Seminar 3: Technologies against Disaster

Monday, September 12, 2011

10:00am-12:00pm

Ambassador Room, The Embassy Row Hotel

Organized by the U.S.-Japan Research Institute

Welcome Remarks

Professor Katsuichi Uchida, *President, USJI/ Vice President, Waseda University*
Prof. Uchida gave a brief introduction to the U.S.-Japan Research Institute, a non-profit organization which was established by 5 prestigious Japanese Universities (Keio University, Kyoto University, Ritsumeikan University, The University of Tokyo, and Waseda University) to connect the United States and Japan through research on security, environmental, and economic issues. This seminar was part of a weeklong series of seminars part of USJI Week: Reconstruction after the Great East Japan Earthquake

Moderator's Remarks and Presentation

Dr. Shuji Hashimoto, *Vice Chair, USJI/ Vice President, Waseda University/ Professor, Faculty of Science and Engineering, Waseda University*
As Moderator of Seminar 3 on "Technologies against Disaster," Dr. Hashimoto opened the seminar by providing some background on Waseda University's prestigious robotics program and the key questions that the seminar would answer. Waseda University's robotics program began in the early 1970's and is most famous for its research on humanoid robots, a program which started in 1992. The program focuses on developing robotics for industrial, agricultural, and service use, and pushing robotics into a new state of beyond just being a production machine, software simulator, graphical user interface, and multimedia. Waseda University's Global Center of Excellence collaborates with leading research institutions to develop robots whose applications are: personal, physical, and psychological; communication, connective, and creative; and social, secure, and safe. The last 3 applications are most important for disaster recovery efforts. Dr. Hashimoto announced that **the era of show-time robotics is ending**, and now robots are being developed for practical use, meaning that robotics research will focus on important factors such as power/battery life, licensing, weather operation, and fusion with IT.

Dr. Hashimoto then moved on to reflecting on the shock of March 11 and the aftermath. The number of people dead or missing after March 11 stands at approximately 20,000. This high number makes Dr. Hashimoto ask, **"what does 'advanced country' mean?"** With all of Japan's scientific advancements, what can it do to prevent or mitigate disasters? Dr. Hashimoto reminded the audience that we develop technology to realize our dreams – and we can shape our future by developing technology to extend human ability. Robotic technology can be used before disasters for forecasts, predictions, and signal processing; during disasters for emergency functions and mitigation; and after disasters for restoration and preparation for the future.

Science and Technology for "Never Again": Looking ahead to the future of science and technology, it is clear that a robust society has much to gain from robotic applications, from natural science to engineering, cultural and social sciences to security technology and strategy. These applications will drastically enhance our civilization, industrialization, and culture for our sustainable happiness and security.

Panelists

Robots: Key Tools for Disaster Response

Dr. Martin Buehler, *Director of Research, Manipulation and Mobility, iRobot Corporation*, presented ways how iRobot's practical robots make a difference in people's lives. iRobot's field-tested robots are used in homes and by governments and industries, from cleaning to military applications and first response. The robots are built around a standard, modular basic platform, with many customizable, flexible payloads. This physical modularity is enabled and enhanced by the Aware robot software architecture across the iRobot family of robots. As a result, the robots can be quickly configured and matched to the required need. This is very important for emergencies and disaster response, because we never know beforehand what kind of disaster might hit, and which robot capabilities (or what kinds/sizes of robots) are needed.

iRobot's robots are supported by research and the expertise from its esteemed robotics R&D staff. The researchers and engineers continue to push the frontiers of robotics, including developing robots that are more intelligent and autonomous, and can collaborate with other robots. Also, these robots are easy to use, reducing the number of operators and training hours. Being so advanced, the robots offer a great platform from which Japanese researchers could harvest existing technology and knowledge and customize it to suit their needs.

Mr. Gerald Rondoe, *Military Division, iRobot Corporation*, followed Dr. Buehler's presentation by highlighting how iRobot's technology helped with the Fukushima rescue, and how that rescue illustrates the importance of robots in disaster response. Mr. Rondoe explained that iRobot has a history of responding to disasters, and the Fukushima disaster was no different. iRobot supplied 4 robots with a host of accessories, tools, and hardware as well as 5 top engineers to train operators for optimal use. These robots are used by TEPCO at the Fukushima nuclear site, and iRobot is providing ongoing support.

TEPCO's priorities were to survey damage, remove debris, and monitor facility recovery efforts. TEPCO's various missions showcased the robot's flexibility and robustness. Exposed to deadly levels of radiation, the robots successfully measure and map radiation and inspect and monitor reactivation. Although the robots have not been radiation hardened they have performed flawlessly in extremely high radiation environments within the reactor site for over 5 months with no degradation in performance.

