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Development of Robotics and Mechatronics Technology for Secure and Better Quality of Life

Special Issue Engineering News in Brief

Message from the President
Inaugural Address of the 89th President

Activities for Overcoming Earthquake Disaster and Building Sustainable Society

Jun'ichi Sato
President , JSME
President & Representative Board Director of IHI Inspection & Instrumentation Co., Ltd.

1. Introduction

A huge earthquake off the coast of Sanriku, about 130 km east-southeast of Oshika Peninsula, Miyagi prefecture, Japan, with a magnitude of 9.0 occurred at 14:46 on 11 March. Not only the earthquake motion but also the enormous tsunami caused by the earthquake brought unprecedented damage to a wide area including the Pacific side of the Tohoku and Kanto regions. It took an enormous number of precious lives, devastated many cities and towns, and caused the economic loss of approximately 25 trillion yen. The members of the Japan Society of Mechanical Engineers (JSME) and their families, friends, colleagues and students were also faced with the tragedy. I express my sincere condolences to those who were affected by this disaster. As a secondary disaster of the

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Disaster Response Robots

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1. Introduction

1. Great Eastern Japan Earthquake

Great Eastern Japan Earthquake happened on March 11, 2011. This was a huge complex disaster of earthquake of magnitude 9.0, tsunami up to 38.9m high, and melt-down accident of Fukushima-Daiichi Nuclear Plant.

The statistics shows unprecedented damage in the Japanese history as shown in Table 1. Many countries, organizations and people have supported Japan in various ways including providing robot systems. The author deeply appreciates their kind offers.

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Computer Aides Surgery(CAS) and Surgical Robotics for Minimally Invasive Therapy

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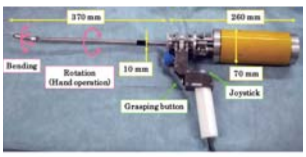
1. Introduction

Minimally invasive surgery is generally recognized as surgery with minimally incision or without incision. Endoscopic surgery shown in Figure 1 is typical example of minimally invasive surgery. Several abdominal ports are prepared for introduction of an endoscope and forceps for surgical operation inside abdominal cavity. Endoscopic surgery has various advantages for patients such as fast recovery, less pain, and shortened hospital stay. However, surgeon must have high skill to manipulate such surgical tools.



Integration in the form of a coneventional surgical tool

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Development of wearable power-assisted robots for care support and rehabilitation

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1. Introduction

Japan is universally recognized as an advanced country in robotic technologies and the global leader in the number of possessed robots. Robotic technologies, which have been advancing rapidly in the last decade, have not only developed biped walking and humanoid robots, but are expected to contribute to the care and rehabilitation fields as basic technologies to support or recover physical functions. This report describes our research achievements as well as the current trend of technologies relating to wearable power-assisted robots.

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Message from the President
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Activities for Overcoming Earthquake Disaster and Building Sustainable Society

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Continued from page 1 earthquake, reactors 1-4 at the Fukushima Daiichi nuclear power plant were damaged, resulting in the dispersion of radioactive substances. I express my heartfelt sympathy to those who are suffering in this serious situation.

What is required of JSME facing this disaster?

JSME has made efforts to build a secure, safe, and sustainable society with achievements in the field of mechanical engineering and the product technologies developed using these achievements. However, in the face of such a disaster, we become aware of our inadequacies in some areas. We must launch a full-scale effort to survey and analyze the events in this disaster and to institute future policies on the basis of the results. The characteristics of this disaster are that significant damage was caused by the earthquake itself and also by the enormous tsunami that followed and the area affected was extremely large. Also, it caused damage to the four reactors of the Fukushima Daiichi nuclear power plant, which led to serious accidents, raising doubts about the reliability of nuclear power generation. Moreover, because many nuclear power plants were suspended and many thermal power plants on the Pacific coast were also damaged, power shortages became a serious problem in the Kanto and Tohoku regions. Therefore, the survey conducted by JSME will cover an extremely wide range.

In addition to the conventional methods for surveying earthquake damage, it is necessary to examine what lessons have been learnt from past earthquakes, what measures have been taken and whether those measures were effective. As part of such an examination, it is important to inspect the machines and facilities that received minimal damage in this disaster. Clarifying why they received no or minimal damage is vital to reducing damage from natural disasters predicted to occur in the future. For example, whether or not nuclear equipment reinforced against earthquakes maintained soundness during this earthquake is important. Also, besides the four reactors at the Fukushima Daiichi nuclear power plant, there are 11 nuclear power facilities in the area affected by the earthquake and tsunami. It is necessary to verify why those facilities received only minimal damage and to recommend measures to be taken in the future.

Because JSME has discussed and published the codes for nuclear power plants through the JSME Committee on Power Generation Facilities Codes, the Center for Codes and Standards, we have, as specialists, the responsibility of evaluating and discussing the appropriateness of those codes. JSME should make proposals in terms of the contribution to the prevention of damage in disasters that are predicted to occur in the future.

Next, I would like to express my wishes from a mid- to long-term standpoint. It is a social consensus that we must aim for a low-carbon community in order to build a sustainable society. Until this disaster, nuclear power generation had been considered an effective solution to this issue. However, the serious accidents at the four reactors of the Fukushima Daiichi nuclear power plant will prompt discussions on the necessity of nuclear power generation. The 54 reactors of nuclear power plants in Japan can supply a vast amount of electricity, namely, a total of approximately 49,000 megawatts, at a low cost. The limited electric power supply after the disaster resulted in power failures. No industry, including machine industries, can continue production activities within Japan without the stable supply of inexpensive electric power. Therefore, the disaster also posed, to industries, the dilemma of whether to keep production in the country or to go abroad by necessity.

