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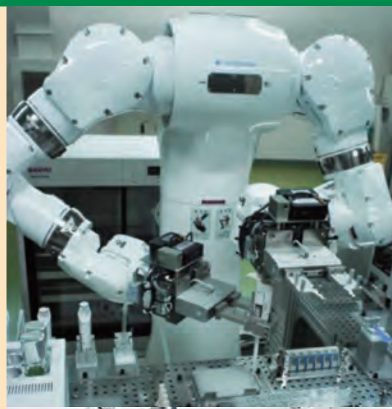

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President's Message

Aiming to Further Contribute to the Development of Japanese Society and Industry by Bridging Innovative Technology Seeds

Ryoji Chubachi

President
National Institute of Advanced Industrial Science and Technology (AIST)

Introduction

I would first like to wish you all a very Happy New Year. The past year was one with increasingly positive news for the industrial sector in Japan. Many companies, particularly those in the manufacturing industry, were able to achieve improvements in their business performance and some recovery was also seen in the employment environment supported partially by the steady trend of the weak yen in the foreign exchange market.

On the other hand, there are still many issues and anxieties about the future in Japanese society. To mention some examples, the rising cost of energy and the problem of energy supplies, global warming and other associated issues, and the problem of the low birth rate and aging of society are unavoidable, urgent, and persistent issues. In addition, the decline of local industries and economies was taken up as a major concern last year, and it turned out to be a year in which movements toward local regeneration aimed at revitalizing Japan's regional areas became quite active.

Presently, the national and local governments, public institutions, companies, universities, and many others are making efforts in various ways to deal with these present and potential future issues facing Japanese society and industry. Under these circumstances, we at AIST have renewed our determination to further contribute to society and industry by creating innovation as a public research institute through research and development activities, particularly in the field of industrial technology.

Establishment of the Fukushima Renewable Energy Institute in Koriyama

In April 2014, the Fukushima Renewable Energy

Institute, AIST (FREA) was opened in Koriyama, Fukushima Prefecture. In setting up this institute, we have received a great deal of support from many quarters including the Japanese government, Fukushima Prefecture, Koriyama City, and related companies.

FREA is promoting a wide range of technology development necessary for the coming large-scale introduction of renewable energy in Japan. The research conducted at FREA is comprehensive and includes, for example, the development of next-generation photovoltaic modules, highly efficient wind turbine technologies, technologies for the production and utilization of hydrogen carriers, and assessment technologies for the use of geothermal and shallow geothermal energy. In addition, FREA is conducting an experiment to prove feasibility of a renewable energy network comprising energy generation and storage grids. It has also signed a memorandum of understanding on comprehensive research cooperation with the National Renewable Energy Laboratory (NREL), U.S.A., as an international research hub in the field. FREA is also expected to contribute to the invigoration of industry in the Tohoku region and to support reconstruction activities there through joint research, development, and promotion of the commercialization of research results with companies and universities in that region, centering around Fukushima Prefecture.

AIST is determined to make every effort in this regard so that FREA will be the focal point of a succession of future innovations as well as expanding collaborations with businesses, and that it will become known as a representative research hub in Japan in the renewable energy field.

Bridging function to transfer technology seeds

AIST is currently formulating a new medium- to long-term plan that will be implemented from April 2015. We will go into the details of the plan after it is finalized, but for now, we would like to say that one of the pillars of the plan is the strengthening of our “bridging” function; that is, the function of refining innovative technology seeds so they can be realized as products and commercialized.

We are engaged in a broad spectrum of research activities from basic research through to product development. Many of these are evaluated to be at the world’s top level. On top of this, over the past several years we have been steadily forming a network with businesses so as to construct and strengthen the foundation for collaborative activities with the industrial sector.

There are strong expectations by Japanese society and industrial sectors that AIST, as an organization that is not only one of the largest technology seed holders in Japan but also has a foundation for collaboration with the industrial sector, will make effective use of these resources and serve as a research institute bridging technology seeds to private businesses in order to achieve the development of products from these seeds and their commercialization.

Our plan to strengthen the bridging function is in line with our mission, “Technology to Society,” and is aimed at supporting industry by creating innovations that will help Japanese businesses to recover their strength and revitalize the economy.

Fostering human resources (HR) and HR exchanges

It goes without saying that the key to the bridging of technology seeds and the creation of innovation is human resources. Since its inception, AIST has actively employed and trained distinguished and promising researchers in a wide range of research fields. Last fiscal year, we established and began to administer a research assistant system that provides competent graduate students with opportunities to participate in research work with pay. In addition to these employment opportunities, we will continue to train practical researchers through, for example, a program that allows researchers to actually experience research and development conducted at businesses so as to enhance their understanding of and motivation for the commercialization of their research results.

AIST will also continue to accept researchers and technicians from businesses and other research institutes and promote collaboration on joint research and commercialization. At the same time, we will make full use of our open innovation platform including the Tsukuba Innovation Arena for Nanotechnology (TIA-nano), FREA, and the AIST Tokyo Waterfront bio-IT research base to establish international hubs for collaboration among industry, academia, and government.

Supporting small and medium-sized businesses and venture companies as well as local regeneration

One of the strengths of Japan's industrial sector is the vitality of its small and medium-sized businesses with their excellent technologies and techniques. Since even before the amendment of the Act on Enhancement of Research and Development Capacity and Efficient Promotion, AIST has been continuously providing support to small and medium-sized businesses in joint research, personnel development, and other areas. Now that the amendment to the Act has come into force, we have, as of last fiscal year, also become able to invest in kind in the form of intellectual property, facilities, equipment, and so on.

Accordingly, we can now provide better and more comprehensive support to small and medium-sized businesses and venture companies that are facing difficulties in commercialization, despite their superior technological capabilities, due to constraints they are facing in terms of research facilities, personnel, or other factors.

As described above, local regeneration is one of the many urgent problems facing present-day Japan.

With our research bases located in seven regions throughout Japan serving as the core, AIST is committed to contributing to the revitalization of local economies by collaborating with local public institutes and universities to solve the problems of local industries and companies.

Conclusion

The two mottos of AIST that I introduced in the President's Message in the last year's issue of AIST TODAY, "Green Technologies for a Flourishing and Environmentally Friendly Society" and "Life Technologies for Healthy and Safe Living," are now well accepted by the members of AIST and are also gradually beginning to be acknowledged by people outside AIST.

AIST must create innovative technology seeds through research and development based on these two mottoes; bridge these seeds to the industrial sector, especially to local businesses, small and medium-sized businesses, and venture companies; and contribute to building a sustainable society. With a renewed and stronger conviction on this point as the president of AIST, we will continue to work vigorously toward this goal together with all of our members.

We would greatly appreciate your ongoing support and guidance in these endeavors.

The 10th AIST Advisory Board Meeting

The National Institute of Advanced Industrial Science and Technology (AIST) convenes Advisory Board meetings, with the participation of leading intellectuals in various fields from both Japan and abroad, in order to solicit and receive advice regarding AIST research activities and all areas of operations.

The 10th meeting of the AIST Advisory Board was held on September 5, 2014, at AIST Tokyo Waterfront.

AIST is currently engaged in research activities under its Third Medium-term Plan (hereinafter “third plan”), but this plan is due to expire at the end of the present fiscal year. Thus, much discussion at AIST is now centered on the fourth plan.

In light of this, the main theme of this Advisory Board meeting was on AIST’s new medium and long-term plans. The meeting featured wide-ranging presentations and discussions about the current state of AIST–focused on the planning and implementation of projects that attract the serious interest of companies, policies to revitalize research through personnel exchanges, and contributing to regional Japan–and on the concepts behind preparations for the fourth-term plan, with a view to enhancing AIST’s role as a “bridge” or intermediary between the spheres of research and industry.

Here is a summary of the meeting and a report on the principal comments and suggestions offered by the board members.

Table 1 The Advisory Board Members

Junichi Hamada (Chair)	President, The University of Tokyo
Hiroyoshi Kimura	Honorary President, Kimura Group
Sadayuki Sakakibara	Chairman, Toray Industries, Inc.
Takashi Shoda	Senior Corporate Adviser, Senior Corporate Adviser, Daiichi Sankyo Co., Ltd.
Waichi Sekiguchi*	Editorialist and Editorial Board Member, Nikkei Inc.
Kyosuke Nagata	President, University of Tsukuba
Hajime Bada	President & CEO, JFE Holdings, Inc.
Sawako Hanyu	President, Ochanomizu University
Ei Yamada	President & CEO, AnGes MG, Inc.
Alain Fuchs	President, National Center for Scientific Research (CNRS), France
Reimund Neugebauer**	President, Fraunhofer-Gesellschaft, Germany
Thaweesak Koanantakool	President, National Science and Technology Development Agency, Thailand
Willie E. May	Acting Director, National Institute of Standards and Technology, USA

(* Visited and offered guidance earlier)

(** Not in attendance)

Table 2 Program

September 5 (Friday), 2014

10:00	Opening Introduction of board members and AIST attendees
10:10	Opening remarks
10:20	AIST’s new medium and long-term plans (Part 1)
12:20	Lunch
12:50	Inspection of research facilities and discussion with researchers
14:50	AIST’s new medium and long-term plans (Part 2)
16:50	Closing remarks
17:00	Adjournment

Summary of the 10th Advisory Board Meeting

This final AIST Advisory Board meeting of the third term was attended by 11 of the 13 eminent members of the board. (See Table 1)

The meeting was split into two sessions focused on AIST's new medium and long-term plans that are set to come into effect the next fiscal year. Also, between the two sessions, which featured presentations of various explanatory materials by AIST, the attendees had the opportunity to inspect research facilities and engage in discussion with researchers. Later, the board members were also able to offer their comments and advice.

Comments and Suggestions by Board Members

Junichi Hamada (Chair) (President, The University of Tokyo)

Firstly, on the question of a cross-appointment system to facilitate personnel exchanges, I see the benefit of expanding opportunities for university teaching staff to get more actively involved in research, but on the other hand I fear that this could end up putting a greater administrative burden on other academics. Personally, I'm in favor of expanding the system, so I want the initiative to move ahead, provided that we think of ways to address such concerns. So, how should personnel exchange be structured? If we reflect on this, it leads us to the more essential question: what does AIST aim to do, and under what kind of system? In light of this, I would say that while there are technical aspects to the way personnel exchanges are implemented, when we think about the system we also need to keep in mind these fundamental questions of "what" and "how."

With regard to AIST's contribution to regional Japan, I believe it's important to carefully examine what form the career of an AIST innovation coordinator should take, and whether such work is sufficiently respected.

In many ways, AIST has come to function as a hub, and in our regional contribution initiative too, we see that AIST plays a similar role. Although, it is a quite demanding role to take on, I hope that AIST can make a big contribution in this area.

Hiroyoshi Kimura (Honorary President, Kimura Group)

On the subject of recognition, I want to mention that I've noticed a rapidly growing number of papers from AIST in the publications of the Japan Foundry Engineering Society (JFS), with which I'm involved. In addition, an AIST member became a board member of JFS, so interaction between the two organizations is now more lively, and AIST has started to develop a notable presence within that society and the foundry industry.

On the question of projects that attract the serious interest of companies, I would say that from the viewpoint of small and medium-size enterprises (SMEs), Japanese technology is highly advanced and refined, so it is difficult to find large-scale projects. More projects like Tsukuba Power-Electronics Constellations (TPEC) would certainly help to liven things up. One reason that there is little happening apart from TPEC is that AIST research, due to its highly advanced nature, becomes vertically divided and it is therefore difficult to organize projects that require the leadership of large groups. Therefore, if the different sections of AIST were organized not vertically but more generally, it might lead to more large projects, which is what the public expects–for example, socially pressing problems concerned with energy and disaster prevention and management could be tackled by horizontal groups.

I don't know if the word "old industries" is appropriate, but from that standpoint, the number of researchers related to such industries is declining. This means that innovation cannot advance, so capable researchers have to try and collaborate internationally. The scary thing here is the question of intellectual property (IP). In some cases of joint research with overseas partners, the Japanese side has been outwitted in IP negotiations. I hope that AIST takes care to protect its IP in such cases.

Concerning personnel exchanges, I would point out that exchanges with AIST have been weakest with middle-ranking companies and SMEs. Considering that AIST conducts 600 to 650 joint research projects per year with such companies, it's clear that personnel exchanges would be very valuable. I definitely want to see this initiative develop.

Speaking of "old industries," we are facing difficulties, as the numbers of related courses, subjects, and researchers in Japanese universities continues to fall. At the same time, competent middle-ranking companies want their employees to be trained and earn PhD degree. In view of this gap, I would like to see AIST partner with universities to somehow help facilitate the training of PhDs for such companies.

Knowledge is vital in the present age, but the centers of growth are now overseas, so we have to partner with foreign companies. To be able to do this, it is essential that we have enough PhDs who would function as technical experts in our companies and are fully versed with ability and knowledge.

With fewer and fewer researchers in Japanese universities and research institutes, it will become increasingly difficult to obtain information on leading edge technology globally. If this happens, our industries will fall behind international standards. I would therefore like to see AIST focus on keeping middle-ranking companies and SMEs up to date with the latest technology from around the world.

I am happy that AIST has set out to get behind global niche top (GNT) companies to support middle-ranking companies and SMEs, as part of the regional contribution.

We can assume that these GNT companies are the most accomplished and unique middle-ranking companies and SMEs around. Such companies often operate both domestically and internationally and they may partner with modular companies (MCs) overseas. In this case, the MCs are likely to put extraordinary ideas and demands to them. One of the challenges facing these GNT companies is to sincerely consider such proposals. However, since they won't have enough of their own management resources to do this, they will need a lot of information about other companies. It would be great to see the AIST regional research bases provide this kind of support.

Sadayuki Sakakibara (Chairman, Toray Industries, Inc.)

On the matter of recognition, I had expected that AIST would naturally become as well known as Riken and JAXA, so the fact that recognition remains low is quite shocking to me. In my day-to-day conversations I find that everyone knows "Tokoshi" and "Daikoshi" (abbreviated names of old government research institutes that were precursors of AIST) when they are mentioned. It's normal that after a merger and change of name that recognition might be lacking, but in any case it's an issue that needs to be considered seriously. The most important factor for raising awareness is communicating research findings that have impact to the world. I would like everyone at AIST to take the situation seriously and work harder on this point.

Since June this year I have served as chairman of Keidanren (Japan Business Federation), where the most pressing challenges at the moment are economic revival, breaking out of deflation, and getting the Japanese economy on a growth trajectory. I always emphasize that the important key to achieving these goals is innovation. To help with this, R&D organizations like AIST have a particularly vital role to play in addressing the challenges that are difficult for the universities or private sectors to deal with alone, by serving as hubs to facilitate cutting-edge research both in Japan and abroad, collaborating closely with companies, and commercializing the fruits of research.

