Guest Editorial for Special Issue on Human-centered Intelligent Robots: Issues and Challenges

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The special issue aims to address a broad spectrum of topics ranging from human-centered intelligent robots acting as a servant, secretary, or companion to intelligent robotic functions. The special issue publishes original papers of innovative ideas and concepts, new discoveries, and novel applications and business models relevant to the field of human-centered intelligent robots. In this special issue, modeling, intelligent control, EEG signal processing, pattern recognition and impedance control in unstructured environments are studied for human-centered intelligent robots. This guest editorial is focused on three major axes: intelligent control, pattern recognition and human-robot interaction. This issue contains 12 papers and the contents of which are summarized below.

Currently, intelligent control has been widely applied to human-centered robots. Taking the assistive mobile robots for instance, a new nonlinear tracking control method with safety angular velocity constraint was proposed for a cushion robot in [1]. The team investigated a fuzzy path planning algorithm and obtained a real-time desired motion path of obstacle avoidance. The significant feature of the planned path can guarantee the safety of users because the controller has the character of angular velocity constraint performance. In [2], the torque tracking control problem was investigated for a class of series elastic actuators (SEAs) in the presence of unknown payload parameters and external disturbances. In [3], the uncertainties/disturbances rejection problem for SEAs was addressed from the view of a continuous nonlinear robust control development. The design concept and mobile control strategy of the human assistant robot I-PENTAR were examined. Different optimal control approaches such as linear quadratic regulator (LQR), linear quadratic Gaussian control (LQG), H_2 control and H_1 control were applied to a linearized model of I-PENTAR. Simulations were performed for all the approaches yielding good performance results. In [4], an EEG-driven online position control scheme was introduced for a robot arm by utilizing motor imagery to activate the movement of the individual links and error-related potential to stop their movement, following a fixed (pre-defined) order of link selection.

In [5], an intent pattern recognition approach for above-knee prosthesis was proposed based on the regularity nature of lower-limb motion. To remedy the defects of recognizer based on electromyogram (EMG), a pure mechanical sensor architecture for intent pattern recognition of lower-limb motion was developed. A hidden Markov model (HMM) was used to recognize the realtime motion state with the reference of the prior step. The proposed method can infer the prosthesis user's intent of walking on different terrain, which includes level ground, stair ascent, stair descent, up and down ramp. The experiments demonstrated that the intent pattern recognizer was capable of identifying five typical terrain-modes with the rate of 95.8 percent. The outcome of this investigation was expected to substantially improve the control performance of powered above-knee prothesis.

Most target grabbing problems were dealt with computer vision system, however, computer vision method is not always enough when it comes to the precision contact grabbing problems during the teleoperation process, and need to be combined with the stiffness display to provide more effective information to the operator in the remote side. In [6], a target grabbing strategy was proposed for telerobot based on developed stiffness display device. Special experimental results demonstrated that the developed stiffness display device could greatly help the operator control the telerobot to grab the target object in the remote side.

In [7], a facial expression emotion recognition was proposed based on human-robot interaction system, for which a four-layer system framework was designed. The human-robot interaction system enabled the robots not only to recognize human emotions, but also to generate facial expression for adapting to human emotions. As a few prospective applications, the system could be applied in home service, smart home, safe driving, and so on.

In [8], a real-time human pose detection and tracking method was presented by using monocular depth sensor based on an extreme point searching algorithm to detect extreme points of human body as a part of the landmarks. To overcome errors in extreme point and landmark detection, an estimation method was devised that used the trajectory information of the feature points to constrain the searching and correct the erroneous detections. Experiments were conducted using depth

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data acquired with Microsoft Kinect time of flight camera. The experimental results demonstrated that the proposed method delivers reliable detection and tracking results at a sufficient speed for processing real-time videos.

A more natural way for non-expert users to express their tasks in an open-ended set is to use natural language. In this case, a human-centered intelligent agent/robot is required to be able to understand and generate plans for these naturally expressed tasks. For this purpose, it is a good way to enhance intelligent robot's abilities by utilizing open knowledge extracted from the web, instead of hand-coding robot's tasks and knowledge. A key challenge of utilizing open knowledge lies in the semantic interpretation of the open knowledge organized in multiple modes, unstructured or semi-structured, before you can use it. In [9], an effective learning method was proposed to interpret semi-structured user instructions. Moreover, they presented a new heuristic method to recover missing semantic information from the context of an instruction.

A complete characterization of the behavior in human-robot interactions includes: the behavior dynamics and the control laws that characterize how the behavior is regulated with the perception data. In this way, a leader-follower coordinate control was proposed based on an impedance control that allows to establish a dynamic relation between social forces and the motion error [10]. This paper presented a scheme to identify the impedance based on fictitious social forces, which were described by distance-based potential fields. According to the results and under the hypothesis that moving like humans will be acceptable by humans, it was believed that the proposed control improved the social acceptance of the robot for this kind of interaction.

Human-robot interaction (HRI) is fundamental for human-centered robotics, and it has been attracting intensive research in recent years. In [11], a novel approach for physical human-robot interactions (pHRI) was presented, where a robot provided guidance forces to a user based on the user performance. This framework tuned the forces in regards to behavior of each user in coping with different tasks, where lower performance resulted in higher intervention from the robot. This personalized physical human-robot interaction (p2HRI) method incorporated adaptive modeling of the interaction between the human and the robot as well as with learning from demonstration (LfD) techniques to adapt to the users' performance. Applying this framework to a field such as haptic guidance for skill improvement, allowed a more personalized learning experience where the interaction between the robot as the intelligent tutor and the student as the user, was better adjusted based on the skill level of the individual and their gradual improvement. The results suggested that the precision of the model of the interaction was improved using this proposed method. In [12], the stiffness rendering problem was addressed for a cable-driven series elastic actuator (SEA) system, to achieve low stiffness for good transparency and high stiffness bigger than the hysical spring constant, and to assess the rendering accuracy with quantified metrics. A cascaded velocity-torque-impedance control structure was established. The 2-DOF(degree of freedom) stabilizing control method together with a compensator was taken to handle the competing requirements on tracking performance, noise and disturbance rejection, and energy optimization in the cable-driven SEA system. By adding a phase-lead compensator into the impedance controller, the stiffness rendering capability was augmented with guaranteed relaxed passivity. Extensive simulations and experiments were performed, and the virtual stiffness was rendered in the extended range of 0.1 to 2.0 times of the physical spring constant with guaranteed relaxed passivity for physical human robot interaction below 5 Hz.

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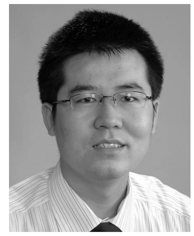

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