JSME has a duty to analyze the safety and problems of nuclear power plants from the viewpoint of specialists, as well as to examine and make proposals on other types of equipment for realizing a low-carbon community. Those proposals should be based on sufficient analysis of each technology and the discussion on their feasibilities. On the other hand, it is also necessary to build an energy-efficient society in order to realize a low-carbon community. Because JSME also comprises a group of specialists working toward achieving this aim, JSME must suggest how our country should work toward that goal. My hope is for JSME to step further into this issue by promoting discussions in terms of civilization and economy from the viewpoint of our expertise and making proposals on the basis of such discussions. JSME will cooperate with other academic societies and the Science Council of Japan to implement these activities.

Roles and challenges of JSME

The disaster posed a great challenge to researchers and engineers involved in mechanical engineering. We see people easily describe the earthquake and tsunami as unexpected in relation to the damage brought about by them. Is this the right attitude? The tasks of mechanical engineering are to analyze, clarify and organize the issues associated with mechanical technologies and to make thus-obtained achievements available for technological development. Also, we should integrate those achievements to construct a process of design and production, aiming at the creation of machines that sustain the coexistence of humans and nature. Should those who develop and manufacture machines be able to evade responsibility for the failure of those machines because of unexpected events?

Mechanical engineers have learned and grown from previous failures. It is true that, in that process, there were many events that were beyond human understanding or that had not been clarified until then. However, whether a certain event is beyond human understanding or not should be determined after sufficient analysis and clarification of that event. The word "unexpected" often means that a certain issue was considered only from the standpoint of a narrow technological field. Researchers may judge things on the basis of an idea generated in the narrow field of their expertise, and engineers may develop products with a narrow range of product technologies. In many cases, the failures in unexpected events are caused by a lack of knowledge, wisdom and experience in a wide variety of fields.

Because JSME covers all the fields related to mechanical engineering, it is necessary for us to provide our members with a forum for exchanging information and carrying out discussions not only on a certain specialized field but also on various fields. Conventionally, only a high level of expertise in a specialized field has tended to be emphasized; however, JSME will aim to provide a panoramic and up to date view on all mechanical technologies.

In addition, JSME will provide a wide variety of cutting-edge information to members through cooperation with the academic societies of other fields. At present, there are 20 divisions in JSME, and another division will be added next year. I would like the members to be immersed in not just the activities of one division but also to participate in the activities of other divisions. In order to promote such interdivisional exchange, some activities involving several related divisions will be planned. My hope is that the individual members will become active all-round mechanical engineers who have their own fields of expertise. Paradoxically, their knowledge and wisdom as all-round mechanical engineers will be helpful to them in developing their expertise in a creative way.

For development of JSME

Individual researchers and engineers support the research, development and technologies of mechanical engineering. The enhancement of industrial competitiveness is nothing but the fostering and enhancement of the people who support it. In order for industries to maintain international competitiveness, there must be researchers who understand industrial technologies and are globally competitive in the academic institutions that play an important role in the development of basic technologies. Also, in the industrial world, there must be engineers who can deeply understand mechanical technologies in the field of engineering and apply those technologies to the manufacture of actual products. Such researchers and engineers will stimulate each other, which will lead to the betterment of mechanical engineering.

The activities of JSME should be helpful for academic institutions and the industrial world to create a deep interrelationship. It is important for the branches of JSME to be engaged in engineering education and to support local industries as centers of mechanical engineering and technologies in their regional areas. For that purpose, exchanges between JSME branches and local industrial groups will be actively promoted. These divisions of JSME, as centers of engineering and technologies of each field, will support specialized education and interact with the related industries. In addition, JSME will make efforts across divisions to foster human resources that can hold a panoramic view of mechanical engineering. Finally, I look forward to and appreciate the continuous support and encouragement from the members of JSME.

Disaster Response Robots

Satoshi Tadokoro

Tohoku University / International Rescue System Institute

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2. Action of Japanese Roboticists

Since just after the shake, roboticists in Japan tried to use robotic systems as listed in Table 2.

Most rescue robots in Japan were intended for search in collapsed buildings. Practical robots that had used in some incidents could not be used because the major damage was caused by tsunami and the nuclear accident.

Table 1: Damage by Great Eastern Japan Earthquake.

Damage	Quantity
Dead / Missing	14,728 / 10,808 on May 2, 2011
Damaged Houses	> 100,000
Evacuated	> 400,000 (maximum)
Ships Washed-Away	> 22,000
Amount of Damage Estimated	>20,000,000,000,000 JYE

Table 2: Major known robot activities of Japanese roboticists after March 11.

Date	Major Activities	Target	Who
3/11	US: Request to CRASAR for deployment (Invitation letter: 3/17)	Collapse	Tadokoro
3/13	Sendai: Active Scope Camera standby with Sendai City FD	Collapse	Tadokoro
3/14	Sendai: Call for robot needs to METI and local governments Sendai: Quince standby	Factory Factory	Tadokoro Koyanagi
3/15	Sendai: Airport investigation	Tsunami	Tadokoro
3/17	Chiba: Quince development for Kashima Petrol Plant Chiba: Quince development for Fukushima Nuclear Plant	Factory Nuclear	Koyanagi Koyanagi
3/19	Hachinohe: KOHGA building inspection, Needs in ports	Collapse	Matsuno
3/28	Sendai: Quince collapsed building inspection	Collapse	Tadokoro
3/31	Iwate: Call for port inspection	Port	Matsuno
4/2	M-Sanriku: Request for port inspection by mayor	Port	Kimura
4/7	Miyagi: Call for port inspection	Port	Murata
4/11	Miyagi, Iwate: Call for digital archive	Town	Murata
4/12	Sendai: 3D & thermo camera for JAEA Team Nippon vehicle	Nuclear	Ohno
4/18-	Watari: Anchor Diver III port inspection M-Sanriku: Seamore, SARbot inspection w CRASAR (Murphy)	Port Port	Hirose Kimura
4/20-	R-Takada: Seamore, SARbot victim search w CRASAR (Murphy)	Port	Matsuno
4/29-	Ohtsuchi: RTV found 2 victims in sea	Sea	Ura