On the main themes of today's meeting, first, the adoption of a way to promote greater collaboration with industry, I believe AIST needs a complete change of direction. It needs to start planning and implementing projects that are compelling enough to attract the deep involvement of companies through investment of human resources and funds. At Fraunhofer the function of marketing to companies is not handled organizationally. Instead, researchers are entrusted to perform "conversational marketing" by themselves. Also, funds distributed by the head office to research centers and researchers are allocated by weight in accordance to the degree of collaboration with industry and the earnings received from industry. I would like to see a similar approach introduced at AIST. I think AIST needs to create a culture like this that enables collaboration with companies from the planning of the research theme.

Another important thing is enhancing AIST's hub function for personnel training and exchange. To draw out the real intentions of companies, we need to build deeper and more individual relationships with companies. One of the factors responsible for the success of TPEC is that it was extensive discussions with companies that allowed them to discover the field of power electronics for which they needed the help of AIST. If AIST moves ahead on the cross-appointment system for university researchers that have a good track record in industry, government, and academia collaborations, the basic research needs of companies can be more clearly identified. It might also be a good idea to hire senior researchers who are retiring from companies, particularly large companies, to select research topics and then develop projects to the point of partnerships with companies. If they are employed as AIST innovation coordinators, such experienced ex-company researchers could serve as valuable "pipelines" to the companies and industry sectors they are from. And by putting them into teams with young researchers, they would not only be valuable in passing on their technical prowess, but also in developing more effective exchanges with companies.

Takashi Shoda (Senior Corporate Adviser, Daiichi Sankyo Company Ltd.)

Firstly, on planning and implementing projects that are compelling to companies, it seems that many of the joint research projects AIST is currently involved in are financially small in scale. From the perspective of relatively large companies particularly, the average funds of joint research projects–around 4 million yen per year–is very low. A likely reason is that quite a large number of joint projects are initiated through personal acquaintance between company researchers and AIST researchers. At least this is my impression on the projects related to the life sciences and pharmaceutical industries.

At Daiichi Sankyo, we aim for a comprehensive approach to joint research with AIST. We present a wish list covering the whole company's activities, then AIST checks this against the technologies available at AIST. On that basis AIST connects us with suitable researchers or research teams. At this point, we have to find out exactly what kind of technologies AIST is offering. We evaluate technologies that AIST considers to be either unique or state-of-the-art and discuss in detail whether they are really at the global cutting edge or not by comparing them with other technologies. In this way, even if the financial stakes are not very big initially, they can be substantial over time, as in the example of TPEC over 30 years. In my view, AIST should first develop large frameworks

for interaction with many companies, and then within the framework identify what exactly a given company is looking for and link that to an AIST technology that meets the need.

Next, on the point of whether the amount of external funding acquired should be used as a performance indicator, I don't think a research group can be fairly judged based only on funding. AIST research work typically evolves slowly through stages focused on fundamentals, application, and development as it approaches commercialization, and ultimately it should be judged on the number of projects that has been commercialized.

Regarding intellectual property (IP), it should be noted that in the life sciences industry, patent applications have to be made in the U.S., Europe, and other regions with developed intellectual property systems, because Japanese patents alone are not adequate. However, maintaining patents is expensive, so it's important to do a regular stock-taking of IP. Every two or three years or so there should be a discussion to decide whether IP filings are still useful or whether they should be left to expire. This is known as IP management.

The issue of the restrictions on independent administrative institutions is not something that AIST alone can resolve, but I personally intend to voice my opinion wherever I can that the idea of reducing grants for operating expenses when external funding is acquired for joint research should be rejected Japan-wide.

Next, I want to comment on the role of regional research bases. Currently, AIST has 78 researchers here at AIST Tokyo Waterfront as well as more than 1,700 at AIST Tsukuba. Certainly the researchers at AIST Tsukuba in particular must clearly understand the needs of regional Japan, and they need to work actively in direct contact with all regional stakeholders. These include local governments, but the industries that they want to stimulate may not necessarily match up with the resources of AIST's regional research bases. In such cases, it's very important that AIST Tsukuba can address the relevant needs.

Finally, two meetings back, I suggested that since big data was increasingly important in the life sciences AIST should provide training in bioinformatics. I am therefore very pleased to see the Bioinformatics Personal Training Program included in today's inspection itinerary.

Waichi Sekiguchi (Editorialist and Editorial Board Member, Nikkei Inc.) (The responsibility for the wording of this article lies with the Advisory Board Meeting Secretariat)

On the question of recognition, it seems to me that AIST is not well known at the executive level of the manufacturing industry or at the executive level and among researchers of the telecommunications industry. The 19 % recognition among telecom industry researchers is certainly a low figure. Although AIST is ranked only No. 6, below the likes of JAXA and Riken, the absolute level of recognition is more important than our relative ranking. As for undergraduate and graduate students, it can't be helped that AIST is little known within the humanities, but you would hope to see a rate of 20 to 30 % in the sciences.

As I see it, the difficulty in planning and implementing projects that interest companies is due to the lack of a system that allows companies to invest according to their needs and demands. As I suggested at the last Advisory Board meeting, the research themes at AIST should be overhauled. In the case of applied research (though depending on the theme of research), a "sunset provision" should be applied so that research themes that do not attract funding from companies are terminated after a certain length of time. I would also like to see researchers with the enthusiasm to go out and launch start-up ventures. This is important for creating a more independent cycle of working that does not rely on grants for operating expenses.

My view on the intellectual property issue is that while AIST should ensure that IP does not leak to anyone other than the joint research partner, you should also think about opening up to bring other companies–even overseas ones in some cases–on board as IP partners. To deal with the large number of joint patent applications that don't lead anywhere, I would first survey companies to find out why they are not making use of the patents. The goal of attracting more funds from large companies is clearly important, but in view of AIST's mission, you shouldn't neglect to seek funds from small and medium-sized enterprises (SMEs) and middle-ranking companies. Sometimes a seemingly minor technology can develop into something major, so it's also worth looking at the return on investment rate. On the possibility of operating expense grants being reduced if income from companies increases, you should consider ways for the government to offer incentives to help increase income from companies.

A cross-appointment system to stimulate personnel exchanges is a good idea. In today's networked world, it's possible for one person to do multiple jobs. However, I think that people will only want to get involved in the system if we work out an appropriate system of remuneration. Of course, it's unreasonable to suggest that researchers working at two places be paid double, but they should get some percentage over and above their base salary, to provide them with incentive. Major universities are being considered for the cross-appointment system, but it's also vital for AIST to strengthen its relationship with the National Institute of Information and Communications Technology (NICT) for the benefit of its IT technology, and also to enable exchanges with other independent administrative institutions. On whether AIST personnel can work effectively in companies, I would say that it's difficult for a researcher from AIST to go and work within a company culture, with its constant focus on profit and loss, but if you have more people who feel like going out to take on such a challenge then that's a good thing.

Finally, a comment on the role of AIST regional research bases. As I understand, AIST regional research bases should conduct the kind of research that is meaningful only if it is conducted locally. Regional research bases as regional centers for collaboration should serve as bridges to local universities and companies.

Although Waichi Sekiguchi was unable to attend the meeting, the Advisory Board Meeting Secretariat visited him before the meeting to get his opinions, as presented here.

Kyosuke Nagata (President, University of Tsukuba)

The reasons for the success of the TPEC project are the originality of AIST's research capabilities in this field, and the fact that AIST had suitable facilities such as clean rooms. It's also important that the research nicely matched up with real-world needs. While maintaining this kind of original research capability, you also need the mental flexibility to generate innovation. Although it's vital to accumulate genuine research capabilities over the long term and connect these to new R&D for the future, at some point it's necessary to break away and produce something new on contract for companies. I want to stress again that unless AIST is able to enhance its originality, it won't be able to repeat the success of TPEC. However, if you concentrate just on this, there is a risk of ignoring connections to the latest innovations, so that careful consideration is needed for this.

On performance indicators, the amount of funds received, the number of connections with society, etc. were mentioned, but it would be good if AIST chooses one and publishes data to show where it stands by international standards. An indicator that is created by an organization by classifying research institutes around the world is worthless unless it is adopted internationally. But if such an index is adopted worldwide, then AIST's rating would be internationally known in terms of that index. In my view AIST should create its own indicator. However, if it is not publicly accepted after it is published, it won't serve any purpose. Therefore, the indicator has to be the best possible indicator for as many people as possible. Such an indicator will also serve to demonstrate the effectiveness of AIST's next-term plan.

With regard to utilizing company personnel, unless AIST lures away people that companies really want to hang on to, I can't see the value. Also, you need a way to pay such people the appropriate level of salary and also make AIST research workplaces appealing enough. If AIST could attract the kind of people who would be badly missed by their companies, it would certainly be very valuable for AIST. In addition, as a means for personnel exchange with universities, a framework for joint research with universities would be good, but it is somewhat irresponsible. The simplest way to ensure responsibility is with cross-appointment, where half the salary of the researcher is paid by each side–even a 70 %-30 % split would be OK–but when AIST pays its share of the salary, the researcher must

complete the appointed task. At our university, the University of Tsukuba, we are running an exchange program with overseas universities. There are many people at universities doing fundamental research, and sometimes their work seems to lead on to some innovation, or to rapidly approach industrial applicability. However, the final step of commercialization is very hard to achieve within the university, because there are so many other tasks to do. Thus a cross-appointment system can potentially make it easier to cross the barrier between research and industrialization. There is also responsibility attached to such work. On the flip side, when some innovation emerges at AIST, some fundamental discovery could be made. In that event, the university partnership would be useful. I think you need to think about the system so that you can make flexible use of it in this kind of way.

Hajime Bada (President & CEO, JFE Holdings, Inc.)

Firstly, on reinforcing AIST's bridging function, even if you pursue this wholeheartedly, unless the universities, basic research institutes, and companies that you partner with share your concept of the role, the effort will prove fruitless.

The number of joint research projects has basically leveled off in the past few years and research funding from the private sector over the same period has been stuck at around 5 billion yen, so you have to accept the reality that there isn't an increase.

At the JFE Group, we engage in two or three joint research projects per year with AIST, spending about 1 to 7 million yen per project. There is no project in which our spending exceeds 10 million yen. We are part of the consortiums working on TPEC, integrated environmental methane hydrate monitoring, and the development of CO_2 separation and recovery, so up till now we have conducted small, individual joint research projects as part of these consortiums.

If I examine our motive for pursuing R&D together with AIST, it essentially comes down to personal connections–for example, through someone one has met at a meeting of a scientific society or had a discussion with long ago. Discussions with companies about the possibilities of large-scale development projects have to be held directly with senior executives. In the case of large R&D undertakings, it is the head of a company's research division or the person in charge of technology development that has the best grasp of technology directions and development within that company. Therefore, the most fruitful approach is to hold discussions with someone like this, or perhaps the leader of

an industry group or a technology body within an industry.

Currently, combined total R&D spending by Japanese companies amounts to 12 trillion yen annually. Of this only 90 billion yen, or 0.7 % of the total goes to universities. AIST gets only 5 billion yen a year, or 0.04 %. This is simply too low. In light of this, more effort is needed to meet our goal of funding from industry–not just by AIST but also on the part of companies themselves. If we can't get about 1 % of the total corporate R&D budget (120 billion yen), I think this represents a national inefficiency.

Till now, Japanese companies have desired to be self-sufficient in their R&D, but with that approach they become unable to compete internationally, so increasingly they have to take maximum advantage of their strong points. In R&D too, it seems that the accepted approach has shifted to forming partnerships between public research institutes, universities, and companies, to produce results faster, more efficiently, and at lower cost. For this reason, if we pursue measures that promote sharing and help in creating a strong current, the process can be further accelerated.

With respect to intellectual property, I think AIST should hold the basic patents, but when a company wishes to apply the technology, a joint patent application can be made, AIST cede exclusive rights of use to the company and then collect usage fees for the basic patent. This seems to me the most correct approach.

On personnel exchanges, although I do note that there is little turnover of people between AIST and companies, if joint research remains central, I think the most logical approach remains that of pursuing research without actually changing the researchers' affiliations. With regard to IP ownership, it is the organization that holds the IP in most cases, with individuals having no rights. When researchers relocate they leave behind the IP relating to their own research. Unfortunately, this means they cannot use the IP. It is perhaps worth thinking, then, of a way to guarantee IP rights to individuals. This would also likely lead to greater mobility of personnel.

Currently, AIST is running a system of training for post-doctoral fellows. At the moment, post-docs in Japan are having a hard time finding suitable jobs, so it's important to work with companies to try and find appropriate career options for these young researchers. Hopefully, AIST would increase the available range of disciplines and the number of researchers.

Finally, on the issue of regional revival and activation across Japan, when AIST regional research bases partner with SMEs, the ultimate goal is to promote industrial and commercial activity. In so doing, we have to think not just about research, but also funds and personnel, otherwise the economic fruits will not be achieved. This is not just a problem for AIST–it's a challenge that has to be met with a concerted effort that includes venture support, as well as national and local government systems.

Sawako Hanyu (President, Ochanomizu University)

On the topic of AIST playing a bridging function, this intermediation is between researchers, between research institutes or organizations, and between the research world and the world of industry. Then when you consider what your aims are, you should keep in mind another keyword that appears on the AIST web site, "cooperation knowledge." Some functions and research findings are only produced through such intermediation. I believe that rather than directly through the activities of AIST, which are focused on its own goals, new knowledge is more readily created through exchanges between people with a wide variety of objectives, working in a wide variety of fields.

For example, in relation to personnel training, at Ochanomizu University we have a partnership agreement with AIST, that allows students, through their research at AIST, to see where and how their research fits into the world of industry. This is something that is virtually impossible to do at a university, and whether we call this function "hub" or "bridging," the important thing is that the process gives rise to new ideas. We could describe this service as a "bridge" between fundamental research and industrial application, which leads to the generation of new research methods and ideas.

Another concern now is regional revival. Much of the latent knowledge in regional Japan that can be harnessed for industrial application lies mainly with SMEs, and paying attention to this is another important function of AIST. I really hope that AIST can contribute to this in many ways–by bringing together individuals with individuals, organizations with organizations, by connecting the center of the country with its regions, and even by connecting with companies that are expanding internationally.

The AIST Fourth Medium and Long-term Plans take effect precisely one year before the Fifth Science and Technology Basic Plan comes into effect, so when you consider your designs for the future at AIST, I would like to see your medium and long-term plans designed in a way that offers inspiration or guidance to the science and technology basic plan. As a person who belongs to an organization that engages in both personnel training and research (a university), I have high expectations for the new plan.

