IROS 2016 Workshop on Twisted String Actuation: State of the Art, Challenges and New Applications

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Organizers

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Observation

- **Electric motor**
  - Average power density: 0.5 W/g
  - Max efficiency: 80%
- **Mammalian skeletal muscle**
  - Average power density: 0.041 W/g
  - Max efficiency: 20%

→ Electric motors has 10 times higher power density
→ **Transmissions** needs drastic improvement

Key Messages “*Problem comes from transmission*”
Twisted String

Windlasses

Catapults
Twisted String as a Transmission

Input: Small Torque

Results in

String = Transmission

Output: Large contraction force
Twisted String Actuator (TSA)

\[ \theta, F_{\tau}, L_{\text{untwisted}}, \Delta X, F_{\tau}, L_{\text{twisted}} \]
Advantages

- **Mass**
  - are *lower* than for conventional gears

- **Price**

- **Compliant**

- **Efficient** energy transmission

- **Motor can be** *coaxial* with the axis of motion

- **Transmit power** *over distance*

- **Silent**

Twisted string actuation workshop
Disadvantages

- Nonlinear gear ratio
- Durability
Objectives

• Present the current state of the art and the future trends in modeling, control and applications in the area of twisted string-based actuators and transmission mechanisms.

• Initiate knowledge sharing among the engineering and research communities

• Outline main future directions and issues of the twisted string-based actuators and transmission mechanisms.
Outcomes

• Assisting in making novel twisted string-based devices and technologies more suitable for various applications in industry and daily life.
• Strengthening collaboration between research groups working in this field around the world
• Attracting interest from the engineering community towards the emerging transmission technology of twisted string actuation
• New and exciting collaboration and funding opportunities.
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<th>Time</th>
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<tr>
<td>14:00 – 14:15</td>
<td>Welcome and Introduction by organizers</td>
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| 14:15 – 14:40 | Michael Stevens, SRI International  
"Twisted String Actuators for Exosuits" |
| 14:40 – 15:05 | Kyung-Soo Kim, KAIST  
"A Dual-mode Twisting Actuation Mechanism and its Application to a Robotic Hand" |
| 15:05 – 15:30 | Igor Gaponov, Korea University of Technology and Education  
"Twisted String Actuators: Life Cycle, Twisting inside Bowden Cables, and Bidirectional Actuation" |
| 15:30 – 16:00 | Coffee Break and Demo                                                       |
| 16:00 – 16:25 | Takahiro Inoue and Shinichi Hirai, Okayama Prefectural University  
"Antagonistically-twisted Elastic Round-belt Actuation Systems" |
| 16:25 – 16:50 | Gianluca Palli, University of Bologna  
"Stiffness Variability and Friction Effects on Twisted String Actuation" |
| 16:50 – 17:15 | Ivan Godler, Twist Drive Technologies, Inc.  
"Twisted Strings Based Robotic Hand and Eyes" |
| 17:15 – 17:40 | Gunter Niemeyer, Disney Research  
"Robotic Muscles from Conductive Nylon Sewing Thread" |
| 17:40 – 18:00 | Closing address and panel discussion                                         |
Questions to Keep in Mind

• What are the limitations and issues in TSAs?

• How to increase durability?

• What are the potential applications which are most suitable and fully utilize advantages of TSAs?

• What are the future directions of TSAs development?