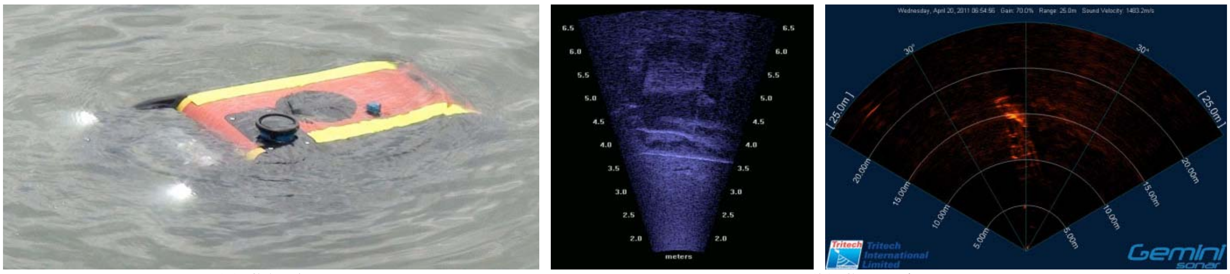
3. Robotic Harbor Inspection in Minami-Sanriku Town and Rikuzen-Takada City

Prof. Tetsuya Kimura, Nagaoka Institute of Technology visited Minami-Sanriku Town on April, 2, 2011 as a delegate of International Rescue System Institute (IRS). The mayor requested him to inspect the seafloor of the new harbor by using robotic systems for the economic recovery. They had to open the harbor and the fish market by September, the sermon season. Prof. Fumitoshi Matsuno, Kyoto University visited Iwate Prefecture, and was requested to apply robotic systems for victim search. A cooperative team of Center for Robot-Assisted Search and Rescue (CRASAR, USA by Prof. Robin Murphy, Texas A&M University) and IRS made survey by two ROVs, Seamore and SARbot as shown in Fig. 1. As a result, they did not find any obstacles nor victims above 5 m deep except for debris near the breakwater in Minami-Sanriku Town. This meant no heavy dredging work is necessary there.

4. Response to Nuclear Disaster

Information gathering for recovery planning is demanded at Fukushima Daiichi Nuclear Plant. Two Packbots, which were donated by iRobot, entered into the 1st floor of the reactor buildings and measured the dose rate, images, temperature, and humidity. They were important data for minimizing human radiation exposure.

Quince was developed by NEDO Strategic Robot Component Technology Project for search and reconnaissance of



(a) SARbot (b) Sonar images

Fig. 1: Robotic Harbor Inspection in Minami-Sanriku Town.

Fig. 2: Exercise of cooperative information gathering by 2 units of Quince.

confined space contaminated by chemical agents, of which PI was Prof. Satoshi Tadokoro, Tohoku University. Quince has advantage of higher mobility than other robots, and has succeeded in traversing large rubble piles of wood and concrete at Disaster City, which is the world largest training facility for urban search and rescue.

Quince was modified for the Fukushima by adding a dose meter, high-power wireless, wired communication, and a temperature-humidity meter by a team managed by Prof. Eiji Koyanagi, Chiba Institute of Technology. It has been used for entering 2-5 floors and B1 floor of the nuclear buildings for more inspection where human can never enter by high-level radiation. It contributed significantly toward establishment of the double cooling system.

5. For the Future

Effectiveness and future possibility of robotic systems at disaster were well demonstrated at first in Great Eastern Japan Earthquake. The Fukushima-Daiichi still needs various robotic systems for recovery. The functions of such response robots are 1) enhancement of human capabilities, 2) prevention of secondary damage, and 3) accelerate operations. Target-oriented research and development must be organized by governmental funds for solving the current problems and preparing for the future.

Computer Aides Surgery(CAS) and Surgical Robotics for Minimally Invasive Therapy

Ichiro Sakuma

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Continued from page 1 Conventional endoscopic surgical tools' degrees of freedom of motion are as four as shown in Figure 1:

2 for bending (inclination) motion around insertion
1 for translational motion along tool axis
1 for rotational motion around tool axis

Since the insertion point functions as a supporting point, the direction of the hand movement and direction of the tool tip movement is opposite. In other words, surgen moves his or her hand upward, the tool moves downwards. In addition, the endoscopic image provide limited narrow view of surgical field. Thus the surgeon should have high skill to conduct endosopic surgery using conventional surgical tools. The surgeon should acquire hand-eye coordination suing endoscope and surgical tools through training. da Vinci Surgical system produced by Intuitive surgical Systems realized this function by a master-slave manipulator system[1]. This system is widely used in endoscopic surgery that requires reconstruction