Ei Yamada (President & CEO, AnGes MG, Inc.)

Regarding the concern about AIST's recognition, my personal impression is that in the field of life sciences in Japan, AIST and Riken are the two big names, but while AIST has a rather modest profile, Riken has an image of setting off fireworks. While it is fairly easy to create a big splash in basic research, AIST on the other hand labors more quietly and patiently over a broader range, from basic research through to commercial development. The difference in recognition is also due to this. Nonetheless, there is a need for more skillful PR work.

The average amount of funds received by AIST from large companies is no more than around 4 million yen per company. From a company's perspective, and in particular a venture company like ours, I think the amount varies depending on how much return can be expected from the market. AIST needs

to review the whole question keeping in mind that a lot depends on whether or not researchers have a detailed understanding of the market for the technology they are working on. In our field the cost of joint research for diagnosis is different to the cost for drug discovery, but from the view point of drug discovery, the sum of 10 million yen is not a big deal, even for a new venture.

On the question of how to draw out the real views and intentions of companies, I think it is absolutely necessary when calling for discussions that the request is made to the most senior executives. This is very much our experience at AnGes MG. With some companies, inquiries from our licensing department barely get any reply. However, if we then contact a board member of the company that we happen to know, sure enough the next day we receive a positive response. So, it's vital to make contact with and provide information to the top level of management. As for the value of unique ("only one") and leading ("number one") technologies, I would say that no matter how great a leading technology is, there is always the possibility that it will be overtaken, so unique technologies definitely have greater value. On the acquisition of external funding from private companies, my feeling is that you should measure achievements not by the amount of money you are receiving but rather by how many private companies you are making contracts with and increasing the success rate of research.

From the standpoint of a venture company, my comment about intellectual property is that since we don't have enough time and people to build sufficiently mature platform technologies, I would like to see national research institutes work on creating high-quality platform technologies. Thus, in connection with platform technologies, I think it is appropriate that any applicable elements of technology covered by the basic patents held solely by AIST be shared with companies. Examples in our particular field would be genetic drugs and nucleic acid-based drugs.

In addition, on the fear that grants for operating expenses and personnel expenses may be reduced, my view is that personnel expenses should be accounted for separately by companies. There is a large difference between Fraunhofer and AIST in terms of the proportion of private sector funding, but this is probably because of AIST's greater deference to the government's position and more modest style of negotiation. On this matter, I think it's necessary to try to develop a different system.

During today's inspection we looked at the natural products library, which I think is a wonderful platform technology. If AIST could develop similar platform technologies for every field, companies would really revise their outlook and we would have greater access to them. I think this project can grow bigger from a variety of standpoints.

Lastly, I'll say something on the issue regarding the function of regional research bases. At AnGes MG we have made use of AIST's facilities for a long time, and I hear that even now, after us, various start-up ventures are using the facilities. This kind of service is very important for activating regional industry I believe. I realize now that this kind of support is indispensable, especially for venture companies.

Alain Fuchs (President, National Center for Scientific Research (CNRS), France)

Let me just tell you in a few words the position of French CNRS. We have actually a very high recognition and this is because we are renowned at least in France and Europe for a certain number of reasons. One reason would be, for instance, one of the last Fields Medal in mathematics was awarded to a CNRS researcher, so people know about CNRS. This is recognition, but about impact, the point we have with companies is that even though they know about CNRS with high recognitions everywhere, what they do not know is how to reach the right team to work with them. So that is the question of impact actually. We are actually working hard, not to increase recognition of CNRS all over the place, but we are working hard to have direct contact with people in the management and in the research units of industry to explain how, and to organize ourselves in a way that it would be easier for them to come into our organization and find the right research and the right team to work with them.

Regarding projects that companies will look at seriously, what we are trying to do in Europe right now is to think about the model of innovation. We have been thinking about innovation for too long time as a linear process, and this leads to the problem that people from basic research do their basic research, and do not communicate because they think that is a matter for other people who are going to do the R&D. And people from R&D do not communicate enough to the corporations.

What we are actually trying to do is to encourage researchers, either in the purely academic university level or in the R&D level, to make this system little bit more complex, and to create their own small business using the technologies that have been developed in the public sector. So we have some laws, rules and regulations for this, and that includes IP, of course. Does it work very well? It does work quite well in the sense that we have more and more usually younger people creating their own small business, or startups. The point is that, when more and more startups are created, then the problem becomes, how do we make these small companies bigger.

In terms of IP, I must say that I was not surprised by the fact that you have explained very clearly why and how a lot of your joint application patents are not actually used. This is something that we see also everywhere and this is the big issue. When we are negotiating with small and medium enterprises, what we find is that they might be very much interested in our intellectual property, technology that we develop, but they do not have time to negotiate. Reducing the barrier of negotiation is something we have to do. When negotiating with small and medium enterprises, if we reduce the barrier of negotiation, we would provide the IP to the company almost for free, and then have, of course, a contract saying that if the company succeeds in its objective, both parties will then have a stronger connection, and help towards industrializing the process. We have a few successes, but we do not know if this is the right direction.

Mobility and flexibility is an issue probably everywhere, but it is very difficult to achieve in France for several reasons. We are heading towards implementing such measures as joint appointments, and are also implementing a research career acceleration as an incentive for those who have some mobility with success. On the other hand, we have another model in parallel which is to build joint laboratories. Instead of moving the people, we organize mixed units, mixed laboratories, and they works very well since most of the CNRS laboratories are located in university premises, and in these laboratories, half of the staff more or less are university teachers and half are CNRS researchers. We do this with companies also; companies with high-level basic research. I mean those who need basic research to feed the R&D with new ideas, new technologies, etcetera. We have a certain number…not thousands of course…of joint laboratories which are usually located in the company premises. We have set up laboratories in some of the largest French companies like Saint-Gobain, for instance, or Rhodia-Solvay, and that works quite well. It is not a solution for everything, but I think it is an interesting tool.

Regarding regional contribution, at the regional level, there is a need for some sort of specialization priorities. Priorities should be as flexible as possible because whenever there are, for instance, new technologies, new scientific concepts, new materials, and so on, the question of what to specialize in, or where to place one's priorities, becomes an issue. Prioritization, local efficiency, plus networking with institutes including regional centers, probably provides the right means to answer this question, and AIST as a national institute again is certainly well suited to push forward these ideas.

Thaweesak Koanantakool (President, National Science and Technology Development Agency, Thailand)

On the issue of recognition, AIST has done very well in many areas. Recognition of the name of an institution is only one part, but there can be public recognition of AIST on other things, such as recognition of some world records of your research. The second part would be the recognition by the government. AIST has been assigned a very important job by the government to be a coordinator. I think that is very important. Being given such an important assignment by the government should be announced as a big achievement. The third part is recognition by industry, which may be characterized by making the industry successful because of your innovation and commercialization which creates impact in the way similar to what NIST has done in the US, and also to make AIST technology readily accessible to industry. I think the industry would like to access more and more of AIST's intellectual properties.

I would like to applaud the initiative of AIST on people-to-people exchange, and I would like to share my experience at NSTDA in Thailand. When NSTDA began, 100 of our team were members of university faculties. This was about 22 years ago, and for the whole period we worked closely with universities at all times. The mechanism that we are using now is to provide funding to universities for many programs where we do not have enough of our own researchers, so it is natural that we collaborate with universities. In certain strategic areas, we invest in joint labs in universities and send a few people there, though the main work will be led by the universities, and we also have joint publications and so on. When we have joint labs and collaborate with universities, many of our researchers who are newly recruited also teach in university in some areas, and through them we can bring in good postgraduate students to our institutes. But of course, we are like AIST; we do not provide degrees to students, so we always use university degrees.

Many researchers from universities are quite motivated to having access to good lab facilities not available in their universities, and if you also have research funds for interesting programs where you accept researchers from anywhere to work together with AIST researchers, that would be even better. It can also help if some of the AIST researchers are already very famous, as then university lecturers would like to associate with those researchers.

Regarding regional contribution, I think the SME in regional areas probably need direct solutions more than their own translation of research into solutions. Therefore, you might need some local agents or partners who can translate good research into solutions which might be made suitable for regional SMEs. I also wonder if you work with technical colleges, that might also help deliver the solutions in a way that the regional companies can accept quickly and therefore make it simple for everyone.

Willie E. May (Acting Director, National Institute of Standards and Technology, USA)

For the improvement of awareness, I have to question whether or not you really want to focus on recognition solely, or should you rather focus on impact? I will give you an example. In the US, we at NIST never seek to be as well recognized as NASA because we do different things. NASA is about space travel, and everybody thinks they know what NASA does. Certainly, not everyone knows what NIST does, but we really strive to make sure that the right people know what we do and recognize the value of the taxpayer's investment in what we do. So, for us, in terms of measuring the impact, return on the taxpayer's investment is far more important than recognition by all of the population.

I agree with the desire by AIST to implement projects that companies will look at seriously. However, I think that what you might be attempting to do is address a very, very complex problem with a very simple solution. This would be difficult. To do what I think you are trying to do, you cannot just use one tool. You have to have lots of tools, and I would caution you on expecting to be totally successful if you rely on industry to fund a lot of your research, because, how constant are the needs of industries? They change quickly. I think…probably…if you looked at developing a more fundamental and broad base research program that would enable you to provide the infrastructural tools that industry can use, you might be closer to realizing what you see as your vision for success.

I applaud your initiative of accelerating your research through personnel exchanges. The devil is in the details of how you implement it. At NIST, if there is a very high profile researcher we would like to attract in a field in which we need to rapidly expand our capabilities, we have many options, one of which is to offer them a joint appointment between NIST and a University. We have done that to help ensure that we retain our four Nobel Prize winners, and have used this to attract new principal investigators in fields such as quantum information. Then there are sabbaticals. We have a lot of professors who come and spend a sabbatical year or two working with us. So in that way, they do not have to give up their university position. We have had some cases where people have come and spent a sabbatical, decided that they wanted to make a career change, and actually became permanent NIST employees. Then there are summer appointments. Professors could actually maintain their course load during the academic year and then come and spend the summers working at AIST.

We are also starting a "Centers of Excellence" program. Our joint institutes like JILA, which is a partnership between NIST and the University of Colorado focused on atomic, molecular and optical physics was actually established on an opportunistic basis and has no defined term. We will use the new Centers of Excellence Program in a more strategic manner to allow us to very quickly establish capabilities and competencies at NIST in new areas needed for future mission delivery. The first of the "Centers" under this Program focuses on materials-by-design, and is based on a Cooperative Agreement ($25M over 5 years) between NIST and a consortium consisting of the University of Chicago, Northwestern University, and Argonne National Laboratory. This Consortium was selected from among 28 applicants that included the best Materials Science Schools in the U.S. During the next year, we will establish new Centers of Excellence to support new NIST efforts in forensics and in disaster resilience.

We (NIST) also sometime use industrial sabbaticals as opportunities for strategic collaborations with various industries and /or industry sectors.

So I would implore you to explore a range of possibilities, and not necessarily get stuck on one idea, and then, over time, you might decide that one, or two, or three of those are most appropriate for your environment, or you might decide to use the entire portfolio. But I would implore you to think very broad and think flexibly as you think about broadening your interaction modalities.

At NIST we typically have staff that come to us and spend their entire career. One of the ways that we gird against stagnation is through our post-doctoral program. We typically make ~70 new 2-year post-doctoral appointments each year. Most of our senior researchers at NIST actually came as post-docs, but the post-docs who leave, go out and transfer knowledge from and about NIST to the society. So, if AIST established a similar program, where top notch researchers were constantly coming into AIST and constantly leaving in a controlled manner, it would keep your research fresh and also allow you to connect to your industry.

Ryoji Chubachi (President, AIST)

In preparation for the Fourth Medium and Long-term Plans, AIST is requested to enhance its bridging function. We need to review whether we can effectively satisfy the current demands of the world of industry in the six research fields that AIST currently specializes in, and to create a system for contributing to industry in a visible way. For this reason, we are seriously re-evaluating our future research strategies and approach to innovation partnerships, as part of an effort to reorganize our whole system for implementing research.

We could say that since there is a gap of personnel and technology between academia and industry, a zone for skillful incubation between the two spheres is necessary. In view of this, AIST is strongly requested to serve as a "baton-passing zone" for linking universities with industry–or in other words, to serve as a "bridge" or intermediary.

In my view AIST has two basic roles. The first is "problem solving" to address a variety of queries of the type "we need a solution to this" or "we don't understand this, could you explain it?" received from the front lines of R&D and manufacturing. The other role is to serve as a "bridge" to the world of industry, to facilitate the commercialization of the technology and ideas of AIST. I would like to see both of these roles bolstered in the coming years.

What is the foundation from which we can supply these answers and match the seeds to needs? The answer is the findings and knowledge backed by solid basic research. Universities are currently shifting their orientation more and more to applied research, while companies aim at getting products to market faster than ever, which allows them less margin than in the past for doing their own basic research. It is now expected that the overall design of the basic research be provided by public research institutes. For example, as I see the situation in Japan, all the basic research in the country needs to be performed effectively by Riken, in science fields, and by AIST, in engineering fields. On the other hand, if we make the bridging function our primary consideration, people might misunderstand that AIST doesn't do any basic research. In the fourth-term plan, which we are now formulating, we will frame our message to companies more positively, as in "how should we proceed with the upcoming basic research by AIST" or "how should we proceed with our bridging."

In relation to marketing too, we of course want each and every researcher to be very conscious of market potential, but we are also starting to examine the idea of creating a department to support marketing activities at the organizational level. An important point in this is to note that the people in a company who most seek innovation are the senior executives. It is vital to negotiate directly with the decision makers and leaders of a company, so I want to see this principle put into practice. At the same time, on the question of how much of the total research expenses a company invests with a university or public research institute, let's keep in mind that these expenses are very low compared to in-house research. We also want to keep on analyzing the reasons why companies do not utilize AIST for research, and examining the responses to questions like "what do you require from AIST?" "is the cost too high?" and "is the level of technology too low?," using data from overseas research institutes like Fraunhofer as benchmarks. To put it in the language of a company, we need to work with great determination by setting sales targets, getting everybody to do their best to contribute to earnings, and to work hard on sales in order to increase the amount of external funding we receive. We also need to reflect on whether or not this attitude is really correct, however, and we will make a decision before the start of the fourth term.

On intellectual property, I want to point out that commercialization is not possible with only one or two intellectual property applications. We really need to push to have 100 times more IP. Looking at any single piece of IP doesn't reveal anything about 100 other pieces of IP. We need to be extremely cautious about simplistically concluding that just because a certain patent, or technology is excellent, it will definitely be useful or valuable industrially. Sony founder Masaru Ibuka calls this the "1-10-100 rule." He used to say something to the effect that university professors talk of 100 ways to commercialize a single idea, which is an absurd exaggeration.

