Journal of Mechanisms and Robotics

Guest Editorial

Special Issue: Selected Papers From IDETC 2015

This second IDETC Special Issue, containing 19 papers from researchers in seven countries on three continents, seeks to capture the current interest topics and latest results from the 39th ASME Mechanisms and Robotics (M&R) conference. The topics span the synthesis and analysis of novel mechanisms and robots as well as their validation in a variety of applications. The papers are organized with contributions to the core theoretical methodologies of M&R (five papers) appearing first. The application areas that follow are micro air vehicles (MAVs) (two papers), modular robotics (three papers), origami applications (three papers), medical robotics (three papers), and exoskeleton-assistive systems (three papers).

The first five papers showcase the conception of novel architectures and innovative modeling and analysis methods. Gan, Dai, Dias, and Seneviratne propose a novel metamorphic parallel mechanism architecture capable of switching its motion between pure translation (3T) and pure rotation (3R) by virtue of a reconfigurable Hooke (rT) joint. Zhang, Laliberté, and Gosselin propose the development of passive force- and torque-limiting devices to ensure the safety of human–robot interaction and illustrate their use in a 2DOF planar serial robot. Almestiri, Murray, Myszka, and Wampler extend the singularity trace method to single-DOF closed-loop linkages with both revolute and prismatic joints to gain insights into gross motion characteristics of a linkage relative to a designated input joint and design parameters. A similarly insightful extension of kinematic mapping theory to facilitate planar discrete motion synthesis of an arbitrary number of approximated poses, as well as up to four exact poses, was offered by Zhao, Ge, Zi, and Ge. The work of Plecnik and McCarthy provides a nice segue from rigorous theory into the application areas in describing a synthesis technique that employs planar six-bar function generators to constrain a spatial serial chain to have a single-DOF, ultimately realizing a biomimetic flapping wing design.

The next two papers discuss the emerging implementations of highly maneuverable, small form-factor MAVs. Perez-Rosado, Bruck, and Gupta integrate flexible solar cells into the wings, tail, and body of flapping wing MAVs to harvest solar energy and enhance flight endurance. Thomas, Pope, Loianno, Hawkes, Estrada, Jiang, Cutkosky, and Kumar propose a novel control and planning algorithm to enable a quadrotor-style MAV with a downward-facing gripper to perch on inclined surfaces while satisfying constraints on actuation and sensing.

A sequence of three papers captures the critical need for design–analysis–validation frameworks to realize the many potential benefits of modular mechanisms and robots. Davis, Sevimli, Eldridge, and Chirikjian develop the general design constraints of a heterogeneous modular robotic system capable of autonomous team repair and diagnosis. Alqasimi, Lusk, and Chimento discuss development of a modular building block in the form of a shape-morphing space frame built on the linear bistable compliant crank–slider mechanism. To achieve graded bulk functional behaviors, Hopkins, Shaw, Weisgraber, Farquar, Harvey, and Spadaccini extend the conventional mechanism frameworks for synthesis, analysis, and optimal organization to lattices with non-repeating unit cells.

The following three papers from the Origami-Based Engineering Design Symposium highlight how origami design frameworks help decompose complex 3D/2D structures into instructions for folding a flat-substrate about predetermined fold-lines. Fuchi, Buskohl, Bazzan, Durstock, Reich, Vaia, and Joo propose design optimization strategies to improve fold patterns for large folding operations by incorporating the influence of both the current configuration and geometric nonlinearity. In contrast to conventional rigid origami, Wheeler and Culpepper discuss the folding of highly compliant "soft origami" sheets into structures, focusing on unique properties, applications, and design drivers for practical implementation. In another exciting new research direction, an extension of classic pseudo-rigid-body modeling approaches enables Zhou, Marras, Castro, and Su to design and analyze compliant nanomechanisms fabricated via DNA origami self-assembly.

The next three papers highlight the challenges that stem from the highly constrained operational envelopes and rigorous patient safety requirements in medical applications. Li, Oo, Nalam, Thang, Ren, Kofidis, and Yu examine a constrained wire-driven flexible mechanism architecture with a continuum backbone to realize a novel flexible cardioscope capable of regulating both the angulation and length of the flexible section for minimally invasive cardiac surgery. In developing an alternative quantitative tool–tissue interaction force-estimation using only the driving motors' current, Zhao and Nelson seek to overcome the traditional technical/logistical challenges surrounding repeated introduction of sensitive electronic-hardware into sterilized environments. Loschak, Degirmenci, Tenzer, Tschabrunn, Anter, and Howe discuss the design, fabrication, and testing of a 4DOF robot for automatic navigation of ultrasound-imaging catheters to provide enhanced visualization of both anatomical structures and working instruments in various minimally invasive procedures.

Exoskeleton-assistive systems, which operate in intimate physical contact with human users while accommodating both human- and environmental-variability, are the focus of the last three papers. Park, Stegall, and Agrawal develop an upper body assistive device that aids load carriage during walking by better distributing the load across the upper torso and actively reducing dynamic load variations. Alamdari and Krovi propose a design architecture and control framework for reconfigurable hybrid articulated-cable robotic systems to assist physiotherapists as an alternative to treadmill-based lower-extremity rehabilitation systems. The sensing and force-feedback exoskeleton robotic glove studied by Ben-Tzvi, Danoff and Ma has applicability both to characterize human hand kinematics/forces and to assist users in common hand/grasping rehabilitative exercises.

We hope the readers will find this Special Issue interesting and informative as we have attempted to capture the richness and diversity across the 11 symposia of M&R 2015. As our editorial work comes to an end, we would like to express our deep appreciation to all the authors who supported this Special Issue by contributing papers. We are also grateful to all the reviewers for their

service and commitment to the journal through rigorous reviews, timely response to the tight schedule, and above all, insightful and constructive comments that helped shape the final outcome. Last but not least, our sincere appreciation goes to the Editor, Professor Vijay Kumar, for his vision, support, and valuable advice throughout this process.

Venkat N. Krovi
Guest Editor
Mechanical and Aerospace Engineering,
University at Buffalo (SUNY),
Buffalo, NY 14260

Andrew P. Murray
Guest Editor
Mechanical and Aerospace Engineering,
University of Dayton,
Dayton, OH 45469

James Schmiedeler
Guest Editor
Aerospace and Mechanical Engineering,
University of Notre Dame,
Notre Dame, IN 46556