Japan Academy Prize to:

Hirochika INOUE
Emeritus Professor, The University of Tokyo

for "Studies on Robots with Sensation and Intelligence"

Outline of the work:

Robotics is a relatively new academic field that has rapidly developed since its inception in the 1960s. It is well known that Japan has played a leading role in the worldwide development of advanced technologies in this field, including its wide application in the industry. Dr. Hirochika Inoue is an international pioneer in the field of robotics who has cultivated and led this realm throughout the past half century by consistently working on robotic systems that have sensation and intelligence.

1. Pioneering Research on Computer Control of Artificial Hands

Dr. Inoue's first major achievement was in 1969 when he succeeded in achieving computer control of an artificial hand. This research pointed out that artificial hands must be bilateral and must be able to move according to the sensation of reactive forces in order to conduct skillful tasks. He presented a way to realize a computer-controlled bilateral manipulator and showed a number of useful basic functions that this hand could achieve. These functions included inserting a pin into a hole, rotating a crank, and detecting reactive forces. He also developed a direct teaching method that allows a person to guide the artificial hand to the desired location[1]. This research was highly regarded by the international research community for its originality and innovativeness in developing the essential functions that enable robots to perform manipulative tasks. His research also became the trigger for robotics research in Japan and was noticed by the academia overseas.

2. Advanced Research on Visual Guidance of Robot Motion

Vision is extremely important for robots. The hand-eye systems were a hot topic in the field of artificial intelligence. Dr. Inoue developed a visual feedback system that enabled a robot to visually detect the error in the location and orientation of a block in order to continuously correct the position of its hand. This type of research was conducted for the first time, enabling the robot to use visual feedback in precise assembly tasks and later, in visual guidance of rope handling[3,4]. In addition, he developed a multiwindow-type robot vision LSI（Large Scale Integrated Circuit）and a tracking vision system that could track an object in real-time using high-speed image correlation[5,6]. These technologies contributed to the actual utilization of robots with vision.

3. Software Platform for Intelligent Programming of Robots

To advance the robot's intelligence capabilities, building a software development platform with high visibility was essential. Dr. Inoue and his team built the programming system COSMOS, which is an integration of various functions including vision, manipulator control, and motion planning[9]. This system contributed to major progress in the experimental research of intelligent robots. In 1990, his team used COSMOS to build a system in which a robot that was shown a human task could visually recognize that task,

program it, and run that program[11,12].

4. Development of Humanoid Robot Systems

A humanoid robot is an ideal research subject that integrates all the functional elements of robotics such as sensation, action, intelligence, and human communication. Dr. Inoue developed software assets for intelligent robots in his lab and then implemented these assets onto the originally developed humanoid robots. This research cultivated the fundamental technology for intelligence research in humanoid robotics and transformed bipedal machines into human-shaped computers that sensed and acted[14–18].

5. Applications and Deployment of the Robotics Technology in Society

Dr. Inoue contributed not only to basic research but also to the deployment of robotics technology in our society. In 1998, he worked as the project leader with great success on the five-year national project on the research and development of humanoid robots. During the EXPO held in Aichi, Japan in 2005, he was in charge of the national robot development project and led a large team comprising representatives from various universities and industries from throughout Japan to show the world how robotics will shape our future society and how robotic technologies developed in Japan will realize our dreams for a better society.

Dr. Inoue is frequently called the “Father of Robotics” for his continuing contribution and visionary leadership in this field during the past half century. For his achievements, he has received the Medal with Purple Ribbon from the Japanese government. A similar prestigious prize from the French government, d’Officier dans l’Ordre National du Mérite, the Joseph Engelberger Robotics Award, and the IEEE Robotics and Automation Award are among the many awards that Dr. Inoue has received for his academic contributions, which are widely acclaimed internationally.

Selected Papers

【Robot Manipulation】

［1］H. Inoue: Computer Controlled Bilateral Manipulator, Bull. of the Japan Society of Mechanical Engineers, Vol.14, No.69, pp.199–207, 1971.

［2］H. Inoue: Force Feedback in Precise Assembly Tasks, Bull. of the Electrotechnical Laboratory, Vol.38, No.12, pp.775–789, 1974.

【Robot Vision System and Visual Guidance of Robot Motion】

［3］Y. Shirai and H. Inoue: Guiding a Robot by Visual Feedback in Assembling Tasks, Pattern Recognition, Vol.5, pp.98–108, 1973.

［4］M. Inaba and H. Inoue: Hand Eye Coordination in Rope Handling, J of the Robotics Society of Japan, Vol.3, No.6, pp.32–41, 1985（in Japanese）.

［5］H. Inoue, H. Mizoguchi, M. Inaba, S. Ikehata, and F. Isogai: Development of Window Control LSI for Multi Window Robot Vision System, Trans. of the Society of Instrumentation and Control Engineering, Vol.23 No.12, pp.1289–1295, 1987（in Japanese）.

［6］H. Inoue, M. Inaba, T. Mori, and T. Tachikawa: Real-Time Robot Vision System based on Correlation Technology, Proc. of the International Symposium on Industrial Robots, 1993.

［7］M. Inaba, Y. Hoshino, and H. Inoue: A Full-Body Tactile Sensor Suit Using Electrically Conductive Fabric, J of the Robotics Society of Japan, Vol.16, No.1, pp.80–86, 1998（in Japanese）.

［8］S. Kagami, K. Okada, T. Aoyama, M. Inaba, and H. Inoue: Follow and Avoid a Walking Human Being

using Real-time 3D Depth Flow Generation, in *Intelligent Autonomous Systems 6*, E. Pagello et al. (Eds), IOS Press, pp.257–264, 2000.

【Software Platform for Intelligent Programming of Robots】

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[11] Y. Kuniyoshi and H. Inoue: Qualitative Recognition of Ongoing Human Action Sequences, 13th Int. Joint Conf. on Artificial Intelligence, pp.1600–1609, 1993.

[12] Y. Kuniyoshi, M. Inaba, and H. Inoue: Learning by Watching: Extracting Reusable Task Knowledge from Visual Observation of Human Performance, IEEE Transactions on Robotics and Automation, Vol.10, No.6, pp.165–170, 1994.

[13] S. Kagami, M. Inaba, and H. Inoue: Construction and Implementation of Software Platform in Remote-Brained Robot Approach, J of the Robotics Society of Japan, Vol.15, No.4, pp.550–556, 1997 (in Japanese).

【Development of Humanoid Robot Systems】

[14] M. Inaba, S. Kagami, F. Kanehiro, and H. Inoue: A Platform for Robotics Research Based on the Remote-Brained Robot Approach, Int. J of Robotics Research, Vol.19, No.10, pp.933–954, 2000.

[15] J. J. Kuffner, S. Kagami, M. Inaba, and H. Inoue: Dynamically-stable Motion Planning for Humanoid Robots, Proc. of IEEE Int. Conf. on Humanoid Robotics, 2000.

[16] S. Kagami, T. Kitagawa, K. Nishiwaki, M. Inaba, and H. Inoue: A Fast Dynamically Equilibrated Walking Trajectory Generation Method of Humanoid Robot, Autonomous Robots, Vo.12, No.1, pp.71–82, Kluwer Academic Publishers, 2001.

[17] J. J. Kuffner, K. Nishiwaki, S. Kagami, M. Inaba, and H. Inoue: Dynamically-Stable Motion Planning for Humanoid Robots, Autonomous Robots, Vol.12, No.1, pp.105–118, Kluwer Academic Publishers, 2001.

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