Next, I want to comment on personnel. I heard some people talking about utilizing seniors who have worked for years in the world of industry in order to strengthen our collaboration with industry, in addition to utilizing women, foreigners, and young people. We shouldn't be too ready to employ people just because they have a background in industry; unless they have really excellent abilities they cannot be skillfully used, and they won't be able to facilitate collaboration. Therefore, we need to have some kind of specification to ensure that hired personnel are able to collaborate, and if necessary we need to train people to learn how to collaborate.

On the exchange of personnel, it is thought that one factor hindering innovation is the overall low level of employment mobility in Japan, so we are told to increase mobility. Even at AIST, personnel exchange with the world of industry happens mostly through joint research projects, but that kind of exchange is not very visible. In the case of Japan, most researchers, such as those at AIST for example, will end their career at their current positions, whereas in Germany, as at Fraunhofer, research jobs are usually considered just one step on the career ladder. Thus, there is a big difference in the environment and culture of employment from country to country.

As for personnel training, the post-doctoral training we provide, which we call "innovation school," is highly regarded outside AIST. About half of the people who complete the training go to work in the corporate world, an employment rate that is well above average. Two industries that typify Japan are automobiles and casting. In the automobile industry for example, casting is very important, and Japan is the world leader in casting technology by market share. When we consider that there is virtually no university that is teaching casting, we can only surmise that there is a mismatch between Japan's industrial structure and its university disciplines. When the Japanese economy was growing steadily, academic disciplines like mechanical engineering, metallurgical engineering, and chemical engineering were very well aligned with fields of industry. Nowadays, companies have to try to fill the gap between academia and industry through in-house training, but that is costly both in terms of money and time. In my view then, AIST has a public duty to provide training in disciplines that are needed by companies but which universities cannot easily cater to.

Regarding the contribution to regional Japan, the government has been advocating "regional revival." If we look over the process of growth in post-war Japan, we note a marked transition from agriculture to manufacturing industry. We can also appreciate, though, that much of the industrialization during this period of rapid growth bypassed many parts of regional Japan. The challenge of correcting this imbalance now is a very difficult one I think. In our preparation for the fourth term, we want to revisit the question of how best AIST can make a real contribution to regional Japan.

As I said, the main roles of AIST are to solve problems and to serve as a "bridge" between academia and industry. The function of problem solving could also be described as technological consulting. I think there is a very strong demand for this function in regional Japan. AIST has appointed "innovation coordinators" to its regional research bases around Japan, whose role is to get out and meet with all the SMEs in the region to try and match the needs of companies to AIST's "seeds" of innovation. We don't have enough of our own internal people to handle this task, however, so we are looking to collaborate more closely with public research and development institutes throughout the country so that we can cover every corner of the country in this way. Of the numerous independent administrative institutions and research institutes AIST is probably the only one that can cover the whole of the country's industry. Our regional research bases operate like so-called "directly managed stores," but through tighter collaboration with public R&D institutes, these can operate like "agencies" of AIST, allowing us to provide support to SMEs across the entire length and breadth of Japan.

Finally, I should say thank you for participating in this long meeting. Today, we managed to have some very insightful discussions about how to formulate compelling research projects, on personnel exchanges, and on contributing more to regional development. All your highly esteemed opinions will be taken into account in the preparation of the Fourth Medium and Long-term Plans, and gradually put into effect. I sincerely hope that they prove useful in our efforts to help Japan grow. I look forward to your continued support and encouragement.

Thank you all very much.

Exhibition of research findings at the meeting venue

An exhibition space was set up for a presentation of a selection of research findings by AIST.

Inspection of research facilities in two groups

Inspections were conducted of eight research topics, including projects that are part of the STAR program, AIST’s flagship research program.

Course A

“Exploratory research: Analysis of pharmacology and side effects by realization of ultrasensitive analysis”

“Screening: Searching for lead compounds through one of the world's-largest libraries of natural products”

“Optimization: Supporting drug development with robotics that raises the accuracy of measurement to more than skilled staff”

“Preclinical test: Promoting technologies utilizing genomic information to realize individually tailored medicine”

Course B

“Fusion of fields: Retrieval of secret genome information from database”

“Fusion of fields: Application of Bio-CAD”

“Human data development and utilization: Fall prevention and gait evaluation for health promotion”

“Data development for human movements and its use: IT support to improve care service productivity”

Scenes during inspection of AIST research facilities

AIST Technology to Drive the Robot Revolution

Serving as a Bridge for the Robot Revolution

Industrial revolution through robots

In 1980, considered the first year that industrial robots were widely deployed, the size of the market for them was around 76 billion yen. Over the next 10 years the industry grew rapidly into a 600 billion yen market. In the quarter century since 1990, however, the scale of the industry has hardly changed–it has only gone through ups and downs in line with the general economic climate. In this time, exports have increased, largely due to the fact that the high value of the yen drove Japanese manufacturers to relocate production abroad, and in the past 15 years the unit price of robots has fallen by half.

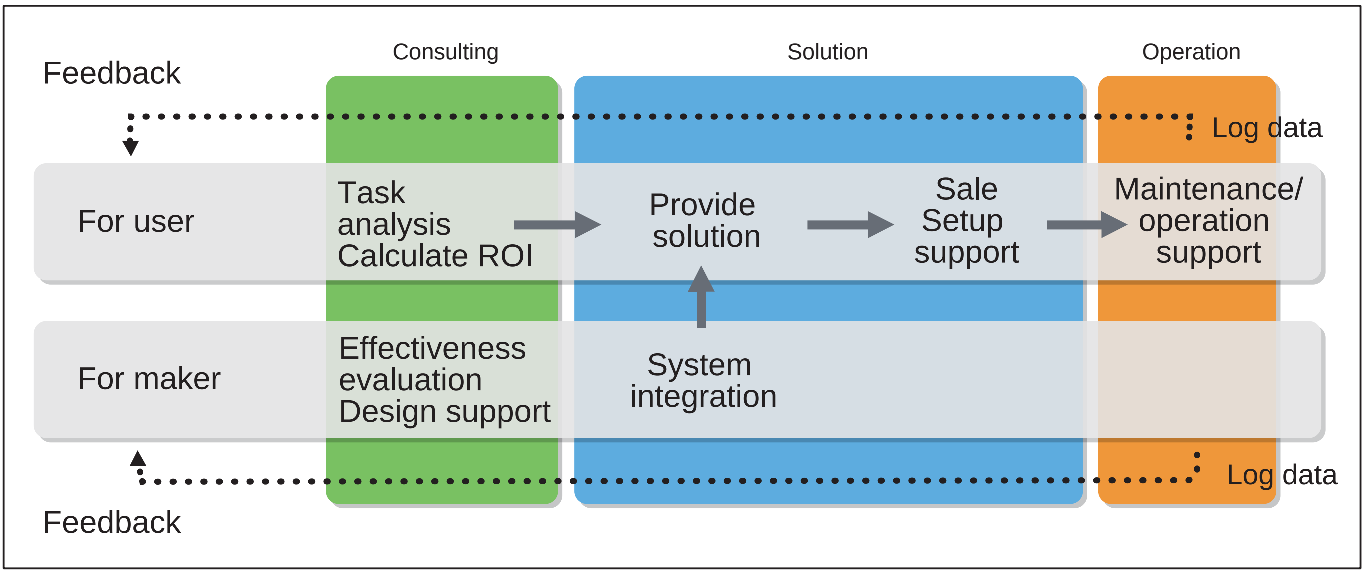
Statistics show that apart from the industrial robot manufacturers themselves, much of the investment to develop industrial robots in the 1990s was made by the R&D arms of light electrical appliance manufacturers. Since about the time of Expo 2005 in Aichi, though, major industrial corporations such as Toyota and Panasonic began making serious investments aimed at commercialization too, forming development teams of around 100 people to serve their companies' needs. The scale of private-sector investment in industrial robot development in recent years has been about 20 to 30 billion yen per year. In the U.S. a number of startup companies attracting billions of yen in investments have been launched, some of which made the news recently when bought out by Google.

At the same time, Japan is facing rapid changes in its social structure. With a falling birth rate and rapidly aging population, it is estimated that over the 20 years from 2005 Japan's workforce will have fallen by 5 million, while its population of elderly (people aged 65 and over) will have risen by 10 million. In view of these social conditions, it is entirely natural that Prime Minister Shinzo Abe has made the realization of a new robot-driven industrial revolution one of the pillars of his economic growth strategy.

How to realize a robot-driven industrial revolution

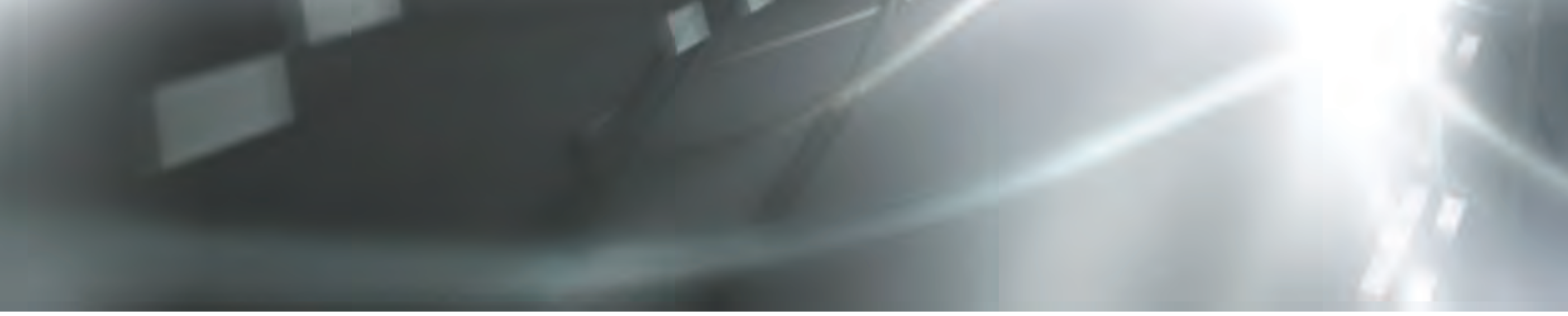
The question is: How can a robot-driven industrial revolution be realized?

According to a 2012 survey by the Ministry of Economy, Trade and Industry, when conventional robots are excluded, the market for industrial robots, including robot technology products (machinery and equipment utilizing robot technology, automated driving systems, etc.) is stuck at around 200 billion yen. The main reason is that robot technology is not providing solutions that can ignite an industrial revolution. It is not particularly that each industrial sector is wanting to use robots.



PDCA cycle for realizing robot solutions

For inquiries about this article : Intelligent Systems Research Institute https://unit.aist.go.jp/is/cie/index_e.html



What is needed are solutions to the range of issues they are facing, such as low productivity, extreme work environments, and labor shortages. A lot of development in robots has been done up to now in collaboration with users, but this approach is not enough.

In the figure on page 4 the first step is to analyze a particular work task to assess how investment in robots or other equipment can increase profitability. A solution is then provided. Then through the implementation of the solution at the premises of leading users, feedback is provided to the user and manufacturer based on detailed log data. Design support in terms of evaluating effectiveness and safety is provided to the manufacturer. It is necessary to rotate through this kind of PDCA cycle on a large scale in a short space of time.

AIST is pursuing R&D on fundamental technologies to realize this cycle, with the goal of conducting robot technology to the industrial world. This feature offers an outline of our various initiatives to achieve this goal.

Director,
Intelligent Systems Research Institute
Hirohisa HIRUKAWA

Mobility Robot Technology to Support Human Locomotion

Introduction

The special zone for mobility robot experiments in Tsukuba-city was launched in June 2011, as a testing ground for personal mobility devices equipped with robot technology, as a means of transport to address the needs of a low-carbon and aging society. We have been utilizing this zone to run driving verification tests on public thoroughfares (sidewalks), including wide-area autonomous driving tests of personal mobility devices and a verification test of mobility robot sharing between AIST and Tsukuba railway station. Through these tests, we are doing R&D on various kinds of technologies relating to information infrastructure support-type navigation.

“Marcus” wheelchair with autonomous traveling capability

We are developing a wheelchair-type

Fig.1 “Marcus” wheelchair with autonomous traveling capability
Attached with sensors for creating 3D environmental maps on the upper rear of the chair

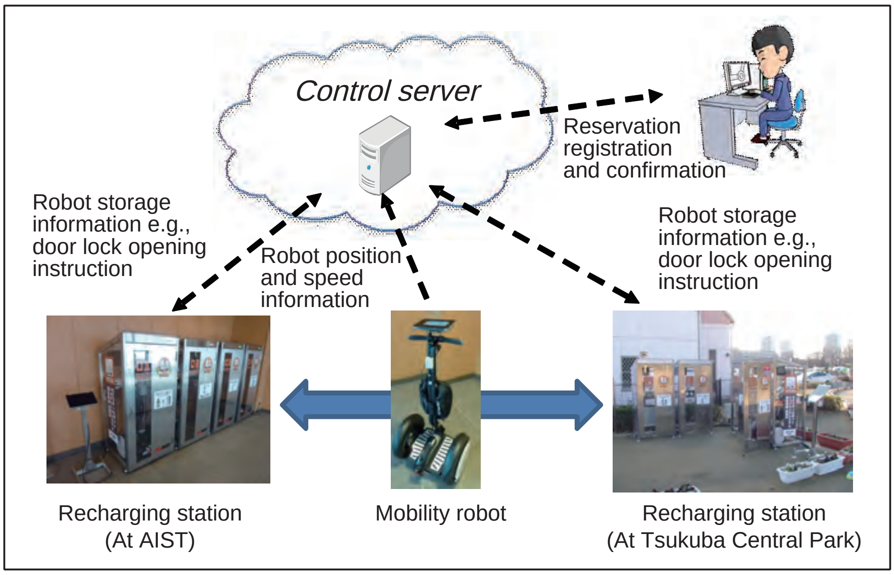


Fig.2 Mobility robot sharing system
Communication with a control server enables movement control and automated mobility robot hire

robot called “Marcus” that enables long-distance autonomous travel both indoors and outdoors. Utilizing environmental data collected using laser range sensors and omni-directional cameras attached to the robot, we created 3D environmental maps of a wide area, covering the central downtown district of Tsukuba City. We used these maps as the basis and developed a self-driving technology for long distances (a few kilometers or more), suitable for both indoor and outdoor transport. It is a highly versatile technology, enabling autonomous movement even in indoor environments where GPS cannot be used, and necessitating absolutely no modifications to the surrounding environment. Furthermore, it includes an avoidance function–whenever it detects a person or other obstacle ahead it automatically changes the trajectory of travel on a real-time basis. Research and development on this device, aimed at use by elderly people for movement in downtown areas in the future, is continuing.

