Twisted String Actuators: Outline, Applications, and Challenges

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***Abstract*—Twisted string actuator is a novel type of actuator which can provide variable stiffness while remaining light, cheap, and mechanically simple. Twisted strings actuators can be efficiently used in various robotics and haptics applications such as wearable robots and exoskeletons, robotic fingers and grippers, mobile robots, and others. In recent years, our group has done extensive experimental study on twisted strings actuators and their implementations in robotics. We would like to share our experience working with these actuators, discuss our present work and implementations of the actuators to exoskeletons, and also outline some important challenges arising in our practice.**

I. Introduction

TWISTED string actuator is a light, compliant and efficient mechanical actuator, where a string connected to an electric motor acts as a gear. When a load is attached to the string on the other end, the rotation imposed on the string by the motor will reduce the length of the string, thus causing the translational motion of the load due to the generated pulling force.

Advantages of twisted string actuators (TSAs) include: low weight and price, quiet operation, intrinsic compliance and high efficiency. Another benefit of such actuators is that the actuators generate force coaxially with the shaft of motor, which allows to design compact drives.

Our group has performed extensive study on such aspects of twisted strings behavior as kinematics, maximum contraction levels, fatigue, changes in strings' stiffness coefficient for different angles of twisting, and others. All of this allowed us to implement twisted string actuators in the following practical robotic setups:

- Linear translational joint: We improved conventional mathematical model of a twisted string which sufficiently increased the correlation between experimental results and the model [1]
- Bidirectional elbow exoskeleton (Fig. 1): We developed an intrinsically compliant device which was very light and utilized a pair of antagonistic TSAs. With such configuration, it was possible to control the stiffness of the joint and to estimate human intention using compliance of the TSAs [2]

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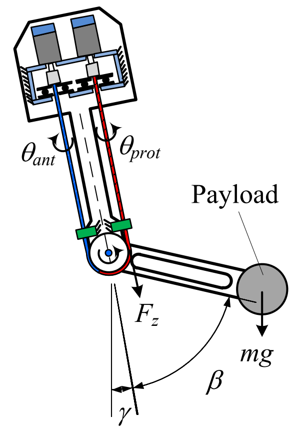

Fig. 1. TSA-based antagonistic elbow exoskeleton

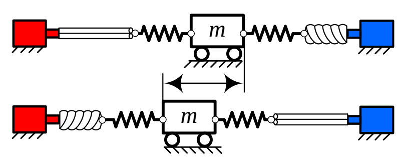

Fig. 2. Basic working principle of a twisted string actuator

- Variable stiffness linear joint (Fig. 2): This is our last application. We developed a mathematical model which takes into account variable stiffness of the twisted strings and makes it possible to control position and stiffness of the joint without the use of any additional position or force sensors at the load side [3]

We are currently working on advanced control methodologies for antagonistic TSA-based actuators. We are also developing a 3-DOF arm exoskeleton system which will be used as a rehabilitation and assistive device.

References

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