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Current Achievements and Challenges (Part I)

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Editorial

Human-Like Locomotion and Manipulation: Current Achievements and Challenges (Part I)

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Humanoid robots walk out of the well-structured labs and helping us in healthcare, industries, service, and even ocean and space domains. Just like humans, they require two important capabilities — locomotion and manipulation — once they are well-designed mechanically and equipped with advanced sensors. Locomotion means that humanoid robots can move in an unstructured environment. Mainly, they depend on the self-contained sensors and dynamically model the scenarios where they are located. Currently, humanoid's locomotion emulates human-like walking, running and overall movement given the articulated limbs and these facilitate them to move through diverse environment with agility and good balancing. Manipulation of humanoid robots exploits their dexterous arms and hands to implement complex interactions with unstructured environment. Some advanced humanoid robots are equipped with multi-fingered hands. These advanced actuators empower them to perform dexterity behavior like the human hand which is not possible if only traditional industrial grippers are used. Current major research topics on manipulation include grasping, lifting, in-hand manipulation, carrying and placing objects. When two arms and hands are involved, the tasks mentioned above can be performed in a more diverse and human-like way.

In this special issue, we invited research scientists in the humanoid domain and discussed the recent progress in locomotion and manipulation. Eight papers are published in the first part of this issue. Five papers are about robotic locomotion and walking. In Ref. 1, Luo *et al.* studied the walking and running for a bipedal robot and the research focus was a two-part control strategy to balance the robot even in a large external disturbance. The research work followed the planning and control tracking line and the landing position was planned and adjusted at every time step to adapt to uncertain disturbances. The control law was based on the quadratic programming approach. Bestmann and Zhang[2] used machine learning approach to study robotic walking. In this work, they studied the reference motion quality and design choices and modeled them as a Proximate Policy Optimization (PPO). Lower limb Exoskeleton is a special humanoid robot which is designed for rehabilitation and walking assistance for dyskinesia persons with spinal or lower limb muscle injury to regain the locomotion ability in daily activities. In Ref. 3, the authors presented a sensory-based feedback control approach for self-balancing the robot and human body. Exploiting the simplified CoM model and the trajectory was generated to enhance the locomotion capability. In Ref. 4, Zou *et al.* discussed an efficient robotic walking way, so-called knee-stretched walk. This paper reported a walking pattern generation — cosine-law-based spatially quantized gait. Compared with SoTA approaches, the authors showed that it was more robust and adaptive to different desired foot locations. Qin *et al.*, in Ref. 5, used the heuristics-based reinforcement learning (HBRL) approach and learned the walking of a bipedal robot. The training was done in a simulation in which exploration rewards, leg-foot reset condition and command curriculum are three important components to train the model. The trained results were evaluated in the real robot and disturbance conditions.

The other three papers studied the manipulation. Tao *et al.*, in Ref. 6, presented a hydraulic-driven multi-fingered robotic hand. The work introduced the design concept and the kinematic analysis in detail. The hand was produced and evaluated in the real world. The major advantage of this hand is (1) bearing the high payload and (2) robustness. Reference 7 focused on the vision-based perception — Semantic Simultaneous Localization and Mapping (SLAM). The proposed approach could enhance a robot's ability to perform tasks, the accurate perception, and the association of semantic objects in complex and dynamic environments. The result was evaluated on both simulated indoor sequences and the KITTI dataset. Lin *et al.*, in Ref. 8, tackled another perception modality — tactile sensing to localize and track an in-hand object. The localization was modeled as an optimization problem by minimizing the computed contact error. The contact positions are computed from two kinematic chains, robotic hand chain and the contacted object, which form a closed kinematic chain. The optimized object pose was iteratively computed via the EKF method.

Because of the space limitation, we will be including several papers in the second part of this special issue. We hope that this special issue can showcase the SoTA approaches to our readers and foster a fruitful discussion. As guest editors' team, we would like to thank the support from the EiC of IJHR — Prof. Ming Xie — and the World Scientific team comprising Dr Han Sun and Mr. T. R. Soundararajan. We would like to thank all reviewers for their time and insightful comments for the contributions and of course we also thank all contributors for publishing their works in this special issue.

This special issue is also part of the result of a joint humanoid robot symposium organized by the Gesellschaft Chinesischer Informatiker in Deutschland e.V.[9] and the Robotics Society of Singapore.[10] We would also like to express our thanks to all organizers and participants from the joint symposium.

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