Mobility robot smart sharing

We developed a sharing system using standing type personal mobility robots attached with GPS and various other sensors, and information display devices, by linking together a reservation system, movement control system, and recharging stations. This fully automated system, which allows individuals to borrow and return an electric personal mobility device in public spaces, is the first trial of its kind in the world. Currently, we are collecting, storing, and analyzing various kinds of data on the operation of the sharing system, which is being used mainly by AIST employees for work-related transport in the area between the recharging stations located at AIST and Tsukuba Central Park close to Tsukuba railway station. The system even features a means for issuing warnings if the device deviates from the regular course of travel or in the event of dangerous operation such as emergency stop. There are plans to expand the sharing system to enable travel between multiple locations by the end of FY2014, when additional recharging stations are installed at Kenkyu-gakuen Station and Tsukuba City Hall.

In addition to fully testing the operation system and examining the commercial feasibility of mobility robot sharing, we hope to demonstrate a model case study of a locomotion support service utilizing an information infrastructure.

Smart Mobility Research Group,
Intelligent Systems Research Institute
Osamu MATSUMOTO

Robot Technology to Support Human Life

The need for personal care robots

As the costs of caring for the growing numbers of elderly people keep rising, much hope is being invested in robotic care devices.

It is estimated that in the 15 years from 2010 to 2025, the number of elderly people (aged 65 and over) in Japan will increase by approximately 7 million, and the proportion of elderly people in the total population will increase from 23 % to 30 %. From 2012 to 2014 alone, the increase in elderly people was more than 1 million people per year. At the same time the total number of care workers needed is predicted to grow to 2.4 million by 2025, an increase of 900,000 from 2010. Reports also indicate that some 70 % of care workers suffer from lower back pain, resulting in an employee turnover rate of around 20 % per year. In order to reduce the burden on care workers, the development of personal care robots to enhance the independence of elderly people is being tackled with urgency.

Initiatives to develop and deploy robotic care devices

Despite this, due to problems of marketability, safety, and practicality, the development and commercialization of care devices based on advanced robot technology is barely progressing. To overcome these problems, in FY2013 the “Project to Promote the Development and Introduction of Robotic Devices for Nursing Care”[1] was launched by the Ministry of Economy, Trade and Industry (METI). It is based on three key concepts:

For inquiries about this article : Intelligent Systems Research Institute https://unit.aist.go.jp/is/cie/index_e.html

1) Identifying key areas based on real workplace needs (“needs oriented”); 2) Accelerating ease-of-use improvement and cost reduction by means of a stage gate process (“low cost”); and 3) Promoting full-scale deployment in the workplace (“mass adoption”). Through support for the development and adoption of robotic care devices in “key areas for the use of robot technology for nursing care” (Fig.1), as identified by METI and the Ministry of Health, Labour and Welfare, this project aims to enhance the independence of people requiring nursing care, to reduce the burden on care providers, and to create new markets for robotic care devices.

This project consists of two elements– a project to assist with the development of robotic care devices, involving more than 50 companies, and a project to formulate and evaluate standards by a consortium (“standards consortium”) made up of 10 organizations and centered around AIST. So far, the standards consortium has provided support by creating models of a “development concept sheet,” “safety concept checklist,” and “risk assessment sheet” to clarify the concepts needed for developing robotic care devices (how devices are used in practice, target users, and technical requirements), and by providing explanations to the development support companies. In addition, the consortium has created assessment standards that combine verification items and methods for the safety and performance levels that devices must satisfy for each key area. At the end of FY2013, assessments based on these standards were conducted at a stage gate conference.

Fig. 1 Key areas for the use of robotic care devices (as of FY2014)
Top: Mobility aid devices (wearable, non-wearable), outdoor mobility support devices
Middle: Excretion support devices, care facility monitoring devices
Bottom: Indoor mobility support devices, home care monitoring devices, bathing support devices

The standards consortium also develops methods and equipment for verifying the effectiveness of devices. Specifically, it is developing a humanoid robot and dynamic simulator (Fig.2) to simulate the behavior of care workers and care recipients, as well as a support system that involves recording the tasks performed at care facilities (including the conditions of use of robotic care devices). Furthermore, we are working to develop a highly reliable embedded CPU board to support modularization and conducting surveys and studies aimed at standardization of robotic care devices. We have also set up a public relations web site for the project (a portal site for robotic care devices),[2] on which we publish research results and information on the progress of our standards formulation efforts.

Safety verification of personal care robots

Assistive devices that are in direct contact with people and devices that move in living environments, such as robotic care devices, can cause great damage to people–if a device goes out of control in some way, for example. For this reason, the safety of robotic care devices and other kinds of personal care robots requires careful attention.

In December 2010 the Robot Safety Center was established as a base for conducting safety verification of personal care robots. The center is equipped with an assortment of testing equipment to verify the safety of personal care robots. Some examples include a system to check that robots do not malfunction under various temperature and humidity conditions (combined environment test system); a system to check that devices do not topple when the inclination of the driving surface changes (driving stability test system) (Fig.3); a system to check the potential for human harm by crashing the robotic device against a dummy (collision test system) (Fig.4); and a system to check that the electromagnetic radiation generated by a robot does not cause human harm or device malfunction (EMC test system).

Currently, the center is running a variety of tests on robotic care devices by companies involved in the robotic care device project mentioned above, but since July 2014 the Robot Safety Center is also conducting tests of other devices, on contract, through the Japan Automobile Research Institute (a non-profit foundation). More and more robot developers and manufacturers are expected to make use of the center's services in the coming years.

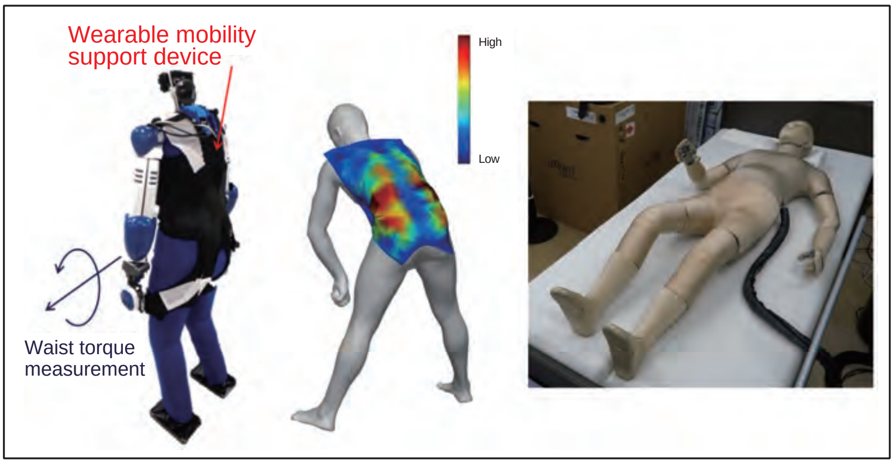


Fig.2 Simulated nursing care robot, simulator, and simulated elderly patient robot


Fig.3 Driving stability test system


Fig.4 Collision test system

International safety standards for personal care robots

While previously there were no standards applicable to personal care robots, on February 1, 2014 ISO 13482 (Robots and robotic devices - Safety requirements for personal care robots) was issued. This international safety standard covers three types of personal care robots–mobile servant robots, wearable physical assistant robots, and person carrier robots. The basic structure of these standards was proposed by Japan and the activities of the Robot Safety Center made a significant contribution to the standards. These standards are not yet defined quantitatively, but through its activities the Robot Safety Center is expected to produce more detailed quantitative data in the coming years.

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[2] Robotic Devices for Nursing Care Project web site: http://robotcare.jp

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The Birth of “Mahoro”: Turning to the Idea of a Multipurpose Two-armed Robot

The life sciences bottleneck

As new, innovative measurement technologies have emerged in the life sciences, the lab benchwork needed for research has expanded greatly, resulting in seemingly endless, laborious work. In view of the fact that the correctness and reproducibility of experiments depend on uncertainties such as the skill, spirit, personality, and concentration of the operator and tacit knowledge, a tremendous number of repeated trial and error processes are needed to reproduce experimental results satisfactorily. In addition, even if perfect procedural protocols are developed at great cost of money and time, it is not unheard of for work to vanish like mist when an operator changes. The fact that in many experiments little effort is made to make the technology visible and standardized is a major impediment when it comes to generalizing and industrializing research findings. On top of this, in biomedical experiments it is sometimes necessary to handle dangerous viruses.

In view of all this, here we present the story of “Mahoro,” born to solve these kinds of problems and to facilitate a revolution in the life sciences and biotech industry.

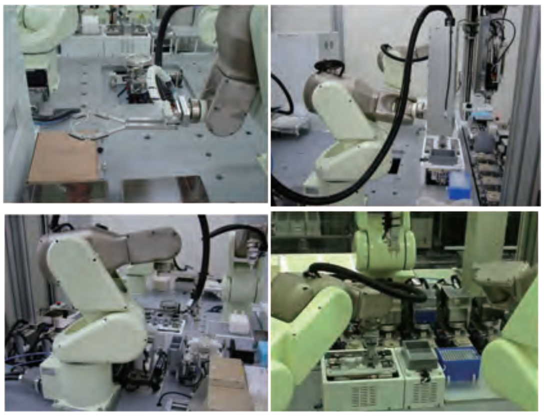

Fig.1 “One robot-one process” type benchwork robot

Fig.2 “Mahoro” multipurpose humanoid robot

The difficulties of benchwork robots

The development of the world’s first benchwork robots was launched around 15 years ago, based on the vertical multi-axis robots that were already widely deployed in manufacturing industry (Fig. 1). However, “one robot-one process” production line type system suffered from a basic limitation–the need to rearrange robot hands and special jigs at each work step. On top of this, customizing peripheral devices such as dispensers, stirrers, and centrifuges that were not originally designed for use in automated processes required around five years for design, trial manufacture, and optimization, and another two years for teaching.

The robot system, completed at great expense of time and money, was a highly specialized automated line that was not amenable to the slightest change or correction of protocol–it was completely unable to adapt to the obsolescence of analysis and experiment methods, or to the incessant minor changes that tend to occur in work procedures.

From specialized lines to multipurpose robots

In view of the above issues, a conceptual transition occurred. Instead of “one robot-one process,” peripheral devices would be used as they are, and all processes would be handled by a multipurpose, two-armed robot at a single benchwork.

When we presented this idea to Takeo Suzuki, then managing director of YASKAWA Electric Corporation in 2001, he arranged for us to pursue research in collaboration with Masahiro Ogawa (now CEO of Yaskawa America, Inc.), the person in charge of developing the two-handed robot, and his elite team. In the summer of 2012 we managed to complete a proof-of-concept of the world’s first multipurpose two-armed robot (Fig. 2), and later through a full-scale collaborative research effort we gradually demonstrated that skilled experiment techniques can be visualized and tansfered and robots can surpass humans at many tasks.

Looking ahead to future projects, we have developed a business model together with companies and shared the concept and values of our “Mahoro” robot system with a wide range of entrepreneurs, engineers,

For inquiries about this article : Molecular Profiling Research Center for Drug Discovery http://www.molprof.jp/english/index.html

and even salespeople. For AIST and the company to function as a single team, we sat together with university researchers and clinicians in meetings and study groups innumerable times. A lot of work in establishing a structure was also done to ensure genuine “open innovation,” for example by setting up a reference web site and establishing a group focused on robot utilization.

A robot that anyone can use

Within several years we hope to see a robot at work on the bench of every research lab. To help bring this about, we want to create a polished interface that allows even people without any special experience or knowledge to instruct the robot to perform sophisticated tasks. It is also necessary that the work procedures of researchers in all fields are quickly adapted, standardized, and accumulated.

Our hope is to help bring about environments that will liberate many researchers from the need for routine benchwork, so that they can devote themselves fully to work that only humans can do.

Related Information:
Advances in Lab Bench Work With “Mahoro,” a Multipurpose Humanoid Robot, AIST, Youtube (www.youtube.com/watch?v=l4W9d9ZVJyQ)

Director,
Molecular Profiling Research Center
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Toru NATSUME

Robot Technology to Support Manufacturing Industry

Introduction

In manufacturing industry, the use of robots for welding and machining processes is now relatively well advanced, but robotization of other processes, such as assembly, parts supply, and product inspection, is still quite undeveloped. At AIST, the Vision and Manipulation Research Group of the Intelligent Systems Research Institute is at the center of research efforts aimed at promoting robotization for such processes. Here, we offer an outline of some of our activities.

Recognizing environments and objects

Versatile Volumetric Vision (VVV), a 3D vision system, is a software system that enables the highly precise, real-time execution of a series of processes–distance measurement, shape representation, object recognition, and motion tracking–applied to arbitrarily shaped objects under a variety of conditions.

For example, the system can detect objects made up of free curved surfaces, by making measurements of 3D information in an observed scene to determine features and then comparing them to geometric models (Fig. 1). It can also detect specific objects from a group of relatively featureless tubular objects by theoretically analyzing vector distributions of principal curvature (Fig. 2).

Grasping and motion planning

“graspPlugin for Choreonoid” whose framework is Choreonoid, a robot motion choreography software package, is capable of solving a wide range of planning problems, such as hand position planning for grasping

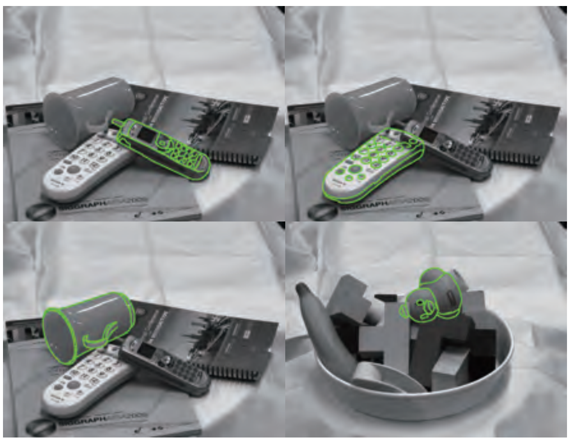

Fig.1 Detection of generic 3D objects

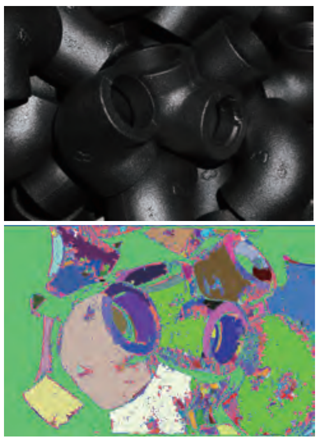

Fig. 2 Detection of tubular objects

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objects and planning of robot motion for grasping objects by hand.