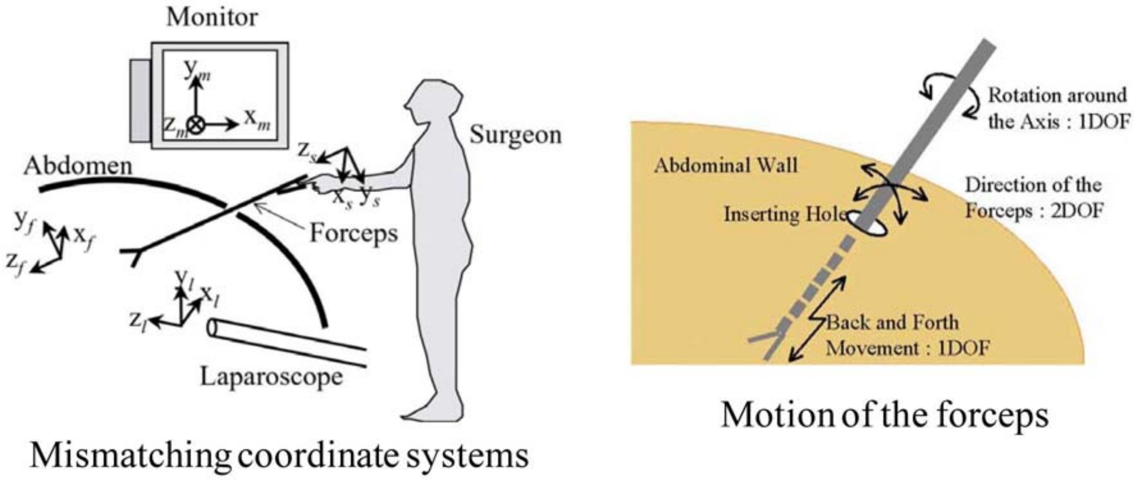

Fig 1 Endoscopic surgery and degrees of freedom of surgical tool

procedure such as anastomosis and precise handling blood vessel and nerve fibers. Endoscopic prostate resection is typical application. Example of limitations of current master-slave surgical manipulator system is its large size occupying large space in an operating room, lack of tactile sensation that provide surgeon with various cues to intra-operative diagnosis of pathological tissue, and lack of surgical navigation capability[2]. There have been studies to miniaturize surgical tools and introduction of tactile sensing system. When tactile sensation is discussed, it is important for engineers to analyze surgeons' requests. Information can be more easily obtained by existing other sensing technologies rather than by tactile sensing technologies in some cases. Simple reproduction of surgeon's maneuver is not always an appropriate solution.

In recent surgery, in addition to conventional forceps, knives, and scissors, so-called energy devices such as electric cautery, radiofrequency ablation device, cryo-ablation device, and ultrasonically activated scalpel are widely used. When these devices are applied to endoscopic surgery, similar problems are encountered. Addition of other two degrees of freedom to conventional endoscopic surgical tools, namely two bending motion like human wrist at the tip of surgical tools is significantly improves their usability[3,4]. Adding additional degrees of freedom to advanced surgical tools such as power controlled electric cautery, cryo-ablation device, radio frequency ablation device, and ultrasonically activated scalpel is also important challenge Fig 2 shows one example of adding additional degrees of freedom of motion to miniaturized ultrasonically activated scalpel[5].

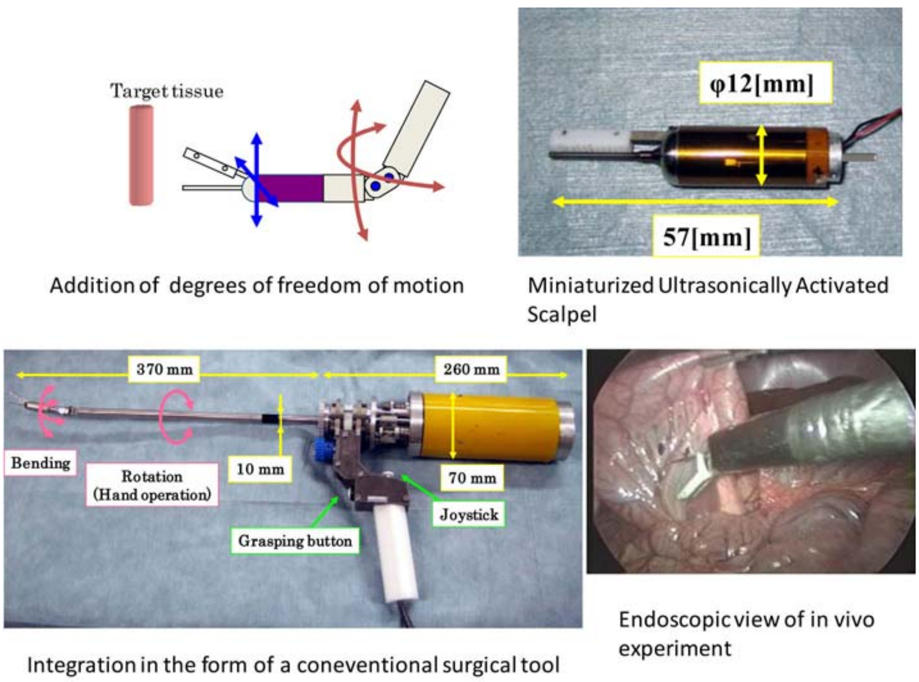

Fig. 2 Ultrasonically activated scalpel with additional two degrees of freedom of motion

Another representation of minimally invasive therapy is therapy that resects or destroys only pathological tissue such as malignant tumor and metastasis of tumor while maintaining normal tissue intact. In case of resection of malignant tumor, surgeon usually resects surrounding tissues or lymph nodes connected to the tumor tissue considering possibility of residual tumor and metastasis. These tissues are not always malignant. Some resected tissues are normal. Excessive resection will lead to deterioration of quality of life of a patient. However, surgeon must resect the tissue unless there is no possibility of residual tissue and matastasis. If we precisely identifying the boundary between normal and malignant tissue intra-operatively, excessive removal of normal tissue can be possible. For this purpose, pre/intra operative diagnosis that can localize pathological tissue and precise positioning of interventional device by robotic technology will be integrated. One example is 5-aminolevulinic and (5-ALA) induced fluorescence measurement for intra-operative detection of brain tumor. We have developed an optical pickup device mounted on a motor driven X-Y stage as shown in Figure 3[6]. The 5-ALA induced fluorescence detection system with a mechanical scanning system was integrated with a surgical navigation system. The fluorescence spectra were registered to the corresponding location in surgical navigation map.

