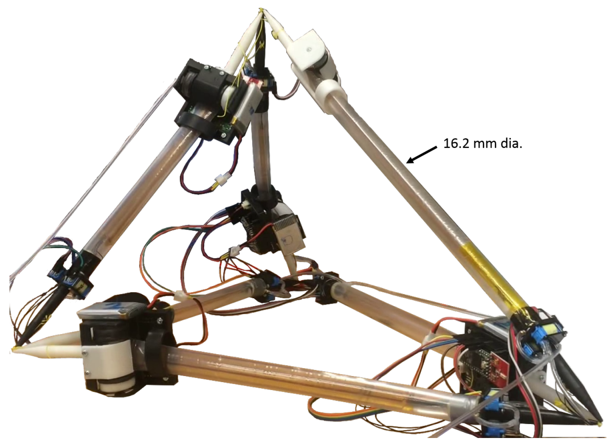

Fig. 1. A LAR constructed with compliant PRAs with integrated solenoids, length sensing, and wireless communication.

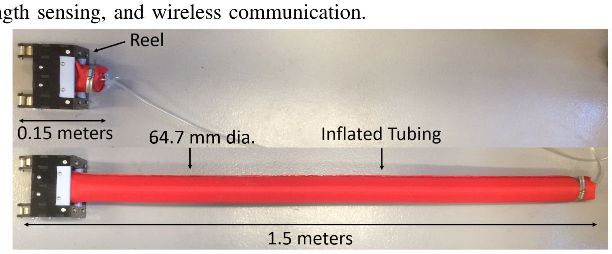

Fig. 2. PRA is shown in its fully contracted form and its extended form.

III. Demonstration

We will demonstrate the PRA in a three actuator variable stiffness LAR. The three PRAs will be connected together at a single node such that the position of this node can be controlled in three translational degrees of freedom. We will show that we can simultaneously change the stiffness of the structure while controlling the nominal location of the node.

References

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