The dual-arm robot in Fig. 3 plans "pick and place" motion, as needed, while passing an object from one hand to the other.

Force control technology

The ability to control the force and moment applied by the hand of a robot enables a variety of useful work to be performed by robots.

The humanoid robot in Fig. 4, for example, is able to tighten nuts, through the use of sensors fitted to the wrist of the robot that measure the 6 dimensional forces and moments. When a nut is tightened, information about the reflective force is used to fit the nut to the bolt at the correct position.

Fig.3 Robot motion planning, including grasping of objects

Through this process, the tightening of the nut is successfully achieved.

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Intelligent Systems Research Institute
Kensuke HARADA

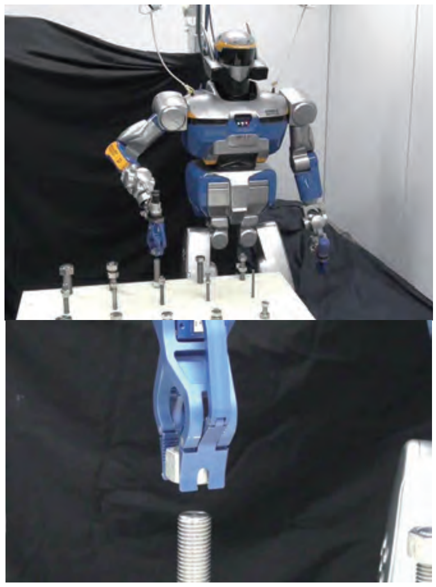


Fig. 4 Nut screwing operation with force control (Below is an enlarged view of the robot's right "hand")

Robot Technology to Make Social Life Safer

Intelligent sensing technology

Sensing technology to serve as the "eyes of machines"

A new age in which the "eyes of machines" in the form of personal care robots, self-driving vehicles, and similar devices, will support us in many aspects of our lives is gradually emerging. Since humans live depending heavily on visual information, it is desirable that the machines we use to support us possess visual capabilities as good or better than our own.

As illustrated in the figure, we are working on R&D to develop a variety of technologies to provide a foundation for realizing the "eyes of machines," and to serve as a bridge between the developed technologies and our society.

Three sensing technologies

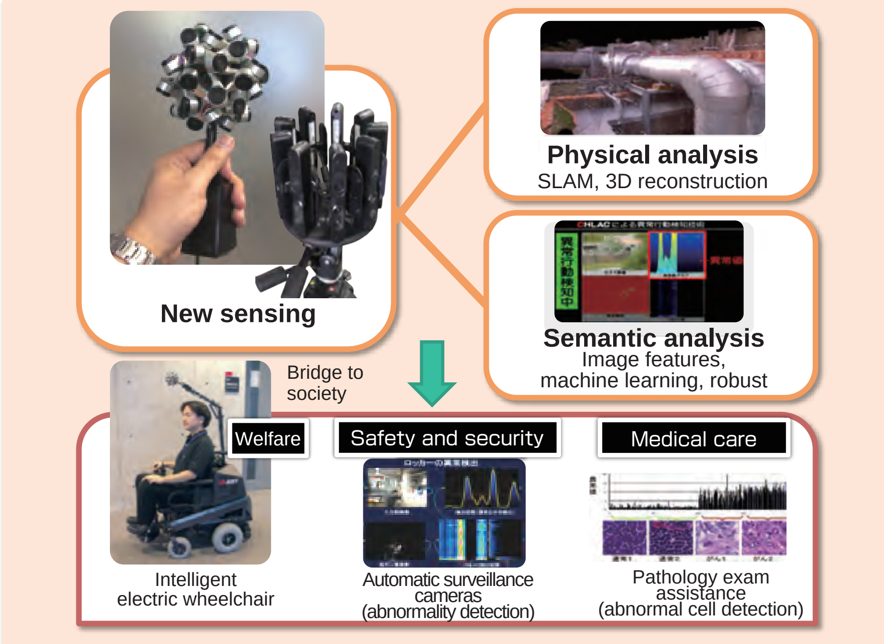
Sensing technologies can be roughly classified into three types. The first type of technology is equivalent to the "eye" of humans. The overall system performance is largely determined by whether or not information can be accurately captured. We are developing and assessing the performance of new sensing systems that defy conventional common sense, like an omnidirectional stereo camera system that simultaneously obtains color images in every direction and distance information by means of 36 "eyes." As an example we are doing research aimed at applying this technology to ensure the safety of electric wheelchairs that are required to move in and around living spaces together with pedestrians–spaces that are far more complex than the roadways that regular motor vehicles travel on.[1]

The second type is a "physical" data analysis technology. This includes reconstruction of 3D information from data captured in 2D, like that of ordinary camera images, integration of multiple captured 3D data sets obtained using lasers, and measurement of various kinds of quantities

and characteristics using these data. This is a fundamental technology that is becoming essential in a wide variety of settings–it is utilized, for example, to detect obstructions to electric wheelchairs like those mentioned above, as well as to serve as the "eyes" of industrial robots.

The third technology is a "semantic" data analysis technology. A typical example of this is Higher Order Local Autocorrelation (HLAC), a technique invented by AIST, and the applied technologies associated with this.[2] Applying thie technology, we developed a system for automatically detecting "abnormalities." It is difficult to define "abnormality," but by combining HLAC with machine learning techniques, the system learned to understand "normality." By then defining the deviation from "normality" as the "degree of abnormality" it was possible to implement automatic detection of abnormal activity from surveillance camera images[3][4] and automatic detection of abnormal cells from pathology exam images.

These three types of technology and their combination represent a technological foundation that gives machines the power to see. Looking ahead, we hope to advance the technologies further and utilize our findings to facilitate safer, more secure social life.



Development of intelligent sensing to address social needs

Smart Communication Research Group,
Intelligent Systems Research Institute
Yutaka SATOH

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[2] N. Otsu: *Synthesiology*, 4(2), 70-79 (2011).

[3] AIST Press Release, "World's Highest Performance Human and Motion Recognition," May 24, 2005.

[4] AIST Press Release, "Automatic Real-time Detection of Abnormal Motion from Camera Images," October 16, 2007.

Robot technology for infrastructure maintenance

Urgent measures to counter infrastructure deterioration

Infrastructure means the equipment and facilities that serve as the foundation for our personal lives and industries. Social infrastructure covers a wide range of things, including roads, rivers and dams, seaports and airports, water supplies and sewerage systems, and electricity and gas supplies. Since the peak of social infrastructure construction in Japan occurred in the period of rapid economic growth of the 1960s and 70s, over the next 20 years the proportion of this infrastructure that will be more than 50 years old will accelerate rapidly.[1] To address the deterioration of this social infrastructure, however, a number of problems have to be faced–a decline in infrastructure function, the financial difficulty of maintenance and renewal, and a serious lack of labor and technology.

Sensing and robot technologies offer promise for their potential to address the problem of maintaining social infrastructure. In December 2013 the Ministry of Economy, Trade and Industry and the Ministry of Land, Infrastructure and Transport designated

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bridges, tunnels, and the underwater parts of rivers and dams as "key areas for the development and deployment of robots for social infrastructure." In FY2014 the ministries launched an R&D project and field verification project. The R&D project is being carried out under contract to the New Energy and Industrial Technology Development Organization (NEDO). Here, we present a description of our efforts to develop a robot for maintenance of bridges and the underwater parts of rivers and dams.

Inspection in difficult environments

There are approximately 700,000 bridges in all of Japan (defined as roadway bridges 2 m or longer). Of these, 68 % are managed by the local government. Guidelines for periodic bridge inspections for maintenance were revised in June 2014 to the effect that all bridges should be visually inspected in close proximity every five years, thereby placing a great burden on local governments and inspection services. In view of this problem, we are pursuing R&D together with Kawada Technologies, Inc. and other companies to create a bridge inspection system that utilizes multicopters (Fig. 1). In this development our aim is to facilitate comprehensive and uniform periodic inspections, by means of a multicopter system with a wired power supply, that flies under bridges to capture detailed images of the parts requiring inspection.

Japan also has some 30,000 river administration facilities at rivers and dams. One problem is scouring of river banks and bridge piers (sand is washed away by flowing water). Together with Q.I., Inc. and others we are engaged in an R&D project to develop a reconfigurable robot system for underwater surveys (Fig.2). This system is principally designed for surveys of dam facilities and deposits, surveys of scour in flowing rivers, and it enables modular configurations suited to the environment and inspection targets. Its key feature is that it enables a wide range of multipurpose surveys.

Like this, robots can make sensors access remote inspection points, and robot technology is an indispensable technology for the inspection of structures that are difficult for people to access.

The problem of infrastructure deterioration is similarly evident with industrial infrastructure, such as oil refineries, chemical plants, ironworks, and electric power plants. In light of this, we are also trying to develop robot systems to support maintenance of industrial infrastructure in more complex environments.

Reference

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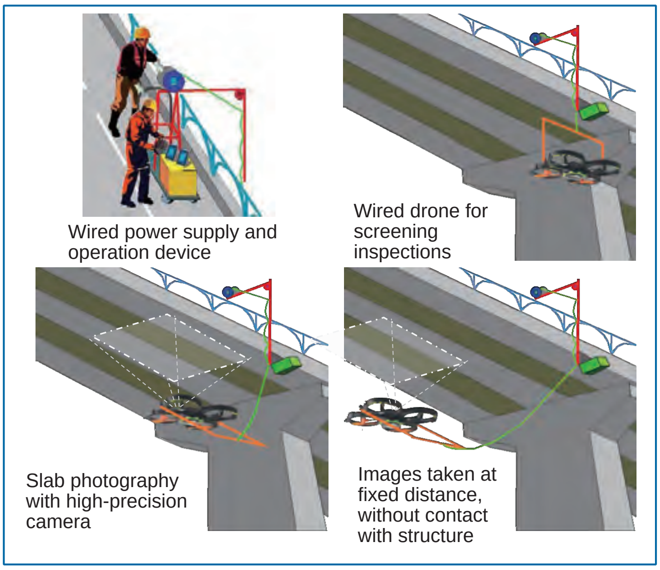


Fig.1 Images of bridge inspection system

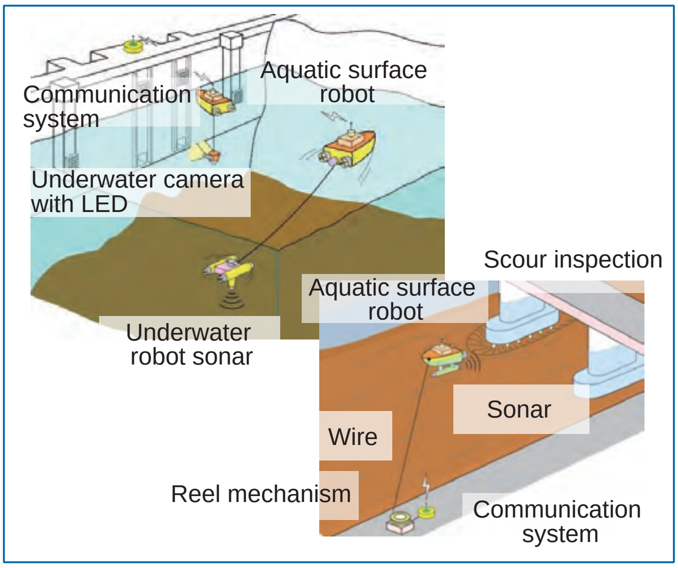


Fig. 2 Images of system for examination of dam facilities and deposits, and scour

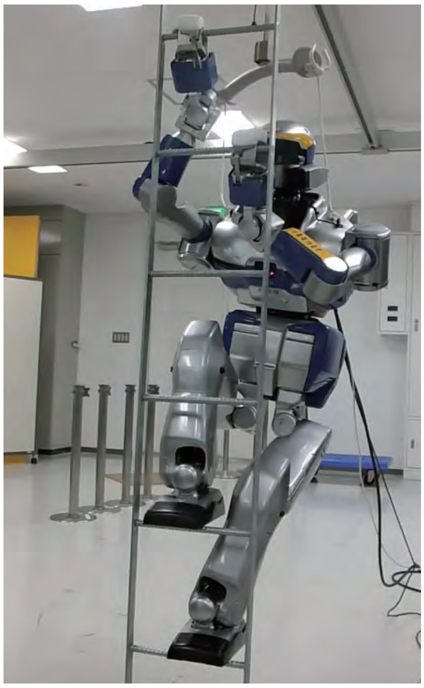
Robots Designed to Work in Extreme Environments

Disaster-response humanoids

There is a need for robots that can replace humans for evaluating and working at dangerous disaster sites. Although crawler robots the mobile Quince and PackBot are being actively deployed at the Fukushima Daiichi Nuclear Power Plant, facilities such as this were designed assuming that all work would be done by humans. Since the widths of passageways and stairs were designed for humans, the movement of robots is not easy, and there are many places where robots cannot move, such as vertical ladders, which are only accessible by humans. Thus, humanoid robots, shaped similarly to humans, are considered a promising solution for working effectively in such environments.

To realize humanoid robots capable of working at the scene of disasters, we are engaged in R&D to equip such robots with the ability for highly dependable movement, by combining three essential functions: 1) An environment recognition function that enables accurate recognition of surrounding conditions when the robot first arrives at the site; 2) A multipoint contact motion planning function for planning the motion needed to execute movement and tasks, whereby the robot makes contact with the environment not only with its “toes” but also with “fingers” and various other parts of the body; and 3) A whole-body motion control function that enables motion plans to be adaptively changed in the course of operation when uncertainties exist, for example when measurement errors occur.

We hope our efforts will hasten the day when human workers will be freed from the need to work in extreme and dangerous environments.



A humanoid robot climbing a fully vertical ladder using its two hands and two feet

Humanoid Research Group,
Intelligent Systems Research Institute
CNRS-AIST JRL (Joint Robotics Laboratory),
UMI3218/CRT

Fumio KANEHIRO

Robots for conducting surveys at disaster sites

In disaster response management, it is important to start by assessing conditions at the site of the emergency. Due to the severity of the environment or the danger posed by possible secondary disasters, however, it is often difficult for people to access the site. For these reasons, robots suitable for the particular environment and site conditions are used.

In the case of nuclear decommissioning at the Fukushima Daiichi Nuclear Power Plant, as assessment of conditions inside the building progressed, it became necessary to conduct a survey of high places with complicated piping. For this purpose, we worked in collaboration with Honda R&D Co., Ltd. to develop a high-access survey robot[1] (See figure). The robot was first deployed in March 2013 and it has so far been used to capture images and measure radiation levels at high places in reactors No. 2 and 3. In this development project, careful study to increase dependability and devise response measures, taking into account both the operation and return of the robot, was vital in improving the usability and safety of the robot.

