Cyborg and Bionic Systems

By Toshio Fukuda, Alois Knoll, Harry Asada, Qiang Huang, and Qing Shi

Cyborg and bionic systems (CBS) are fusions of organic and biomechatronic body parts that integrate some artificial components or technology, such as biohybrid actuators and sensors. These systems aim to restore or even enhance an organism beyond its original biological characteristics. As shown in Figure 1, a cyborg and bionic system can be a combination of a humanoid robot and a biomedical robot or a mouse-inspired artificial organism with a brain and a body.

The future will see such systems applied to 1) engineering of tissues structured with biocell-assembled structures, 2) individual rehabilitation treatment such as artificial limbs and direct brain implants, 3) neurorobotics, and 4) larger neural networks for control. With the rapid development of bionic technology and nanotechnology, many researchers believe that CBS can assist humans in overcoming many limitations, such as those related to disease, speed, strength, and even intelligence.

To explore these applications, as well as potential limits and threats, the IEEE Technical Committee (TC) on CBS was created. There are numerous technology exchange paths between the biological organism and the cyborg sides (Figure 2). The committee, therefore, seeks to establish a unique, new community of research scientists and engineers to foster discussion, cooperation, and coordination of education and research in the interdisciplinary field of hybrid fusion and integration bionic system. Thus, the TC can contribute to human society by improving the quality of life, enhancing human capabilities and life activities, assisting the elderly and the disabled, and supporting medical rehabilitation and treatment.

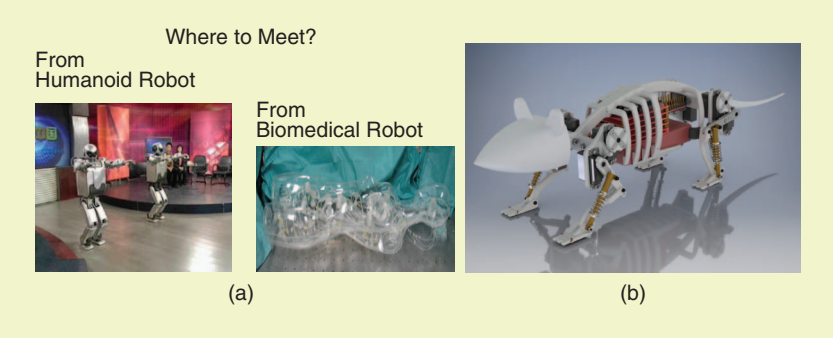

Figure 1. The concept of CBS. (a) A humanoid robot and human simulator; (b) a mouse-inspired cyborg organism developed by the Human Brain Project [Photo courtesy of European Union (EU) Horizon 2020 Flagship.]

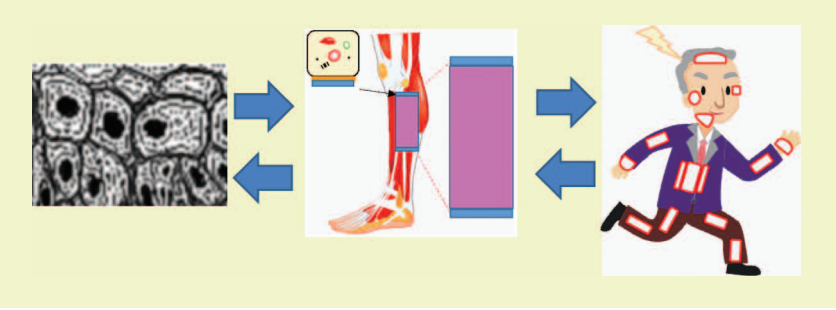

Figure 2. The technology pathways for cyborg development.

TC Activities

2016 IEEE International Workshop on Cyborg Bionic Systems

The first workshop was held on 25 April 2016 at the International Education Communication Center, in Haidian, Beijing. As a pre-event of the IEEE Robotics and Automation Society (RAS) TC on CBS, we invited six leading international academic scholars, all of whom have rich experience in rehabilitation robots. They shared their experiences and visions on CBS with the participants. The academic scholars' needs and ideas in this area will guide researchers in developing the optimal effective research solutions.

2016 IEEE International Conference on Robotics and Automation Workshop on Human 2.0

Organized by H. Harry Asada and Hugh Herr (Massachusetts Institute of Technology), the workshop was a full day event within the 2016 IEEE International

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Figure 3. Three academic activities organized by the TC on Cyborg and Bionic Systems: (a) an International Workshop on Human 2.0 during ICRA 2016; (b) an IEEE International Workshop on Intelligent Robots and System; and (c) the Third Japan-EU Workshop on Neurorobotics.

Conference on Robotics and Automation (ICRA) [Figure 3(a)].

Humans will be able to extend their physical and cognitive abilities to an unprecedented level in the near future. The human 2.0 is stronger, smarter, and more productive than humans today, and they can live longer and maintain their abilities for a longer period in life. This workshop addressed the possibility of creating a new generation of humans based on biohybrid robotics and bioengineering.

2017 IEEE International Workshop on Intelligent Robots and Systems

The workshop, sponsored by Beijing Institute of Technology (BIT), was held on 15–16 June 2017 [Figure 3(b)] at the Science Park of BIT, Beijing, China. It was attended by over 60 professors, scholars, and researchers from Germany, Italy, Japan, and China. The workshop dealt with the challenges of applying biologically based concepts to improve the capabilities of robots, with a particular focus on the fusion of organic and biomechatronic body parts to reduce the gap between roboticists and biologists, as mechatronic systems and robots are controlled in such a way that reflect a better understanding of the complex living organisms.

2017 Third Japan-EU Workshop on Neurorobotics and the Symposium: Building Bodies for Brains and Brains for Bodies

This workshop was held on 15–16 June 2017 at Biotech Campus Geneva, Switzerland [Figure 3(c)]. It focused on the field of neurorobotics, with the goal of improving robot behavior by exploiting ideas from neuroscience and investigating brain function using real physical robots or simulations thereof. Contributions to this workshop focused on the relation between neural systems—artificial or biological—and soft-material robotic platforms, in particular the control of such systems by capitalizing on their intrinsic dynamical characteristics like stiffness, viscosity, and compliance.

2017 IEEE International Conference on CBS

This event took place 17–19 October 2017 at the Science Park of BIT, Beijing, China. It was sponsored by the new TC on CBS, and coorganized by the IEEE RAS, BIT, and Beijing Advanced Innovation Center for Intelligent Robots and Systems. With 84 paper submissions from ten countries or regions, 64 papers have been selected for publication after going through a rigorous review process. The technical program of the IEEE CBS 2017 consists of two plenary talks, three keynote speeches, and 14 technical sessions. The CBS 2017 is a key conference focusing on frontier research and realistic applications related to CBS.

If you are interested in CBS and have not done so already, we invite you to join the TC on CBS, which currently comprises approximately 60 RAS members from academia and industry, through the RAS web page (http://www.ieee-ras.org/cyborg-bionic-system).