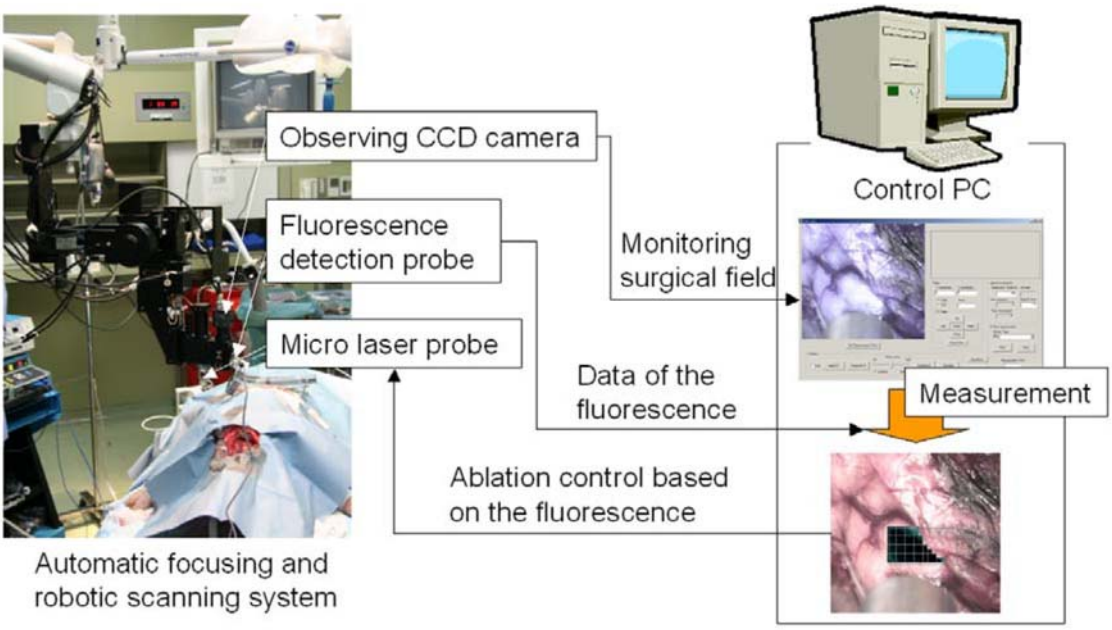

Fig.3 An integrated diagnosis and therapeutic system using intra-operative 5-aminolevulinic-acid-induced fluorescence guided robotic laser ablation

This field of technology is called as Computer Aides Surgery(CAS), Computer Assisted Intervention(CAI), or Computer Integrated Surgery(CIS). Combination of advanced medical instrumentation including three dimensional anatomical/functional imaging, robotic/mechatornic devices and advance information processing and computer control will realize more efficient, safer medical intervention with less invasiveness.

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Development of wearable power-assisted robots for care support and rehabilitation

Ryu Kato, Hiroshi Yokoi

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2. Power-assisted robots

Wearable power-assisted robots aim to extend or support physical functions of humans, and their applications to various fields have been extensively attempted. However, the required specifications of these robots vary according to their purpose and location. Table 1 summarizes such specifications. Research and development of such robots can be categorized into two types: 1) designing power units to actively support joint motion and 2) designing control systems to extract the human intention in the motion and to control robots.

2.1 Power Units

To actively support the flexion and extension of a joint, developed systems must mechanically hold and drive two or more bones comprising a joint. Typically electric motors have been used as a power source of such systems due to their good controllability. However, air/oil pressure actuators, electrostatic actuators, and shape-memory alloy actuators have also been employed.

Power transmission devices that transmit the driving power generated by a power source to movable parts are classified as either exoskeletal or non-skeletal type. For the exoskeletal type, a mechanical joint is placed on the side of a human joint (on a rotation center axis of a system), and the mechanical joint moves in synchronization with the rotating motion of the human joint on a one-on-one basis. Consequently, the driving power is transmitted to the human joint by equipping the mechanical joint with a motor (Fig. 1(a)). One example is the Hybrid Assistive Limb (HAL), a robotic suit developed by Sankai and colleagues [1]. However, because mechanical joints protrude outward on the side of human joints, this type of device cannot be applied to structures such as fingers where human joints are in close proximity. To overcome this difficulty, a slider mechanism (Fig. 1(b)) or link mechanism (Fig. 1(c)) is used in the mechanical joints of the system to place the external mechanism on the back of the human joint.

On the other hand, non-skeletal robots directly utilize the human skeleton without their own mechanical skeleton (Fig. 2). They are often used for body parts such as the shoulder and waist where the size of the mechanism can become large. Research on these robots strives mainly to reduce weight by eliminating the exoskeleton. For example, Noritsugu and colleagues have reduced the stress on human joints by developing waist power-assisted devices using a curved pneumatic artificial rubber muscle placed around the waist [2]. However, shoulder joints are difficult to support due to the complex construction of the shoulder joint where the rotation center changes according to the shoulder motion. Kobayashi and colleagues have developed a muscle suit with a three-degree-of-freedom in the shoulder joint and a single-degree-of-freedom in the elbow joint using a pneumatic artificial rubber muscle [3]. This suit supports the shoulder joint via a three-degree-of-freedom mechanism with a closed arch link structure.