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AIST Technology to Drive the Robot Revolution

Robot technology is also used for disaster responses to volcanic eruptions and mudflows. Currently, we are developing a "complex terrestrial/aerial robot system for disaster surveys," designed for operation in integrated form, making use of the advantages and characteristics of terrestrial mobile robots and aerial flying robots. We are working on this in collaboration with Hitachi, Ltd., under contract to the New Energy and Industrial Technology Development Organization (NEDO).

Looking ahead, we will continue striving to develop robust, highly dependable robot systems, capable of working effectively under extreme disaster conditions. We will also perform evaluations and formulate relevant standards to help in deciding on robot deployment.

Reference

[1] N. Yamanobe *et al.*: *Journal of the Japan Robotics Society*, 32-2, 145-147 (2014).

Field Robotics Research Group,
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Shin KATO

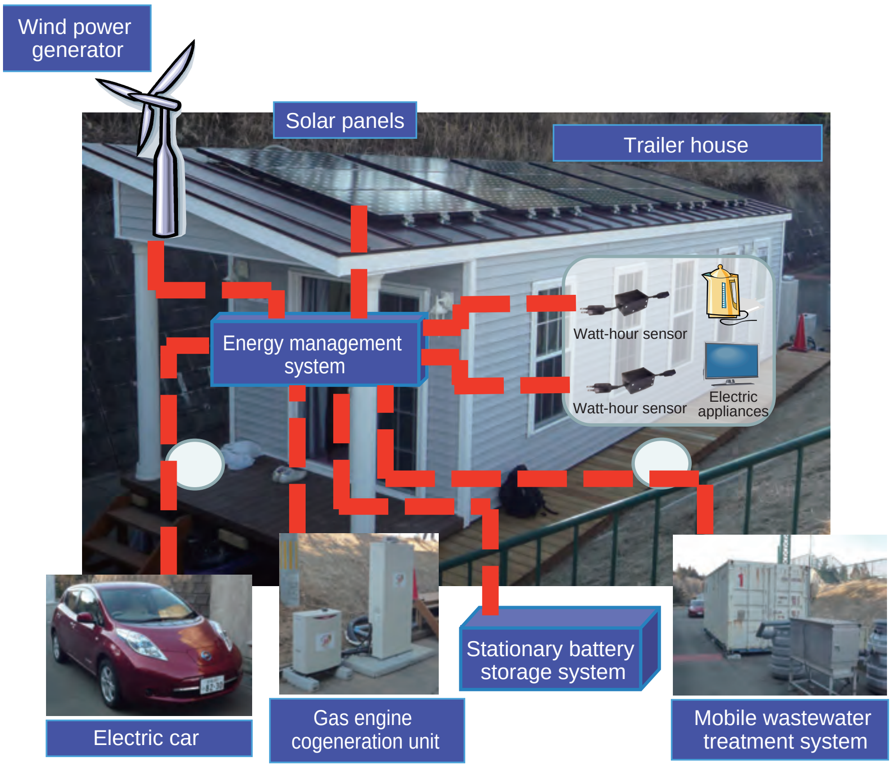
Appearance and specifications of high-access survey robot
Left: when used for high-access survey, Right: when transported or moved

Robot Technology to Create Value

Spreading the use of robots in society

Even if we create a car that can travel very fast, its performance can not be demonstrated if there are no roads. Similarly, even if high-performance robots are available, they cannot do much good if there is no way to get them used in society. It was an awareness of this problem that led to the launch of the Kesennuma Kizuna Project.[1]

When we first visited the disaster-affected areas following the Great East Japan Earthquake, we tried to identify problems that could be solved with technology. We realized, however, that this was putting the cart before the horse–that technology was essentially a secondary issue. The right approach is to start by clarifying "what kind of support is needed in the disaster area" and then creating



Trailer house and energy management technology

a means to get the necessary support adopted. Only after this would it be clear what technology was appropriate.

Conditions in the disaster area and the future of Japan's rapidly aging society

Local communities within the affected area were devastated by the disaster. Many of the elderly victims moved into temporary housing, but without any local community they had no motivation to go out. As a result, they tended to become reclusive, shut away in their homes. This in turn affected their health, leading to a rise in cases of a disease known as "disuse syndrome" (a disease caused by lack of activity). This situation in the disaster area struck me as a microcosm of a problem that is becoming more prominent in the wider Japanese community, so a solution to this problem could also be valuable for the country's aging society in the years ahead.

Robot technology needed for support

To prevent disuse syndrome it was necessary to create a sense of community to motivate people to get out of their homes. It was first necessary to create a social space in which community could be established, then to prepare and provide some kind of attraction to ensure that the community would be active and sustainable. At this point the required technology became clear. To provide a social space we needed a building. It was not possible to construct a building immediately, so we decided to bring in a "trailer house"–a mobile house fitted with wheels (See lower figure on page 15). In addition to a building, electricity and water supplies were also needed, of course. In the disaster area, the quickest option for this was a self-sufficient energy management system, with solar panels, a battery storage system, etc.

Robot introduced at a health and fitness event

The next step was to provide something to engage the interest and participation of the people. For this we brought in several robots connected to health. Rather than simply placing the robots in the trailer house, it was important to make effective use of them, as part of running health events and consultations allowing people to keep track of how much their health improved from day to day (See the figure above).

A social system linking governments and private sectors

The presence of engineers in a disaster area and the support provided through their knowledge can make a valuable contribution to the recovery of a community, but ultimately the locals have to run things on their own. So unless we leave them with a practical way to operate the adopted technology themselves, the community cannot be genuinely revived. What is needed is some kind of system in which governments or NPOs adopt technology from the private sector themselves and then develop appropriate government services.

Currently we are collaborating with Kesennuma City to start up a revival support system, the "Kesennuma City Good Life Creation Promotion Scheme," linking the government and private sectors, with the aim of tying together technology provided by private sectors to local government services. This will serve as a social system that can help ensure that robots and other kinds of technology make a valuable contribution to communities.

Reference

[1] *Ikirukizuna* web site: http://ikirukizuna.jp/

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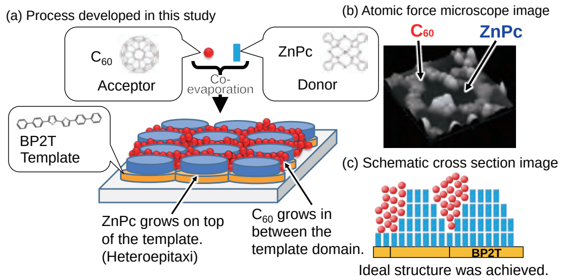
Tamio TANIKAWA

**The abstracts of the recent research information appearing in Vol.14 No.10-12 of "AIST TODAY" are introduced here, classified by research areas.
For inquiry about the full article, please contact the author via e-mail.**

Environment and Energy

Achievement of ideal organic-solar-cell architecture
Improvement of photo conversion efficiency by controlling crystal structure

We have achieved construction of highly controlled organic-solar-cell architecture by means of a crystal growth technique. The technique known as heteroepitaxy was applied to the co-evaporation of donor and acceptor materials. The ideal film morphology with high crystallinity was achieved, where carriers can be transported smoothly. As a result, the solar-cell power conversion efficiency was doubled from 1.85 % to 4.15 %. Further improvement of organic solar cells will accelerate the realization of flexible and low-cost solar panels.



Detail of process and the structure of bulk heterojunction
(a) The process developed in this study
(b) An atomic force microscopy image of the co-evaporated film (10-nm thick)
The phase separated structure was constructed by molecular interactions.
(c) A schematic illustration of the cross-section of a film

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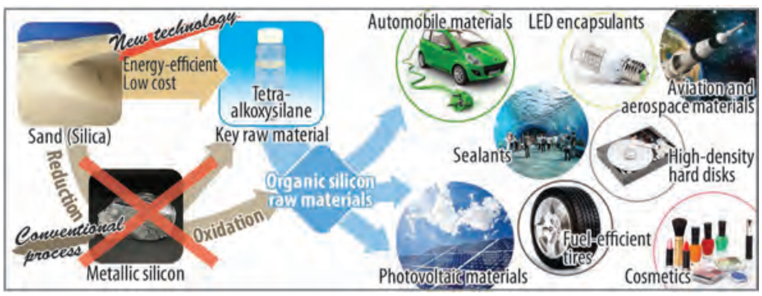
AIST TODAY Vol.14 No.10 p.12 (2014)

Environment and Energy

Effectively synthesizing a key raw material of the silicon chemical industry
A one step synthesis of tetraalkoxysilane from silica and alcohol

Tetraalkoxysilane is a key raw material of the silicon chemical industry and a promising raw material for silicone and other various organic silicon materials. We developed a technology capable of efficiently synthesizing tetraalkoxysilane through a one-step reaction between alcohol and silica, the primary constituent of sand. We discovered that tetraalkoxysilane could be obtained in one step by adding an organic dehydrating agent to the reaction system of silica and alcohol to remove the water by-product. Also, the efficiency of the reaction was further increased by performing it in the presence of carbon dioxide and catalysts, metal alkoxide and alkali metal hydride. This technology paves a new path to the energy-efficient, low-cost manufacture of organic silicon raw materials from sand.



Manufacture of organic silicon raw materials from sand and diverse product groups containing organic silicon

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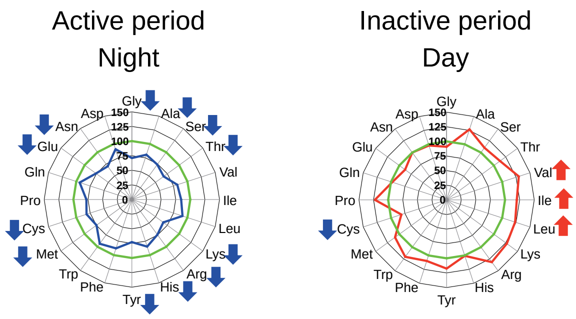
AIST TODAY Vol.14 No.10 p.13 (2014)

Amino acids as a potential biomarker of sleep-wake disorders

Plasma free amino acids profiles in a model mouse of sleep-wake disorders

Disordered circadian rhythms are associated with various psychiatric conditions and metabolic diseases. We recently established a mouse model of a psychophysiological stress-induced chronic sleep disorder (CSD) characterized by reduced amplitude of circadian wheel-running activity and sleep-wake cycles, sleep fragmentation and hyperphagia. Here, we evaluate day-night fluctuations in plasma concentrations of free amino acids (FAA) in mice with CSD (CSD mice). Day-night fluctuations in plasma FAA contents were severely disrupted without affecting total FAA levels in CSD mice. Nocturnal increases in branched-chain amino acids such as Ile, Leu, and Val were further augmented in CSD mice, while daytime increases in Gly, Ala, Ser, Thr, Lys, Arg, His, Tyr, Met, Cys, Glu, and Asn were significantly attenuated. These findings suggest that plasma FFA profiles could serve as a potential biomarker of circadian rhythm disorders.



The radar charts for the relative changes in plasma FAAs
Averaged value for control mice is expressed as 100 % at each time point. Upward and downward arrows indicate significant increases and decreases, respectively, in CSD mice.

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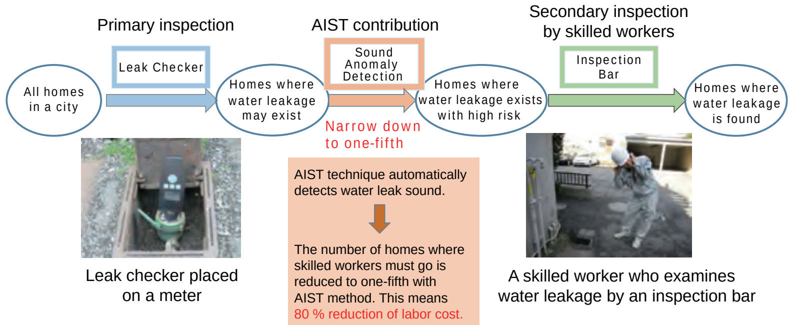
Detection of water leakage from water pipes using a learning-type sound anomaly analysis technology

Reduces labor required for water leakage inspection by skilled workers to one-fifth

We have developed a technology to narrow down the locations that must be inspected for water leakage by skilled workers with high-accuracy in advance, using a sound anomaly analysis technology which learns the workers' judgments by machine learning. Field tests have been conducted in two cities which resulted in a reduction of the inspection locations to one-fifth, compared to the past. Narrowing down the inspection locations will lead to significant reduction in inspection costs, which will provide relief to local governments that need to reduce maintenance and management costs brought on by the decline in water rate revenue due to a decrease in population. In addition, providing this as a maintenance and management technology for social infrastructure is expected to contribute to the low-cost supply of safe drinking water in countries of Southeast Asia, now suffering from a water leakage rate of over 30 %.



Positioning of water leakage detection through learning-type sound anomaly analysis

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New technology for ultra-low power magnetic information writing
First demonstration of radio-frequency-voltage-assisted magnetization switching

We have developed a new technology to reduce the energy for magnetic information writing using the radio-frequency-voltage-induced ferromagnetic resonance (FMR). Magnetization reversal assisted by resonance dynamics is an important technique for future magnetic information technology, such as in the next-generation hard disc drive. However, we usually need an application of high-electric current to induce the large magnetization precession, which results in unwanted energy loss due to Ohmic dissipation. In this study, we employed the voltage control of magnetic anisotropy in an ultrathin ferromagnet to excite the FMR dynamics, and observed clear reduction in the magnetization reversal field, as large as 80 %, without the electric-current application.

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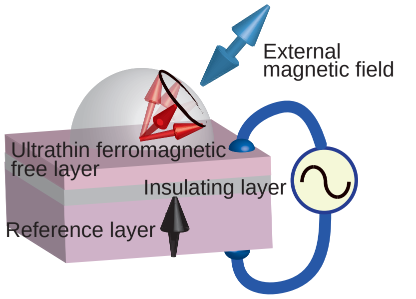
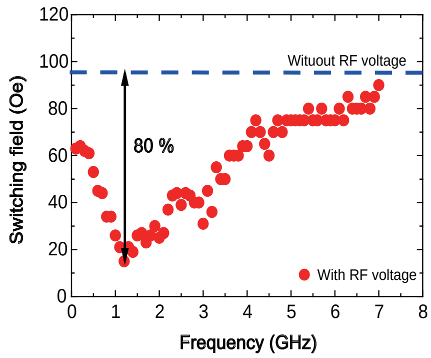


Schematic of the magnetic tunnel junction used in this study
Radio-frequency voltage application induces ferromagnetic resonance dynamics in the magnetization of an ultrathin ferromagnetic free layer (red arrow) and causes reduction in the magnetization switching field.



