

Wearable Robotics for Motion Assistance and Rehabilitation

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The IEEE Robotics and Automation Society (RAS) Technical Committee (TC) on Wearable Robotics was approved during the IEEE RAS Technical Activities Board meeting that was held 15 May 2016 in Stockholm, Sweden, in conjunction with the IEEE International Conference on Robotics and Automation (ICRA) 2016. The TC membership started with 51 members (four cochairs, three advisors, and 44 founding members) and more than tripled to 152 members during the first 18 months of its lifetime. The TC has maintained a high level of activities, including the organization of a series of scientific events such as conferences, summer schools, and special sessions/workshops in major RAS and non-RAS conferences, as well as leading special issues in prestigious Institute for Scientific Information journals. Young and senior researchers have been invited to join the activities of the TC, which seeks to bring together researchers with interest in the latest technological and scientific advancements achieved in the field of wearable powered robotic technologies.

RESEARCH ACTIVITIES

The TC provides a platform for practitioners and researchers to exchange information and resources related to the fields of rehabilitation and motion assistance through such technologies. It seeks to gather researchers from different backgrounds to discuss and learn about this highly interdisciplinary field (safety, ergonomics, light-

weight efficient actuation, control, autonomy, human-machine interaction, soft robotics, wearable sensors, textile and apparel design, and material science). The TC provides discussions about the state of the art, challenges and limiting factors for developing sustainable wearable robots for assistance, and augmentation and rehabilitation of human movements in real-life scenarios. Issues related to novel kinematics and actuation solutions for wearable robots as well as the growing challenges of using novel human-robot multimodal interaction paradigms and cognitive/physical human-robot interactions are also treated.

The proposed solutions are aimed at promoting energy harvesting, complete wearability, portability and reliability of the device, as well as user's safety. The TC provides a platform to promote international initiatives, innovative and/or industrial solutions for the assistance

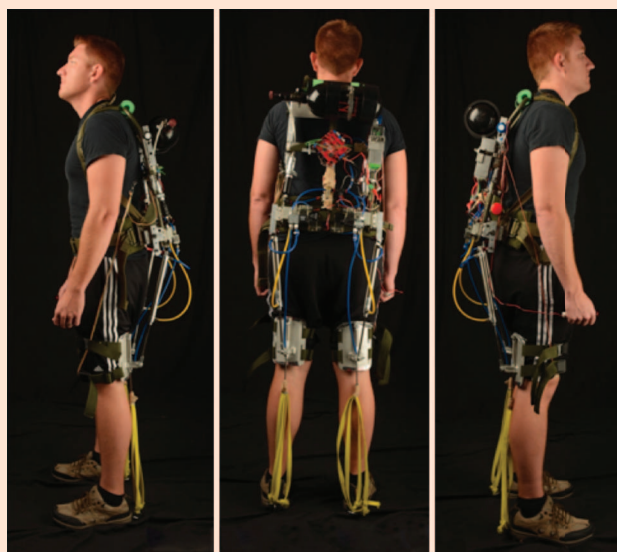
of frail people, which will provide an excellent opportunity to share information and technology transfer between experts from different fields such as medical, social, caregiving, and industry. While initially conceived for human motion augmentation purposes, wearable powered robots have been gradually proposed as a technological aid for motion rehabilitation and assistance and functional substitution in patients suffering from motor disorders. Over the last decades, despite the significant technological and scientific advancements achieved in the field of wearable powered robotic technologies, we have not yet witnessed the success of a fully wearable powered assistive robotic device, e.g., a robotic suit that is easy to wear and intuitive to use.

New technological challenges such as technologies enabling better sensing and interpretation of human-robot interaction, new controllable actuators enabling

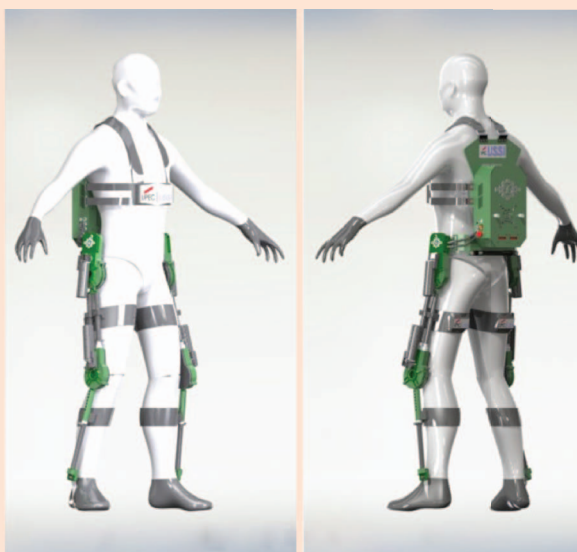


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H2 exoskeleton by CSIC-Technaid S.L., Spain.



(a)



(b)

(a) A lower-limb exoskeleton at Arizona State University. (b) A lower-limb exoskeleton at University Paris-Est Créteil, France.



