Guest Editorial Cyborgs and Bionic Systems—Wearables and Its Control

I. Introduction

THE EDITORIAL link established between the IEEE TRANSACTIONS ON MEDICAL ROBOTICS AND BIONICS (T-MRB) and the IEEE International Conference on Cyborg and Bionic Systems (CBS) is now in its second year.

The 2019 edition of CBS was held between September 18 and 20, 2019, in Munich, Germany. The Conference attracted scientists, engineers and clinicians from all over the world.

The main purpose of the 2019 edition of CBS was to discuss frontier research and realistic applications on cyborg and bionic systems, which are concerned with hybrid fusion techniques for organic and biomechatronic body parts.

Of central interest was the integration of artifacts and technologies like biomorphic actuators and sensors into an effective biocybernetic system. With the rapid development of bionic technologies, biomorphic chips and nanotechnology, we think that cyborgs and bionic systems can assist humans to conquer many limitations such as disease, disabilities, speed, strength, dexterity as well as intelligence.

The topics of interest included but were not limited to the following: biomorphic and neurorobotics; building brains for robots and cognitive skills; prosthesis and exoskeleton robotics; biomorphic computation and chips; cyborg intelligence; generative learning; cyber-physical bio-system; regenerative medicine; neural-machine interfaces.

The conference was supported by relevant committees who ensured a timely and robust peer-review of the submitted papers. Authors of selected papers, either candidate for the Best Conference Paper Award and the Best Student Paper Award, were invited to submit an extended version of their work for possible inclusion in this Special Section of T-MRB. All the papers have undergone full peer-reviews.

II. Special Section Content

This Special Section includes 12 of those manuscripts that represent an extended journal version of the original papers submitted to the conference and either candidate for the Best Conference Paper Award and the Best Student Paper Award.

The order of the papers is structured as follows. The first three papers address the topic of wearable robotics, starting with robotic components, followed by the optimal selection of components and a presentation of a proof of concept of a compact wearable robot.

In the work "Interlimb Parallel-Link Powered Orthosis (IPPO): Compact Wearable Robot With Lateral Weight Bearing Mechanisms for Gait Assistance" by Kawaga *et al.*, a newly developed wearable robot with a compact drive mechanism, the Interlimb Parallel-link Powered Orthosis (IPPO), is presented. The IPPO has nine active degrees of freedom including a mechanism allowing the simultaneous movement of the stance hip adduction and swing hip abduction using one actuator.

The work "High-Performance Perpendicularly-Enfolded-Textile Actuators for Soft Wearable Robots: Design and Realization" by Nassour *et al.* introduces a soft pneumatic bending actuator composed of one folded textile tube surrounded by a straightening textile lube for the usage in wearable robots.

In the last paper addressing wearable robotics, "Optimal Selection of Motors and Transmissions in Backe-Support Exoskeleton Applications" by Barjuei *et al.*, the authors propose an optimal approach to the selection of the main components of an actuation system for back-support exoskeletons.

The next two papers address the topic of cyborg insects. In the work "Sideways Walking Control of a Cyborg Beetle" by Nguyen *et al.*, the authors demonstrate the control of sideways and forward walking in a cyborg beetle by emulating the touch responses of mechanoreceptors on the insect's elytra using electrical stimulations.

In the next work, "A Chemosensory Navigation Model Inspired by the On/Off Neural Processing Mechanism in Cockroaches" by Pequeño-Zurro *et al.*, a neurorobotic model for chemotaxis that implements the sensory processing of cockroaches is presented.

The next four papers address the topics of modelling and simulation in the field of bionic systems. In the first paper, "Continuous Prediction of Joint Angular Positions and Moments: A Potential Control Strategy for Active Knee-Ankle Prostheses" by Dey *et al.*, a random forest regression model is employed for the continuous prediction of the gait variables of knee-ankle protheses for level ground walking at self-selected normal speed.

In the work "A Nonlinear and Failure Numerical Calculation Method for Vessel Preservation Simulations Based on Subarachnoid Space Structure Considerations" by Chen *et al.*, the authors propose a numerical calculation

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method for vessel preservation simulations to help brain surgeons for training techniques.

In "FEM-Based Mechanics Modeling of Bio-Inspired Compliant Mechanisms for Medical Applications" by Sun *et al.*, a novel finite element method (FEM)-based modelling framework in MATLAB is presented in order to analyze the mechanics of different bio-inspired compliant mechanisms.

In the last paper addressing the topics of modelling and simulation, "Simultaneous Estimation of Upper Limb Pose and Joint Torque Based on Upper Arm Deformation" by Kurasumi *et al.*, the authors propose a novel method to simultaneously estimate the pose and joint torque considering external load using only the upper arm deformation measured by a distance sensor array.

The following two papers address the topic of vision-based systems in cyborg and bionics systems. In the first work, "Multilevel Cross-Aware RGBD Indoor Semantic Segmentation for Bionic Binocular Robot" by Shi *et al.*, the authors propose a multilevel cross-aware network (MCA-Net) for RGBD semantic segmentation, which utilizes basic residual structure to encode texture information and depth geometric information, respectively.

In the next paper, "Real-Time Robust Stereo Visual SLAM System Based on Bionic Eyes" by Liu *et al.*, the authors propose a real-time stereo visual SLAM system using bionic eyes. This sensor type named bionic eyes are stereo cameras and performing similar movements of human eyes.

The last work, "Calibration-Free Error-Related Potential Decoding With Adaptive Subject-Independent Models: A Comparative Study" by Schönleitner *et al.*, the authors focus on adaptive subject-independent decoding models particularly suitable for error-related potentials classification. As individualized decoding models require a time-consuming calibration phase, such models provide a promising alternative.

III. Conclusion

This Special Section documents and confirms the impressive progress made in the areas of Cyborg and Bionic Systems. In particular, we hope that this Special Section will help to anticipate the challenges and opportunities in this field. We also hope that they will provide timely and interesting samples for the research community and will foster further work in this exciting research area.

Acknowledgment

In closing, we would like to extend our appreciation to all reviewers who played a crucial role in the peer-review process for the manuscripts submitted to this Special Section for their timely and professional comments.

Most importantly, thanks to all the authors who submitted their manuscripts for consideration of publication and to Paolo Dario, who encouraged the Guest Editors to prepare this issue and to Christoph Segler and all individuals helping to handle the review process.

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