2.2 Control System (Evaluating human intension in the motion)

To develop control systems, determining the amount and timing of power transmission to the human body, especially to the joints, is a major task. In particular, research to extract the human intention in real time motion has been mainly conducted to define an assisting force appropriate for the intention. When research in this area began, the assisting force was calculated based on a simple switch operation and kinematic state measurements such as angles and angular momenta of

Table 1 The required specifications of wearable power-assisted robots

	Degree of freedom of motion[DOF]	Required power [W/DOF]	Response speed [Hz]	Restriction of size-weight [kg]	Required function
Upper limb(hand)	High(~24)	Low(1~10)	High(10~100)	Heavy(<1.5)	Indefinable
Upper limb(elbow, shoulder)	Middle(~7)	Middle(~250)	Middle(~100)	Middle(<2.0)	Gravity Compensation
Lower limb	Middle(~7)	High(250~)	High(10~100)	Light (<10.0)	Movement of center of gravity Stability
Body trunk(waist)	Low(~3)	High(250~)	Low(~10)	Light (<10.0)	Gravity Compensation Stability
Head(jaw)	Low(~3)	Middle(~250)	Low(~10)	Light (<10.0)	Gravity Compensation Stability

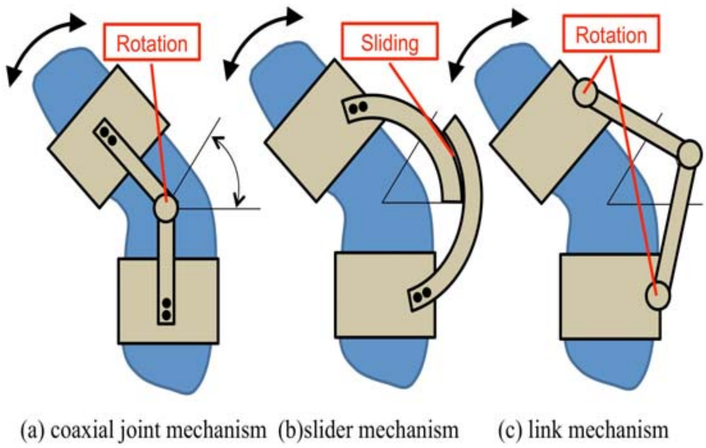

Figure 1. Exoskeletal type

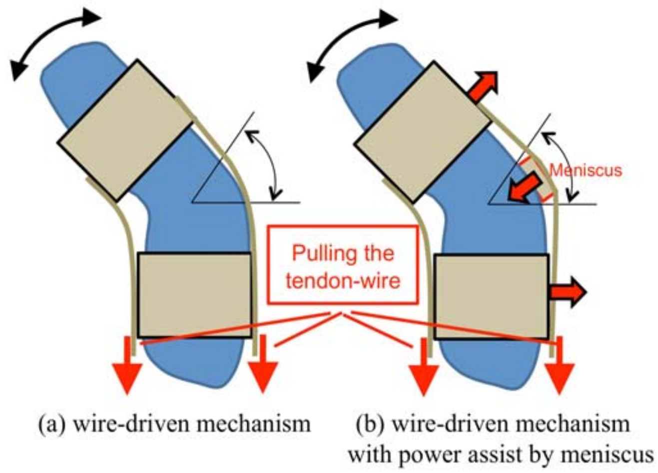

Figure 2. Non-skeletal type

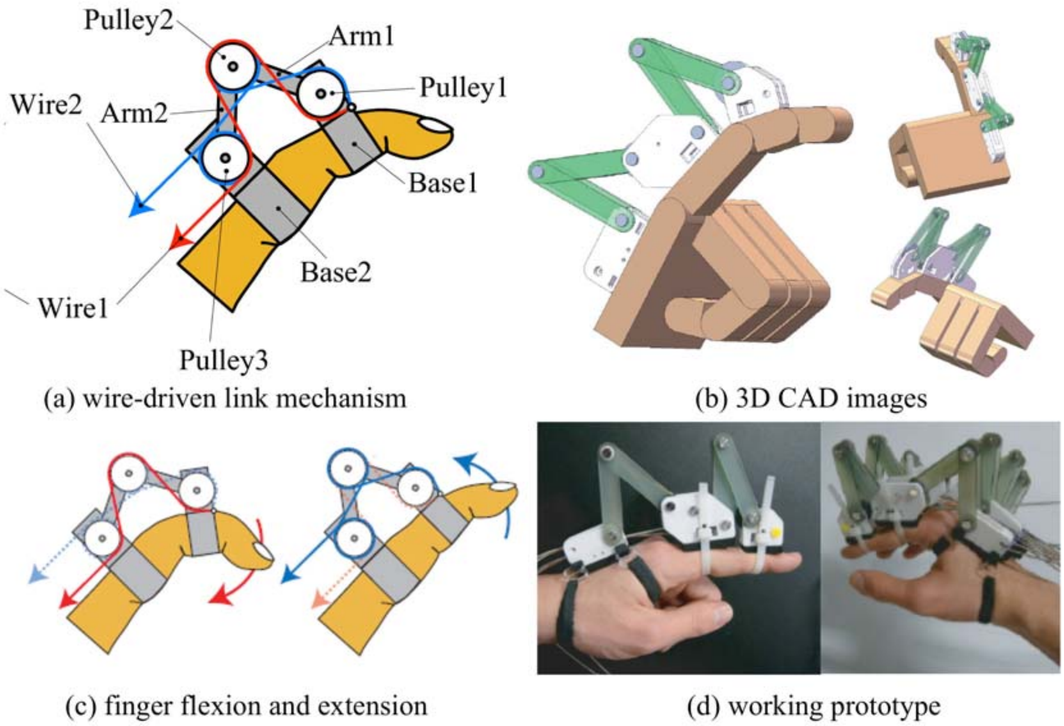

Figure 3. Power-assisted robot that passively moves paralyzed fingers by a wire-driven link mechanism

the joints to be supported. Today, the position and speed as well as power, consumed energy, and physical conditions such as fatigue can be measured, allowing precise control of the assisting force. Cutting-edge research topics in this field include developing methodology to extract the intention in complex motions. Applications of this methodology to the brain machine interface (BMI) based on myogenic potential as well as brain waves and the hemoglobin concentration of blood are under way.

