Editorial for the special issue on wearable robots and intelligent device

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Editorial

Editorial for the special issue on wearable robots and intelligent device

Wearable devices have a long history, even though wearable robots as emerging area is relatively new. An early report of wearable device can be found in the book Tian Gong Kai Wu (天工开物), published in 1637 where an ancient mechanism that was mounted on human body for cotton fluffing was documented. This type of wearable cotton fluffing tool can still be found in rural areas of China today.

Modern wearable robots and intelligent devices were mainly developed in last two decades. They are developed for human users to enhance their motion and physical capabilities with applications mostly in rehabilitation, military, and industrial fields, among others [1–3]. Wearable technology is progressing rapidly addressing challenging issues covering robot design, novel sensing techniques, control methods and applications.

This special issue on "Wearable Robots and Intelligent Device" reports original research contributions and reviews on the current state-of-the-art in this field. It contains five papers covering a broad range of topics including robot modeling and control, simulation, sensors, terrain detection, each for human-centered systems and applications.

The paper by Liao et al. [4] presents a control interface based on sEMG enveloped signal for a collaborative upper-limb wearable robot. Their objective is to improve the accuracy of sEMG recognition based on the Time-Domain (TD) features. This was achieved through a device designed to obtain the sEMG envelope signal. They also developed a method to transform the 11-dimensional feature into a five-dimensional envelope feature set. Finally, a recognition algorithm based on a neural network was proposed and tested for gesture classification.

Yang et al. investigated terrain classification and force assistance strategies to address challenges of walking assistance in complex environments [5]. A Vision Transformer (ViT) and optimized control algorithm, known as a ViT-Based Terrain Recognition System (TTRS), was developed. The TTRS is integrated with a soft exosuit with force assistance strategies proposed to provide different force assistance to the exosuit when walking in different terrains. The system was tested with seven able-bodied subjects, showing promising results that demonstrated a terrain classification accuracy of 99%.

The review paper by Wang al. [6] provides an overview of wearable sensors for activity monitoring and motion control of wearable devices, including for exoskeletons. In the review, sensor technologies, including electromechanical, bioelectrical, and biomechanical sensors, are firstly outlined. Their applications in healthcare, daily life and robot control are reviewed. Moreover, existing commercial wearable products are listed, which provide useful information for researchers to facilitate sensor selection. In addition, computation methods, in particular, machine learning techniques for motion classification and analysis, are summarized. Finally, future research issues are identified and discussed.

In the survey paper by Wu [7], a systematic literature search was conducted, covering a total of 65 studies, focusing on use of Inertial Measurement Unit (IMU) based motion capture systems for rehabilitation applications. The survey showed that the primary focus of the studies was for stroke patients. Additionally, general rehabilitation without targeting a specific pathology emphasized on gait analysis, for which the most common setup was two IMUs measuring spatiotemporal parameters of the lower limb. The survey reveals that the upper limb studies lacked training applications, arguably due to the limited battery life and sensor drift.

The paper by Xiong and Fang presents their study on variable impedance control for safe robot and human interaction in unknown external environments [8]. The paper first outlines the state-of-the-art of research on intelligent skills in human and robot. An Online Impedance Adaptation Control (OIAC) for variable compliant joint motions is introduced. OIAC is a feedback control which can be integrated into a feedforward control, e.g., learned by data-driven methods, to achieve intelligent robot control. Research examples are included with Python code available for quick implementation purpose.

The Guest Editors thank all authors and reviewers who made great contributions to this Special Issue. All the of papers underwent a two-round rigorous review process to ensure the high quality of the publications. A special thanks to the journal Editors for their support and effort in the organization and publication of this Special Issue. We hope the papers in this collection are helpful for researchers to develop advanced wearable robots and sensors for the benefit of our society.

References

[1] S. Bai, G. Virk, T. Suger (Eds.), Wearable Exoskeleton Systems: Design, Control and Applications, the IET Press, 2018.

[2] M.A. Gull, S. Bai, T. Bak, A review on design of upper limb exoskeletons, Robotics 9 (1) (2020) 16, http://dx.doi.org/10.3390/robotics9010016.

[3] A. Rodríguez-Fernández, J. Lobo-Prat, J.M. Font-Llagunes, Systematic review on wearable lower-limb exoskeletons for gait training in neuromuscular impairments, J NeuroEng. Rehabil. 18 (2021) 22, http://dx.doi.org/10.1186/s12984-021-00815-5.

[4] Z. Liao, B. Chen, D. Bai, et al., Human–robot interface based on sEMG envelope signal for the collaborative wearable robot, Biomim. Intell. Robotics 3 (2023) 100079, http://dx.doi.org/10.1016/j.birob.2022.100079.

[5] F. Yang, C. Chen, Z. Wang, et al., Vit-based terrain recognition system for wearable soft exosuit, Biomim. Intell. Robotics 3 (2023) 100087, http://dx.doi.org/10.1016/j.birob.2023.100087.

https://doi.org/10.1016/j.birob.2023.100102

[6] X. Wang, H. Yu, S. Kold, et al., Wearable sensors for activity monitoring and motion control: A review, Biomim. Intell. Robotics 3 (2023) 100089, http://dx.doi.org/10.1016/j.birob.2023.100089.
[7] C. Gu, W. Lin, X. He, et al., IMU mocap system for rehabilitation applications: A systematic review, Biomim. Intell. Robotics 3 (2023) 100097, http://dx.doi.org/10.1016/j.birob.2023.100097.
[8] X. Xiong, C. Fang, An online impedance adaptation controller for decoding skillintelligence, Biomim. Intell. Robotics 3 (2023) 100100, http://dx.doi.org/10.1016/j.birob.2023.100100.

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