Tendon-Driven Actuation Module for Robotic Hands

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INVENTORS

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OTHER INFORMATION

KEYWORDS

humanoid robotics, mechatronics, biomechatronics, animatronics, robotic actuation, prosthetic hands, powered prosthetics, myoelectric prostheses, bionics, bio-inspired, biomimetic, cable-driven robots, tendon-driven robots, artificial proprioception system

CATEGORIZED AS

- **Medical**
  - Disease: Musculoskeletal Disorders
  - Rehabilitation
  - Research Tools
- **Engineering**
  - Robotics and Automation

RELATED CASES

2015-071-0

SUMMARY

UCLA researchers in the Department of Mechanical Engineering have developed a modular actuation system that can control robotic manipulators the size and form of the human hand with an unprecedented combination of speed, strength, and precision.

BACKGROUND

The design of humanoid robotic hands is limited by their small volume constraints. To achieve a desirable combination of dexterity and strength, many robotic hands use an “extrinsic” actuation scheme akin to the human hand, wherein muscles (actuators) located in the forearm control the fingers via tendons. Though many robotic systems have been developed based on this tendon (i.e. cable)-driven design concept, no robotic hand has yet achieved the collective performance of the human hand in terms of speed, strength, and precision of control. Thus, there remains a need for improvement in the design of compact robotic manipulators and actuation schemes.

INNOVATION

Researchers led by Dr. Veronica J. Santos in the UCLA Biomechatronics Lab have developed a compact actuation module that can deliver fast, forceful, high-precision control of any tendon-driven robotic manipulator. The design is based on a rotary motor unit that can exert either uni- or bi-directional (“push-pull”) control of any tendon-driven rotational joint, thereby enabling independent, high-performance control of each individual active degree of freedom in a robotic hand, including a palmar flexion degree of freedom.

APPLICATIONS

- Robotic prosthetic hands
- Robotic manipulators
  - For tele-operated systems – e.g. robotic telesurgery, bomb disarmament, brain-controlled robotic devices for neuro-rehabilitation
  - For automated robotic systems – e.g. mobile housekeeping & courier robots
- Robotics & machine learning research platforms

ADVANTAGES

- Performance:
- Speed: operation at human-like speeds without performance degradation; tendon excursions and tensions can each be sampled at 200 Hz
- Strength: 25 lbf dynamic operating range
- Precision Control: enabled by cable pre-tensioning mechanism (prevents tendon slack) and integrated load cell (measures loads & joint torques in real time)
- Simplicity: bi-directional motor action simplifies hardware requirements
- Compliance: actuation unit can be back-driven; a spring-loaded pulley that maintains tendon tension also provides passive compliance for unexpected loads or impacts during operation
- Versatility: compatible with a variety of robotic manipulator designs
- Modularity & Scalability: can be configured for various arrangements of robotic fingers and actuation units
- Bio-inspired Design: tendon-driven actuation and artificial proprioception system are compatible with human form factor for robotic and prosthetic applications
- Adaptability: Can be implemented with a variety of end effectors and sensors, for varying requirements.

STATE OF DEVELOPMENT

This technology has been prototyped and extensively tested by the research group of Dr. Veronica J. Santos in the UCLA Biomechatronics Laboratory. The test platform is comprised of the novel actuation unit in conjunction with a robotic finger.

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	10,029,364	07/24/2018	2015-071

RELATED MATERIALS

- Hellman, R. B., Chang, E., Tanner, J., Helms Tillery, S. I., and Santos, V. J. “A robot hand testbed designed for enhancing embodiment and functional neurorehabilitation of body schema in subjects with upper limb impairment or loss.” Front. Hum. Neurosci. 2015:9(26):1-10. doi.org/10.3389/fnhum.2015.00026
- Hellman RB and Santos VJ, “Design of a back-driveable actuation system for modular control of tendon-driven robot hands,” in 2012 4th IEEE RAS & EMBS International Conference on Biomedical Robotics and Biomechatronics (BioRob), 2012

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

- Soft Shear Force Resistive Sensor Embedded Artificial Skin

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