Prosthesis at Peking University, Beijing, China.

a better interaction, and the enhanced computing power enabling complex reasoning and control strategies affect the scope of the TC and modify the limitations and drawbacks of the existing wearable robot devices. The emerging area of soft wearable robots continues to grow in interest. This rapidly emerging field will not replace traditional exoskeletons but offers new possibilities to augment the performance of healthy individuals while also restoring function for impaired individuals with residual

capacity, i.e., where only small-to-moderate levels of assistance are needed to improve function ability (e.g., walking and grasping). As the field of soft wearable robotics is a relatively new area of research, we do not yet have sufficient knowledge on how to most effectively tailor systems to match the need of different application areas across populations. Specifically, there is benefit to understanding which joints/tissues (or combinations) can benefit from assistance and what levels of force and power are needed, as this will also impact component- and system-level requirements (e.g., actuation modality). There will likely be an opportunity to explore new actuation and sensing approaches such as those made from electroactive materials, and working closely with the material science community will be critical to achieve robust components suitable for integration into systems.

TC ACTIVITIES

In the 18 months since the TC was created, cochairs have made great efforts in joining wearable robotics professionals and entrepreneurs from industry, academia, and government through the promotion of specialized conferences in the field of wearable robotics such as the IEEE International

Symposium on Wearable and Rehabilitation Robotics (WeRob), held 5–8 November 2017 in Houston, Texas, and the Wearable Robotics Association (WearRA), which has held a series of WearRA conferences (WearRAcons), which are technically cosponsored by RAS. WearRA has held two conferences in Phoenix, in 2016 and 2017. WearRAcon16 had more than 150 attendees, and WearRAcon17 had more than 200. It also held a session in Beijing, China, on 14 September 2017. Ten chief executive officers spoke at WearRAcon17 in Phoenix to ensure that industry was involved.

WearRAcon18 is being hosted in March 2018 in Scottsdale, Arizona, and it will move to a new location in 2019. The cochairs of the TC were also involved in the organization of a series of special sessions and workshops in conjunction with IEEE RAS conferences such as the IEEE/Robotics Society of Japan (RSJ) International Conference on Intelligent Robots and Systems (IROS) 2016 and 2017. TC cochairs have organized a series of special issues related to wearable robotics:

- *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, volume 25, issue 2, February 2017

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with socioethical issues surrounding postdeployment of robotics in the personal health-care domain. A key finding in the study was that over 62% of respondents indicated they would typically or completely trust their child to handle risky situations with an exoskeleton.

While the guest editors decided to accept only three articles, these are indicative of various perspectives in theoretical or applied foundations (e.g., explorative experiments versus robotics and ELSI and aspects of trust and risk), in context (e.g., search and rescue with respect to defense and emergency services versus industrial robots versus personal health-care robots), and end users (citizens, employees, patients, and consumers).

References

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TC Spotlight *(continued from page 20)*

- *Autonomous Robots*, volume 41, issue 3, March 2017
- *IEEE Robotics and Automation Magazine*, volume 23, issue 1, March 2016
- *Robotics and Autonomous Systems*, volume 73, pages 1–170, November 2015.

The TC was also involved in the organization of the 2017 Summer School and Symposium in Advanced Neurorehabilitation (SSN R2017), which was aimed at providing in depth education on advanced procedures for neurorehabilitation of motor dysfunction, covering, at the basic and advanced levels, practical applications based on innovative neuroprosthetic systems, robotic interfaces (including Wearable Robots), and other combinational approaches. Seven workshops were sponsored and accepted by our TC at the major IEEE RAS conferences: four workshops at ICRA 2017, two workshops at IROS 2017, and one workshop at HUMANOIDS 2017. Following the TC suggestion, a senior researcher has been granted the IEEE-RAS Distinguished Lecture Program Award.

One of the main technical innovations in the field of wearable robotics is

the creation of a new IEEE RAS Standing Committee for Standards Activities. The TC has been involved in the organization of a working group within RAS to study and classify wearable robots and determine which existing standards apply and what new standards should be developed. The group has been meeting virtually every month to discuss standards being developed around the world. Japanese Industrial Standards in Japan are developing standards for hip exoskeletons. ISO 13482 for Personal Care Robots has been published. Finally, the American Society for Testing and Materials is starting an effort to create test methods for wearable robots.

In terms of educational materials, TC cochairs have led the development of educational materials related to wearable robotics. Examples of soft wearable educational materials are hosted online and available to use at <https://softroboticstoolkit.com/resources-for-educators>. Further details about the TC goals, events, contacts, membership, and supported activities can be found on the TC website: <http://www.ieee-ras.org/wearable-robotics>.

Future Directions

The TC's goals for the next three years are to keep organizing workshops and social events related to RAS conferences. It will be working on the development of close relationships with industry through the organization of dedicated events to foster academic-industry cross fertilization in the field of wearable robotics. They will be also promoting the organization of an annual international fair of Wearable Robots, sponsored by the IEEE. The TCs also aim to promote, in the near future, the establishment of a Young Researcher Award to be granted during major RAS conferences and to sponsor Student Travel Awards for attending special events that will held by the TC. Finally, the TC is willing to edit a new textbook about Wearable Robotics for educational purposes. If you are interested in wearable robotics and have not done so already, you are invited to join the Wearable Robotics TC through the RAS page <http://www.ieee-ras.org/wearable-robotics>.

