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Modelling and Control of Humanoid Robots

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This Special Issue collects outstanding papers from the 2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2018), which was held in Madrid, Spain, on October 1st-5th, 2018.

IROS 2018 was a flagship conference in the field of Robotics and finished its thirtieth first edition breaking all the records of Robotics congresses worldwide up to this date. This edition saw a record number of papers, with 2,704 submissions and 1,254 accepted papers for oral presentation with an acceptance rate of 46,4%. The number of workshops and tutorials also broke the previous editions figures with 99 submissions and 56 accepted proposals (57%). Including papers, workshops and tutorials, special sessions and late breaking results, the number of total submissions was 3,010.

The Guest Editors invited authors of selected outstanding papers from IROS 2018 to submit the extended version of their papers to this Special Issue of the International Journal of Humanoid Robotics (IJHR). After a strict peer-review process, seven papers were accepted for publication, covering the key areas of modelling and control of humanoid robots. The main topics are summarized next:

(1) Walking stability of a variable length inverted pendulum controlled with virtual constraints.

    Q. Luo et al. propose a kinematic model of the legs of a humanoid robot, based on a double pendulum, with two joints, one turning at the hip, and a prismatic in the knee, with variable length (VLIP). With this model, the authors can also simulate the vertical oscillations of the center of mass (CoM). The authors propose a set of functions, continuous at different ranges, where they study in

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detail the change from one phase to another. It is shown that the vertical CoM oscillation, positions of the swing foot and the choice of the switching condition play crucial roles in stability. Then, stable natural walking gaits can be achieved.

(2) Capture steps: robust walking for humanoid robots.

M. Missura et al. propose a new whole solution for humanoid bipedal gait based on the foot placement and timing to produce stable walks. The most important contribution of this approach is its simplicity, allowing the gait to be solved with a minimal computing cost, and reducing hardware costs by leaving several sensors out of the loop. The goodness of the method is presented by showing the results of different push-recovery experiments.

(3) Joint position control based on fractional order PD and PI controllers for the arm of the humanoid robot TEO.

J. Muñoz et al. present a control scheme for the humanoid robot TEO's elbow joint, based on a novel tuning method for fractional order PD and PI controllers. Due to the graphical nature of the proposed method, a few basic operations are enough to tune the controllers, offering very competitive results compared to classic methods. The experiments show a robust performance of the system to mass changes at the tip of the humanoid arm.

(4) Planning grasping motions for humanoid robots.

J. Rosell et al. address in this paper the problem of obtaining required motions for grasping. The first step consists of acquiring human movements and translating them into motion patterns or synergies. The potential grasps for a given object are planned using a bi-directional multi-goal sampling-based planner, which efficiently guides the motion planning following the synergies in a reduced search space, resulting in paths with human-like appearance.

(5) External force observer for small and medium-sized humanoid robots.

L. Hawley et al. present a work that deals with the observation of external forces applied to a humanoid robot, more specifically to the humanoid robot NAO. Instead of using high quality six degree of freedom force/torque sensors, the sensors used in their work are low cost force-sensing resistors (FSR) mounted under the feet of the robot. This requires a high-quality sensor signal processing in order to compensate the associated drawbacks, which was accomplished by the authors with great success.

(6) Development of applications for humanoid robots using multiple platforms, tools, and cloud data sharing.

S. Martínez et al. describe the procedure followed for using third-party tools and applications for humanoid robots, avoiding the development of complex communication software modules for data sharing. The main advantage of this approach is the possibility of using existing powerful tools of different architectures in order to speed up the development of real applications for humanoid robots. The robot model serves as a bridge relating the different incompatible systems involved. The solution proposed has been tested using kinematic tools from ArmarX middleware to develop movement applications for the humanoid robot TEO, which uses YARP middleware.

(7) Trait-based module for culturally-competent robots.

S. Borgo et al. discuss the relation between robotics and culture. In many cases, understanding, expectations and behavior are constrained, if not driven, by culture, and a robot that knows about human culture could improve the quality level of human-robot interaction. The authors propose the integration of a culture module in order to improve robot behavior, interpretations of situations and, therefore, human-robot interaction.

Among the contributions to this special issue, the Best Paper Award is for the work by Muñoz et al., with title *Joint position control based on fractional order PD and PI controllers for the arm of the humanoid robot TEO.*

Concepción A. Monje received her MSc. Degree in Electronics Engineering from the Industrial Engineering School of the University of Extremadura, Spain, in 2001, and her Ph.D. Degree in Industrial Engineering from the University of Extremadura, Spain, in 2006. In September 2006 she joined the University Carlos III of Madrid as a Visiting Professor in the Department of Electronics and Electromechanical Engineering, where she is currently an Associate Professor.
Her research focuses on control theory and applications of fractional calculus to control systems and robotics. She has participated in several EU and National research projects mainly related with these topics and has published over 100 technical

papers on these fields.

Santiago Martínez received his Ph.D. Degree in Electric, Electronics and Industrial Automation Engineering from the University Carlos III of Madrid in 2012. He is currently Associate Professor at the Systems Engineering and Automation Department and he belongs to the RoboticsLab research group. He has participated in several EU and National research projects mainly related with assistive robotics and construction robotics. Actually, he is the responsible of the development of the development of the humanoid robot TEO.