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Guest Editorial: Special Issue on Soft Robotics

It is my great pleasure and honor to present this Special Issus on rapidly growing 'Soft Robotics' which is intended to address the state-of-art of Soft Robot related researches. Eight outstanding researches are carefully selected through rigorous peer review process and those covers sensors, actuators, materials & structures, modeling & control, electronics, and fabrication techniques, including human interface, in soft robot area. I hope that this Special Issues is informative to the Soft Robot research community and brief summaries of each paper are followed:

The first paper entitled "Soft Robot Review" will be a good starting manuscript since it describes the overall summary on Soft Robotics over the past few decades. Several advantages of soft robots over the conventional robots are described; safe human-machine interaction, adaptability to wearable devices and simple gripping system, and so on. With these unique features and advantages, soft robots cover wide range of applications. Also, it is emphasized that novel control idea should be developed because the conventional control techniques may be inadequate to handle soft robots. In the review article, a wide range of soft robots are characterized and analyzed based on the following sub-categories; actuation, sensing, structure, control and electronics, materials, fabrication and system, and applications.

In the next paper entitled "Design of an Optical Soft Sensor for Measuring Fingertip Force and Contact Recognition," a novel idea of soft force sensor is presented. The idea is motivated to measure a contact force more precisely which is crucial to estimate user intention in hand exoskeletons. This work presents the mechanical design, implementation, and evaluation of a soft fingertip force sensor. To maximize tactile sensation of the user, a horse shoe shape structure has been adopted to leave the finger pad exposed. The whole sensor system has a soft exterior in order to provide flexibility and a user-friendly interface. Also, both static and dynamic responses are investigated.

The following paper entitled "Design and Fabrication of Twisted Monolithic Dielectric Elastomer Actuator" presents an innovative design of dielectric elastomer actuator (DEA), called single body dielectric elastomer actuator (SDEA), to improve the performance of existing DEAs. While the conventional DEA is typically configured with stacking multiple dielectric elastomer film, the proposed SDEA is fabricated monolithically without external frame and has the advantages of flexibility and light weight. Thus, it is applicable to various configurations of actuators such as twisting or bending, etc. and it could further amplify the stroke with its basic principles of operations.

In the work entitled "Development of a Transformable Wheel Actuated by Soft Pneumatic Actuators," it is proposed that a wheel that could be transformed from its starting circular shape (radius, 56 mm) to a wheel with three legs (radius, 99 mm). The key design principle of this wheel is to kinematically decoupled legs and passive locking. Its legs are kinematically decoupled but operated by a single air pump using a pneumatic channel connected to soft pneumatic actuators installed at each leg. Application of pressure causes the legs to behave like a coupled system through the pneumatic channel. The extended legs are locked and this legged wheel can overcome obstacles up to 2.9 times the radius of the wheel in its circular form.

In the fifth paper entitled "An Electrical Model with Equivalent Elements in a Time-variant Environment for an Ionic-polymer-metal-composite System," a linear time-variant (LTV) model is introduced and applied to model an Ionic polymer metal composite (IPMC) system. The IPMC is a kind of ionic electroactive polymer smart material that can exhibit conspicuous deflection with low external voltages. It could be cut in various sizes and shapes and then being utilized for robots and artificial muscles. The proposed LTV model is different from linear time-invariant (LTI) models because the internal environment of IPMC could be unsteady and the influence of surface conductivity is simulated and proven based on this model.

In the next paper entitled "A Soft Robotics Nonlinear Hybrid Position/Force Control for Tendon Driven Catheters," hybrid force/position control strategy is proposed to apply a constant force to the cardiac tissue while tracking the desired trajectory. A motivation of this study is that highly accurate stable control platform for precise force/position control on the moving tissue is required for robot-assisted cardiac ablation. The position controller is based on a nonlinear model predictive tracking control satisfying the input constraints. Lyapunov-based stability analysis is also conducted. To apply the controller, the force-displacement mapping of the cardiac tissue is obtained. Then, the performance of the controller

is evaluated.

The following paper entitled “Design of a Discrete Bending Joint Using Multiple Unit PREF Joints for Isotropic 2-DOF Motion” proposes a 2-DOF discrete bending joint. For various medical applications, miniature steerable robots are often required and it is difficult to achieve a small bending radius of curvature. With a discrete joint, it is easy to secure definite bending with strength. In the manuscript, the effects of the stacking sequence on its performance are analyzed and then and the best stacking sequences are determined. The proposed design method could be applied to the structural design of soft robots similar to snakes or elephant trunks.

In the last paper entitled “Auxilio: A Portable Cable-driven Exosuit for Upper Extremity Assistance,” a fully portable, lightweight exosuit-type device for shoulder and elbow assistance is introduced. The proposed device is intended to assist dynamic rehabilitation tasks by providing assistance for shoulder flexion and abduction, as well as for elbow flexion. A unique feature of the proposed exosuit is the absence of rigid links or joints around the arm. A simulation of rehabilitation scenario with the proposed wearable prototype is also addressed.

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