A few key characteristics help with the success of the missions, with **multi-mission capability** being one of the most important. The controls are **easy to learn** and **software features are menu-driven** and **common across all platforms**. The robot's **robust design** and **multiple sensor and communication options** helped guide missions through the reactor's challenging environment.

iRobot engineers were able to successfully turn over the robots to TEPCO, but not without some challenges. The rapid response requirements were challenging – there was no direct access to the disaster site and specific mission objectives were unknown. Nonetheless, with the robot's flexible application parts, TEPCO operators had most of the tools they needed and iRobot engineers provided on-going support, without a formal agreement. iRobot engineers had daily conference calls with Japan the first month after deployment and ensured that TEPCO had parts on or near the site.

Requirements for Disaster Robots:
As a result of the numerous missions, Mr. Rondoe identified the critical requirements for effective disaster response robots. These robots must:

- Be flexible, easily changeable to adapt to dynamic conditions
- Feature open software architecture, which allows for continuous enhancements and facilitates new payload development
- Be operator-friendly – menu-driven, easy to learn and use
- Come with logistics and operation support, such as spare parts, maintenance, and field services that can be rapidly deployed
- Have open institutional architecture, or a global knowledge base and local application payload development
- Be field proven
- Protect humans by offering reliable communication, rechargeable power supply, and remote surveillance, all of which decrease the number of operators needed to be onsite
- Offer preparedness for future terrorism and outside threats – natural or otherwise

Mitigating Structural Damage to Save Lives
Dr. Steven McCabe, *Deputy Director, National Earthquake Hazards Reduction Program (NEHERP)/ Engineering Laboratory, National Institute of Standards and Technology*, shared his expertise in mitigating damage from earthquakes. He reminded the audience that the challenges with mitigation are: the unknowns in earthquake source locations and ground motion; the structure-ground motion interaction (different soils, etc.); uncertainty in response and damage anticipated; how these factors translate into design approaches for new structures; social issues such as large costs, hazards education and economic tradeoffs; and barriers to retrofitting older buildings that were designed to meet different standards.

Engineering a response to an earthquake
Dr. McCabe offered solutions to these challenges, which are: knowledge-sharing between government and academic researchers and researchers and practitioners; private-public partnerships; widespread use of new materials and methods and new experimental and computational capabilities for disaster response; and improving building codes and standards for new buildings (and old, if possible).

NEHERP is comprised of 4 key agencies in earthquake and tsunami disaster research and response: FEMA, NIST, NSF, and USGS. As such, NEHERP plays an instrumental role in identifying problems and finding solutions by conducting interdisciplinary research on earthquakes and their effects on communities, structures, buildings, lifelines, and national design (economic impacts of earthquakes on existing buildings). NEHERP works globally to better understand the dynamics of earthquake, but Dr. McCable reminded us that NEHERP faces two major challenges: system problems (soil foundation, structural and non-structural interaction) and existing buildings (few drawings, limited internal access, and liability and monetary concerns).

Despite these challenges, **prediction models and warning systems for tsunamis caused by earthquakes are becoming more reliable**. In addition, **improved evacuation and analytical models are being used to predict the impact of tsunamis and vertically evacuate accordingly**. These models help urban and community planning, which in turn saves lives.

The mechanisms by which NEHERP conducts its studies are sensors, active control, and experimental facilities. Sensors detect damage and collect data in real time. Active control goes beyond sensing by modifying structures to improve response to shaking – though this often requires power. Finally, experimental facilities conduct large-scale tests to simulate earthquakes in order to collect and store experimental data and computational results for present and future R&D. Through these mechanisms, NEHERP has advised on new building rules, which has led to much more robust building environments. New building foundations can use isolators, and older buildings can add dampers and external frames to buildings. These measures can be costly, but Dr. McCabe emphasized that there are important reasons to abide by the rules; most importantly, to help save lives during a disaster.

Question and Answer

A few of the open discussion questions and the experts' answers follow below.

Question: **What is the relationship between autonomy and radio communication mix – how long can operators leave a robot without communication?**

> Answer: Each robot has 2 operating frequencies, with a distance of up to 800 meters. Robots also have the ability to retrotraverse, so if they lose communication, they can back up until it is re-established.

Question: **What determines the look of robots? Japanese robots look more humanoid, but U.S. robots don't look like humans? Why is that?**

> Answer: At first iRobot's robots were for explosive disposal, so it didn't really matter what they looked like. Professor Hashimoto added that the main purpose of the robots is very different: in the U.S., robots are used as tools, while in Japan they are more like a friend to help out in the household.

Question: **How does NEHERP engage the end users to implement its recommendations?**

> Answer: NEHERP can set up best practices, but implementation ultimately depends on states, cities, etc. California, which experiences many earthquakes, regularly implements earthquake mitigating designs and tools, but the rest of the states are less concerned. However, the federal government has incentive to adopt these preventive measures, because often the federal government is responsible for part of the disaster recovery efforts.