3. Our approach: Finger rehabilitation using a wearable power-assisted robot

Our research group aims to apply the aforementioned robotic technologies to support finger rehabilitation. In general, exercise, such as repetitive motion of finger joints, is passively applied to improve finger paralysis. However, passive exercise of paralyzed limbs has problems, including a shortage of therapists and limited insurance coverage. Thus, the development of assistance devices capable of performing rehabilitation without a therapist is highly demanded. Hence, we have been developing exoskeletal robots that can replace therapists and can passively move fingers by a wire-driven link mechanism [4].

Figure 3 shows a device we developed where fixtures (called ‘bases’) are placed on the phalanges. Two phalanges that fix the bases are connected to two links by free joints to form a closed link mechanism. Each mechanical joint of the link is equipped with pulleys and two wires, one for extension and the other for flexion. Each wire fixed on the edge of the base is pulled by a motor through each pulley, allowing the joint to extend or flex. When this device is not fixed on the fingers (not fixed on the phalanges), the bases easily move forward and backward, allowing a user to intuitively adjust the placement position of the device according to user's finger length. Moreover, it is lighter than existing systems, and can provide safer and more driving torque. Consequently, it is very practical. During our clinical evaluations, which were conducted in collaboration with Fukui University School of Medicine, we confirmed that our device can yield sufficient torque to move paralyzed limbs and can provide a full range of motion. We are currently conducting experiments on self-motion control of the device using motions from a data glove worn on a healthy hand that a robot reproduces on a paralyzed hand. Implementation of this device as an output-type BMI is expected to contribute not only to the realization of recovery training of motor function based on neurorehabilitation, but also to allow robots to extend the motor function of paralyzed fingers that cannot be recovered by rehabilitation.

4. Conclusion

In 2008, over 22% of Japan's population was over 65, and consequently, Japan is becoming a super-aged society. Therefore, increasing the number of applications of wearable power-assisted robots in numerous medical and welfare fields, including senior care and rehabilitation for disabled persons, will become a significant area of research. In addition to research on power-assisted robots using external forces discussed herein, many studies have been conducted to support muscle flexing by directly applying electric stimuli, and have revealed the usefulness of this technique. Thus, it is clear that power-assisted robots as a part of BMI technologies in regenerative medicine will reduce the gap between robots and humans.

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Special Issue

Engineering News in Brief

Localized Chemical Stimulation of Cultured Cells Using a Microfluidic Device

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A microfluidic device for localized chemical stimulation of cultured cells was fabricated and tested. The device consists of a micro-chamber for cell culture, nano-holes for releasing nerve growth factors (NGF), and a microvalve for their release control. The microvalve has hydrophilic and hydrophobic channels. Liquids injected into the hydrophilic channels stop at the boundary between the hydrophilic and hydrophobic channels. The air that was initially in the hydrophobic channel separates the two liquids. When pressure is applied from the inlet, the inlet liquid will break into the hydrophobic channel and merge with the outlet liquid. If the inlet liquid includes NGF, it will diffuse into the outlet liquid and eventually be released from the nano-holes. The amount of NGF that will stimulate a nerve cell can be controlled very precisely by opening and closing the microvalve. Experiments using a fluorescent solution showed that chemical release through the nano-holes was successfully controlled by the microvalve switching. Moreover, we succeeded in differentiating nerve cells and guiding their axons in the direction of the nano-hole array by localized NGF stimulation.

Digital Model Railroad

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Digital system is getting more popular also in the world of model railroad. With digital system, many trains can be controlled independently on the same layout. And that was very difficult in the conventional analog system. Furthermore, sound system such as horn, steam locomotive operating sound, or diesel engine operating sound are heard from digital locomotives on the layout. Above-mentioned functions are achieved by micro chips called decoder inside the model locomotives. Although the appearance of model locomotives is same, they become more realistic in operation and sound with these micro technologies. You can see a huge layout of digital model railroad system in Hamburg Germany. The facility is called Miniatur Wunderland.
http://www.miniatur-wunderland.de/anlage/video/zugmitfahrt/aktuell/

Single-axis Actuator for High Load Application

Toshiharu Kajita
NSK Ltd.

Electrically driven actuators are used extensively for many applications, but in many cases the load position and guide section are separated, which generates large moment loads and requires higher load capacity. NSK has developed the new Toughcarrier™ single-axis actuator for high load applications. The single-axis actuator uses rollers as rolling elements of the guide to greatly increase the load capacity, while retaining the same dimensions as existing actuators. NSK has also developed a compact fire-resistant anti-spatter cover for welding processes.

The Rolling Stock Field Test Simulator(Komaki)

Satoshi Kikuno
Technology Research and Development Department (Komaki) Team Manager

For the further improvement of the Tokaido Shinkansen, Central Japan Railway Company introduced the Rolling Stock Field Test Simulator at Technology Research and Development Department(Komaki) in 2007. The Rolling Stock Field Test Simulator reproduces actual rolling stock running conditions by simulating vibrations caused by aerodynamic force in a tunnel , and by track irregularities and rail roughness , etc. By making the structure of testing device as rigid as possible , the device enables durability tests of various train parts. In these durability tests it is also possible to identify preliminary fault signs. The testing device will contribute to technical developments that will further improve the Tokaido Shinkansen. In this paper, we introduce the outline of this testing device.

