Guest editorial

Special issue on cross-modal perception for industrial robots

Cross-modal perception means learning knowledge from some modality (e.g. vision) and using this knowledge to understand the environment with another modality (e.g. touch). The key to cross-modal perception is to establish a unified representation between multi-modal data sources. Cross-modal learning has been extensively used in Web search and human–computer interaction, but it finds little application in industrial robots. Currently, we can find several sensors in industrial robots, but the multi-modal integration and cross-modal transferring problems are still difficult. The first challenge stems from the heterogeneous gap: there exists significant feature space difference between modalities, and direct comparison or matching between them is difficult. The second challenge stems from the weak pairing: it is difficult to establish the sample correspondence relationship between modalities. These challenges incur many unsolved problems worthy of research.

This special issue mainly focuses on cross-modal perception and learning technology for modern industrial robots, solving both original theoretical development and engineering applications of cross-modal learning and transferring. We received many high-quality submissions, and only 15 have been finally accepted for publication after several rounds of peer review. They can be divided into three categories: sensing, perception and applications.

A few papers solve some basic sensing problems for cross-modal perception tasks. In "A cross-modal tactile sensor design for measuring robotic grasping forces," a cross-modal tactile sensor design for measuring robotic grasping forces has been developed. In "The perceptually-inspired model of tactile texture sensor based on the inverse-magnetostrictive effect) has described the development of a new perceptually inspired model of tactile texture sensor based on the inverse-magnetostrictive effect. The paper "An investigation of stimuli-current thresholds on the non-steady contact condition" describes the investigation of the stimuli–current thresholds on the non-steady contact condition. In addition, the authors of "Incorporating artificial skin signals in the constraint-based reactive control of human-robot collaborative manipulation tasks" incorporate artificial skin signals in the constraint-based reactive control of human–robot collaborative manipulation tasks. All of these works provide strong support for the cross-modal perception technology.

In few papers, various challenging cross-modal perception problems are tackled. In "An effective multifocus image fusion method using guided filter, multifocus image fusion based on coefficient significance of redundant discrete wavelet transform," two representative image fusion methods are developed. "Road segmentation of cross-modal remote sensing images using deep segmentation network and transfer learning" and "Radar and vision fusion for the real-time obstacle detection and identification" are concerned with the perception of road using vision and radar. In "Online weakly-paired similarity learning for surface material retrieval," an online weakly paired similarity learning for surface material retrieval is developed. "Natural teaching for humanoid robot via human-in-the-loop scene-motion cross-modal perception" investigates the natural teaching of a humanoid robot via human-in-the-loop scene-motion cross-modal perception.

The third part, which focuses on the applications, contains five papers. This part addresses various application problems including satellite attitude control ("Model-based deep reinforcement learning with heuristic search for satellite attitude control"), lower-limb exoskeleton systems ("Learning and planning of stair ascent for lower-limb exoskeleton systems"), bilateral-wheeled cable-climbing robot ("Dynamic obstacle-surmounting analysis of a bilateral-wheeled cable-climbing robot for cable-stayed bridges"), autonomous vehicles ("Research on decision-making of autonomous vehicle following based on reinforcement learning method) and welding systems ("A welding seam identification method based on cross modal perception").

We are glad to see that the papers included in this special issue cover different aspects of sensing, perception and applications. In particular, we can find lots of promising results using different perception modalities including vision, tactile, radar, etc.

We have to acknowledge that many submissions to this special issue exhibit high quality, but we were not able to accept them because of space limitations. During the review process, reviewers contributed a lot to the quality of this special issue by thoroughly evaluating the papers and providing a great deal of constructive comments. Last, but not the least, the completion of this special issue cannot be separated from the strong support from the Editor-in-Chief Dr Clive Loughlin. We would like to thank him for his great support.

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