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PREFACE

Special Issue on Interactive Robots and Sensor Systems

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Future robots require interactive communication and task-sharing capabilities in the context of a social interaction with a human partner. Along with evolutionary computer programming either with self or behavior-based learning algorithms, ergonomically design and multi-interaction sensing systems are among the most important components for robot to face the challenge and needs from modern society. Sensors are a critical part of any robot, whether autonomous or teleoperated, or whether for land, space or underwater applications. Sensor provides important information about the environment and also to feedback information about the internal operation and motion of the robot's body parts. There are many types of sensors for use in robots and they have served robot based on its nature and sensing principles. Future interactive robots require many types of sensors to integrate and interactively communicate each other as sensing fusion to expend the capability of robots. This special issue focuses on some of the issues and challenges that arise when sensors interactively used in robot systems. It covers from developmental up to the system architecture and applications, which each of them potentially expand the capabilities of the robot system during interaction with human partner. Some of the articles also discussed about development of new type of sensor with unique sensing principles, as well as interactive control algorithms in robot system.

The importance of simple but effective teleoperation-based control system in industry and service robots through imitation of human's movement is highlighted in the article by Mavridis et al. This article present task-based teleoperation evaluation framework for real-time remote teleoperation of robotic arm commanded through human-arm motion capture by vision sensor. Their result shows that the desired trajectory of a remote robotic arm is easily and naturally controlled through imitation of simple movement of the operator's physical arm, obtained through motion capture.

One common problem in interactive robot and sensor is related to multiple robots to cooperate each other in desired tasks. Kobayashi and Hosoe address this topic in their article of behavior-based multiple mobile robots. They presented a design of a decentralized capturing behavior by multiple mobile robots with local observation via omni-directional CCD cameras. The proposed control policy can be similarly expressed both in enclosing and grasping tasks, although the coordinate systems used are different. One of the advantages of the proposed decentralized control is that each robot can judge whether the force-closure condition is archived by using locally observed information.

Towards human-assistive function, Capi and Toda present a new robotic system to assist visually impaired people in unknown indoor and outdoor environment. The robotic system, which is equipped with a visual sensor, laser range finders, speaker, gives visually impaired people information about the environment around them. The laser data are analyzed using the clustering technique, making it possible to detect obstacles, steps and stairs. By using the visual sensor, the system is able to distinguish between objects and humans. The PC analyses the sensors data and send infor-

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mation to the visually impaired people by natural language or beep signal. The usefulness of the proposed system is examined experimentally.

For space exploration and operation in rough terrains, Iizuka and Kubota study the performance evaluation of flexible wheel for lunar rovers on loose soil. The proposed wheel is made of an elastic metallic material copper beryllium due to its Young's modulus and bending stress are superior compared to other copper spring materials. The proposed design of the wheel give advantage during such operation since the soil under the wheel hardens without any destruction of the soil assembly. Their experiment results show that the flexible wheel performed high running performance on the loose and inclined soil surface.

The challenge of interactive sensor system in robotics is not only limited for robots working on land and space. Rahman et al. address challenge of sensor for underwater robotic platform. Small in size, higher sensitivities and lower power consumption are the ideal sensor characteristics for underwater robot application. They present a small size and high sensitivity micro-ultrasonic transducer (MUT) designs for underwater application with two sensing mechanism; piezoelectric (pMUT) and capacitive (cMUT). Their result proposed design and guideline for the use of such sensor in underwater robot within the specified performance.

Bahari et al. introduced interesting robotic hand having 14-degree of freedom as prosthetic hand which is approximately similar with the size of a human's hand. This simple but interesting design comprised of servo motors located at the palm to drive the pulley and belt mechanism connected to each of the finger joints enabling independent flexion finger link movement. A lightweight Light Dependent Resistor (LDR) sensor is positioned at the middle of the palm is to close around objects. The prosthetic provides three different controls of finger movement through the use of a Graphical User Interface (GUI) with computer interface.

On the other hand, Kawamura et al. investigated the directionality of tactile sensation capability of human fingertip and measure the human tactile sensation capability. The psychophysical tests were conducted on human fingertip in recognizing fine step-heights of about 10 μm and the mechanism of the directionality were discussed. From these psychophysical tests, the difference thresholds and subjective equalities for the step-heights are determined and the relationship between the fine-step's presentation angle and the fingertip's tactile sensation is revealed. As a result, it is found that the step's presentation angle has an influence on the human tactile sensation capability.

Rajaei et al. similarly investigated several characteristics of one kind of tactile illusion, called the Velvet Hand Illusion (VHI) in order to generate virtual feeling of a material in human's brain. VHI mechanism for new tactile displays in the virtual reality field was selected because such tactile illusions play a useful role in deceiving the brain so that operators believe a virtual sensation is real. VHI characteristics are obtained from accomplishing a series of psychophysical experiments using Thurstone's method of paired comparison. The important finding from the psychophysical experiments confirms that VHI does not occur in the mechanoreceptive units themselves but in the brain.

The work of Ali et al. present the development of tactile sensor based on an optical and image processing analysis. Their article highlights the experimental investigation to analyze the characteristic of the sensor which includes linearity behavior, hysteresis loss and deformations of the proposed tactile sensor.

In a different kind of approach, Kawamura et al. introduced a hybrid tactile sensor system consisting of a Carbon Micro Coil (CMC) touch sensor and a force sensor. This sensor system has the capability of measuring fine deformation of several micrometers occurring to a CMC sensor element, as well as the compression force. The sensor element is made of silicon rubber containing CMCs, and it is considered that the sensor element constitutes an LCR circuit. When the sensor element is deformed mechanically, the CMC sensor produces signals due to the modification of the circuit.

The work of Toda and Capi proposed new gas sensing technique for application in rescue operation to detect survivors. The novel idea is mainly on the usage of ultrasound in the chamber and a signal processing method that capable to detect the temporal change of average molecular weight within a chamber with a high sampling rate. This device could measure the change of the gas concentration over 400 kHz sampling rate in principle, which is much higher than commercially used or published gas sensing systems.

Reliable control method to solve problems in position and force control in robotic system is highlighted by Mehdi and Boubaker for robot-aided rehabilitation. New asymptotic stability conditions are proposed using a suitable Lyapunov approach and based on the relationship between the dynamics of the robot and its energy. The efficiency of the proposed approach is tested on a planar 3 DOF robot-aided rehabilitation constrained to a circular trajectory.

This work was supported by work of Yamano et al. proposed flexible and efficient control system of a robot hand for intelligent human-interactive tasks. They have designed the hardware and software of the control system. The hardware includes a PC and multiple micro control units (MCUs) so that various sensors such as range sensors, acceleration sensors and photo sensors can be added flexibly and efficiently. The calculation in the system can be distributed to the PC and the multiple MCUs. The software system is designed so that various software elements can be easily integrated. RT-middleware is utilized for the integration. Two applications of the system are presented to show the flexibility of the system. The hand is integrated with range sensor

in one application and microphone in the other. The results of the experiments show the effectiveness of the control system.

In conclusion, this special issue presents a broad cross-section of interactive robots and sensor systems, particularly as it relates to social robotics. Presented articles range from fundamental to applications, covering both robots and sensors, and interaction between both of them. The diversity of articles underscores the broad and breadth of research questions posed by interactive robot and sensor systems, which each of them discussed and presented based on unique scientific and technical explanation towards expand the capabilities of the robot system during interaction with human partner.

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