Fabrication of Ultra-small-diameter Cutting Tools by Electrical Discharge Machining

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Kyoto Institute of Technology

Ultra-small-diameter cutting tools, the diameters of which can be less than 10 μm, are fabricated with ease by electrical discharge machining (EDM). EDM is suitable for fabricating small-diameter cutting tools because it can process materials of high hardness and realize fragile minute structures with small unit removal. Gun-barrel-

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drill-type tools made of cemented tungsten carbide, diamond and cubic boron nitride (CBN) were successfully produced when electrically conductive materials of those were used as the tool materials. Tools with a diameter of as small as 3 μm were fabricated and used for drilling and slot milling. As a result, holes of 4 μm diameter and slots of 4 μm width were processed. They are the smallest holes and slots fabricated by rotating cutting tools. The tools were employed also in turning and carried out the boring and face turning of small-diameter pipes.

Air-blown IGCC Demonstration Project

Takeharu Sato
Clean Coal Power R&D Co., Ltd.

The Integrated coal Gasification Combined Cycle (IGCC) is a highly effective power generation system because a gas turbine is operated with coal gasified in the gasifier. Japanese electric power industry has carried out the development of the air-blown IGCC technology (two stage entrained flow gasifier), which is expected to be more efficient than current technology (oxygen-blown gasifier) developed overseas. In Japan, a national IGCC project was launched to operate the Pilot Plant during the period from FY 1986 to FY 1996. The project proved validity of the IGCC technology with the air-blown gasifier. Based on the success, the IGCC Demonstration Project has been carried out for the purpose of demonstrating reliability, operability, maintainability, and economy at the final step toward commercialization. It has been continued in Nakoso Power Station of Joban Joint Power Co., Ltd. in where Pilot Plant Project was carried out.

Importance of the Science Communication

Tomoaki Sato
Kanagawa Institute of Technology

Recently, Science-Cafe is spreading to a whole world. The science-cafe is the event in which scientists and citizens can talk about science and technology in a relaxed atmosphere unlike a lecture of university. In Japan the first Science-Cafe was held at Kyoto by volunteers of scientist in 2004. Generally, in a Science-Cafe there are scientists, citizens and a facilitator. The facilitator is an emcee who has a role to make the participants understand each other about scientific topics. Therefore, the facilitator must have enough knowledge of science and have a sufficient skill of communication and we call such person Science Communicator. The Science Communicator includes science journalists, school teachers of science and also the facilitator of Science-Cafe. The Japanese Ministry of Education, Culture, Sports, Science and Technology advocated the importance of the communication between science-technology and society in WHITE PAPER ON SCIENCE AND TECHNOLOGY 2004. Science-Cafe and Science-Communicator are of increasing importance now.

Quantitative Evaluation of Scratch Property for Polymers

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Kyoto Institute of Technology

A linearly increasing load scratch test method standardized by ISO and ASTM for polymers is introduced in this article. The advantages of the test method in comparison with a constant load test include: (a) scratch properties are quantitatively evaluated, (b) load dependency to scratch behavior is realized by a single scratch test, and (c) the number of tests is minimized. Scratch test results according to ISO/ASTM investigating scratch velocity effect on scratch behavior of polypropylene are reported. The critical normal load for the onset of scratch visibility decreases with increasing scratch velocity. It is found that scratch property of polymers is sensitive to scratch velocity. The results clearly show the capability of the test method for the quantitative evaluation of scratch property of polymers.

Innovative Urban Transport System "Eco-Ride"

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Institute of Industrial Science, The University of Tokyo

Hisanori Omote
Senyo Kiko Co., Ltd.

The track line to test an energy saving urban transportation system, called "Eco-Ride," at Chiba Experimental Station, Institute of Industrial Science, The University of Tokyo, was built in November 2008. The aim of the test track is to develop an energy saving drive system using the height differences of rail tracks, as well as to develop a high-performance train and rail that produces less vibration and noise, by adopting an advanced coupling structure to prevent derailment.

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The test track was constructed as a rail course about 100 meters long with a height difference of about three meters and a maximum downward slope of eight degrees. A box-type vehicle operates at 20 km/h on the track to generate electricity using the forces of air resistance and the speed of the train. On commercial rail tracks, lift motors will be used at multiple places to move the train up slopes to gain potential energy using the same principal as a roller coaster. This transport system is aimed at traveling short distances of under 10 kilometers, and is expected to operate between mass-transit sites such as rail and subway stations and local transit systems such as minibuses and taxis.

Novel Nano-scale Servo Technology for Atomic Force Microscope

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The University of Tokyo
Takayuki Shiraishi
Yokohama National University

Atomic force microscope (AFM) is the device which can measure a sample surface on nano-scale. It is known that the measurement time of the AFM is very long. Therefore, realization of the high-speed AFM is required from industrial application. The conventional AFM was controlled only by the feedback. In this case, the feedback controller is designed for high bandwidth. However, its bandwidth is restricted by the resonance peak of the AFM system. Our research group proposed surface topography observer(STO) which is based on the observer theory. Poles of the STO can locate as the high-speed, because STO is no relationship to the closed loop system. Furthermore, to suppress the contact force, our research group proposed surface topography learning observer which is the learning control. By these proposed control methods, we succeeded in development of high-speed AFM which achieved the 20 times faster conventional measurement. We continue approaching fast AFM from a viewpoint of control engineering.

Measurement of Brain Function of Car Drivers Using Near-Infrared Spectroscopy (NIRS)

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Nihon University

This study examines driver's brain activity when using driving assistance systems such as Adaptive Cruise Control (ACC) system by driving simulator experiments. Driver's brain activity is measured using near-infrared spectroscopy (NIRS). Subjects follow a leading vehicle, which has a certain speed pattern including stop and go situations, with and without ACC system. The brain activities of the drivers without ACC system, i.e. manual driving, is related to their recognitions and driving behaviors of accelerating and decelerating. The brain activities of the drivers with ACC system is, on the other hand, not observed in their driving behaviors.

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