Radio-frequency (RF) voltage-assisted magnetization reversal
Reduction rate of more than 80 % was achieved at around 1GHz.

A novel switchable mirror with visible transmittance of over 70 % in the transparent state
Annual cooling and heating load in buildings can be reduced using this mirror as window panes.

With switchable mirrors, their optical properties can be changed reversibly between reflective and transparent states. Therefore, the mirrors in the reflective state can reduce cooling load in office buildings by blocking the solar radiation entering the rooms through windows. However, if the transmittance in the transparent state is not high enough, the heating load increases more than the decrease in cooling load, and consequently the annual load increases. We have improved the optical properties of switchable mirrors using antireflection coating and have achieved switchable mirrors with visible transmittance of over 70 % with neutral color appearance in the transparent state. The mirror also has large dynamic range of over 60 % between reflective and transparent states. Thus, it is expected that the newly developed switchable mirror can reduce annual cooling and heating loads in buildings. From now, we will estimate its weatherproof performance against solar radiation.

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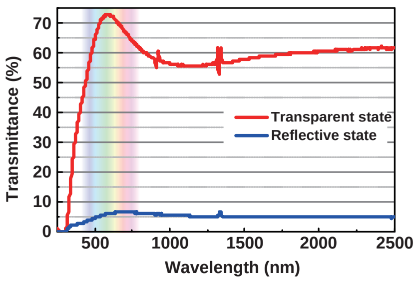


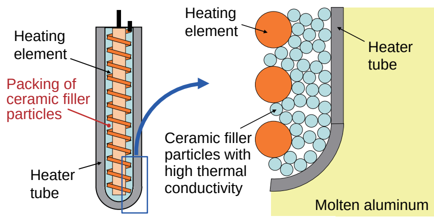
Transmittance spectra of a newly developed switchable mirror in the reflective and transparent states

A newly developed switchable mirror coated with antireflection layer
Upper: the reflective state, Lower: the transparent state

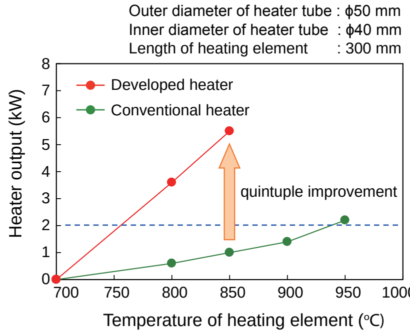
High-output heater to heat molten aluminum

Heater output quintupled by high-density packing of high thermal conductivity ceramic filler

We have developed a high-output heater to heat molten aluminum. The developed heater uses a ceramic heater tube with excellent corrosion resistance against molten aluminum, packed to high density with high-thermal-conductivity ceramic filler particles. This structure improves the heat transfer from the heater element to the molten aluminum thereby achieving a quintuple increase in heater output in comparison to a conventional heater. This high output will allow reduction in the number of heaters required for heating molten aluminum and is expected to contribute to the reduction of heater equipment and to energy conservation in the metal casting industry.



Schematic diagram of the high-density packed high-thermal-conductivity ceramic filler particles



Results of heater output test

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AIST TODAY Vol.14 No.11 p.13 (2014)

Extrusion process for long-fine Mg alloy tube with high dimension accuracy

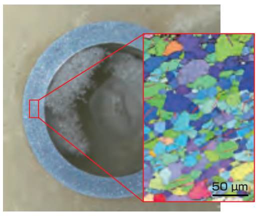
Enables the development of biodegradable Mg-based stent

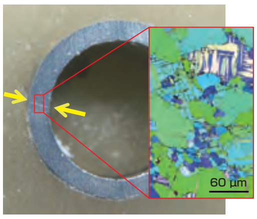
Magnesium (Mg) alloy has attracted attention as a biomaterial for biodegradable stents. However, it is difficult to fabricate a long-fine Mg alloy tube precisely because of its low-plastic deformability. Additionally, conventional extrusion using a porthole die has problems in making extruded tubes with thin wall thickness and homogeneous microstructures.

We have developed a precise extrusion method without the porthole die for long-fine Mg alloy tubes with high dimension accuracy. The Mg alloy tube (meter-length scale, 3.0-3.4 mm in tube diameter) fabricated by the developed extrusion method had low wall thickness error below ±4 % and a homogeneous fine grain structure. On the other hand, the Mg alloy tube fabricated by conventional extrusion using the porthole die had welding lines and an inhomogeneous grain structure and segregation around the lines.

The developed extrusion method is expected to be used in developing biodegradable Mg alloy medical devices.

Long-fine Mg alloy tubes fabricated by developed tube extrusion method





Cross-sectional microstructures of Mg alloy fine tubes
Developed method (left), conventional method with a porthole die (right) and the arrows indicating the welding line

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Reduction technique in amount of platinum used for diesel oxidation catalyst

Preparation technique of precious metal nano-particle catalyst suitable for mass production

For the practical use of PGM (platinum group metal) nano-particle catalysts with high thermal durability, the surface polyol reduction method suitable for mass production was newly developed. In this method, PGM nano-particles are directly deposited on the support surface through reduction using a small amount of polyol. The catalysts exhibited high thermal durability in lab-scale testing, proving that composite formation between Pt and Pd through this method is effective. The catalyst containing 50 % less PGMs than one prepared by an impregnation method was prepared and subjected for the purification of hydrocarbon and as a result, it was found that the catalyst had sufficient performance.

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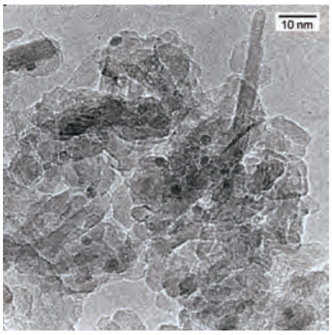
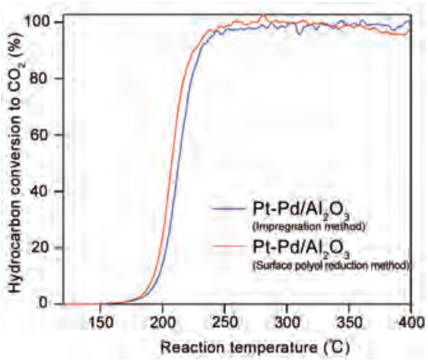


TEM photograph of platinum nano-particles deposited on an alumina support



Hydrocarbon purification performance of catalysts prepared by an impregnation method and a surface polyol reduction method after a high-temperature thermal durability test

Organic semiconductor nanoparticles with several-nanometer thickness

Continuous-flow production of nanoparticles for thin-film devices using a micromixer

We have developed a new process for continuous-flow production of very thin organic semiconductor nanoparticles by a reprecipitation method. Rapid mixing of an organic semiconductor solution with a poor solvent, that is, a solvent which cannot dissolve the organic semiconductor compound, through a micromixer with an inner diameter of 0.1 to 1 mm provided semiconductor nanoparticles stably dispersed in the solvent. Atomic force microscopy measurement showed that the nanoparticles have thin disk-like shapes with diameters of about 60 nm and thicknesses of several nanometers. We expect that the nanoparticles can be used for fabrications of layered thin films in organic solar cells and electroluminescent devices. This work was performed in collaboration with Konica Minolta, Inc.

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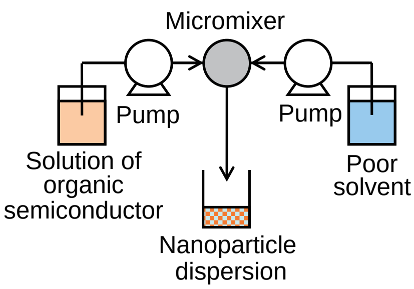
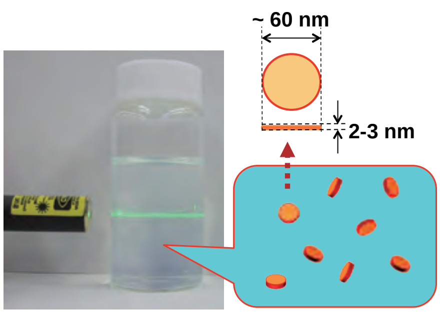


Continuous-flow production of organic semiconductor nanoparticles
Rapid mixing of poor solvent with a micromixer induces reprecipitation of nanoparticles.



Dispersion of disk-like organic semiconductor nanoparticles
Laser light is scattered by the nanoparticles.

Room temperature metal bonding in atmospheric air

Expectations for reduction of apparatus cost and improvement of manufacturing efficiency

We have developed a new process for replicating a surface shape of an atomically smooth master substrate onto electroplated Au patterns by a lift-off process using a thin sacrificial layer. In this process, a Ti sacrificial layer and a thin Au seed layer were first deposited on the master substrate. Sealing ring patterns were then formed using a combination of photolithography and Au electroplating. These patterns were next bonded to a Au thin film on a Si wafer. Finally, by chemically dissolving the Ti sacrificial layer, the patterns were released from the master substrate and transferred to the Si wafer. The resulting patterns had an atomically smooth surface with a root-mean-square surface roughness of 0.8 nm. These smooth patterns were bonded to another Au-coated Si wafer at room temperature in atmospheric air. Tensile tests were carried out and a high bonding strength of about 250 MPa was confirmed, with fracture eventually occurring within the Si substrate.

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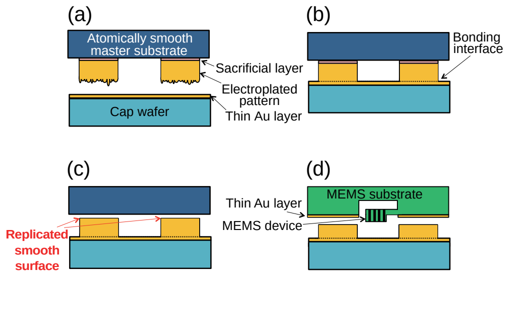
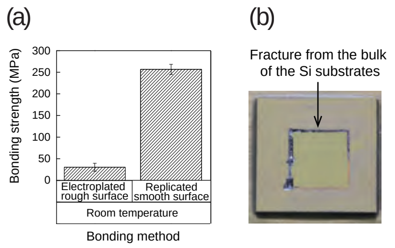


Developed bonding process



(a) Bonding strength
(b) Bonding interface of the sample bonded by using replicated smooth surface

Compact, lightweight pulsed X-ray source for non-destructive inspection

Obtaining X-ray images in narrow places such as parallel pipes in a chemical plant

We have developed a compact (width = 155 mm, height = 160 mm, depth (X-ray outgoing direction) = 70 mm), lightweight (2.5 kg), portable high-energy X-ray source using a coniferous carbon nano-structure (CCNS) electron source for non-destructive inspection. There are several advantages of CCNS for portable X-ray sources including no warm up time and low standby power consumption. Our pulsed X-ray source can operate using USB5V or AA-sized batteries as its power source, with a maximum tube voltage of about 150 kV, maximum tube current of 20 mA and an exposure time of 1 ~ 100 ms. The source can generate 10,000,000 X-ray pulses at an input power of 15 mWh/pulse. We can obtain X-ray images in narrow places such as pipes in a chemical plant. In the future, we will develop a higher-voltage (200 kV) X-ray source and an automatic inspection system using a robot for efficient non-destructive inspection.

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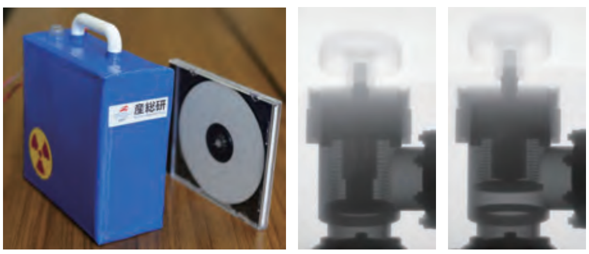
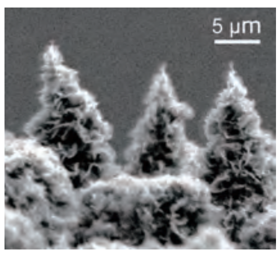


Picture (left figure) of the pulsed X-ray source compared with a CD case, and X-ray images (middle and right figures) of metallic valve at close and open positions



SEM image of CCNSs

Visit to Fraunhofer in Germany and Participation in the High Level Forum in France

Dr. Ryoji Chubachi, President, and Dr. Masahiro Seto, Vice-President of AIST visited Germany in September, 2014, where they called on Fraunhofer, state governments, universities, and private companies. Dr. Chubachi then traveled on to Grenoble, France, and with Mr. Kenichi Ichihara, Mayor of Tsukuba City, participated in the High Level Forum hosted by the French Alternative Energies and Atomic Energy Commission.

During their stay in Germany, Dr. Chubachi and Dr. Seto individually visited a total of 14 Fraunhofer research institutes that were seen as representative models for “bridging research.” These visits were made with a view to bolstering AIST’s functionality by strengthening its ability to conduct research which will lead to practical application through the facilitation of collaboration with private companies among others. Furthermore, Dr. Chubachi and Dr. Seto met with the authorities from state governments and private companies of Saxony and Bavaria to better understand the mechanism behind the innovation ecosystem with Fraunhofer at its center. At Fraunhofer, the delegation learned about the system which leaves the management of each Fraunhofer institute to the discretion of their respective directors, and the Fraunhofer model wherein 1/3 of the funding is provided each by the government, competitive funds from the EU, and private companies.

Dr. Chubachi also met and exchanged opinions with Prof. Dr.-ing. Reimund Neugebauer, President of Fraunhofer, on company marketing and research strategies needed to pursue the Fraunhofer model. Prof. Neugebauer commented that Germany in EU and Japan in Asia have many aspects in common in terms of politics, diplomacy, and in science and technology, and emphasized the importance and his desire for an even closer collaborative relations with Japan in the future.

In the third High Level Forum held in Grenoble, whose purpose was to bring together representatives from international centers for collaboration among government, industry and academia to exchange views on innovation promotion, there were participants from institutions representing 11 different countries and regions. Besides Dr. Chubachi and Mayor Ichihara, participants from Japan included Dr. Sukekatsu Ushioda, President of the National Institute for Materials Science, Dr. Michiharu Nakamura, Chairman of the Tsukuba Global Innovation Promotion Agency, Dr. Akira Yoshikawa, Vice-President of the University of Tsukuba, and Dr. Masaharu Nomura, Trustee of the High Energy Accelerator Research Organization. A panel discussion on new organizational strategies and the impact of transitions in information communication technologies was held during the forum, and examples of research activities at AIST were introduced by Dr. Chubachi in each session. Moreover, the regional and scientific presence of Tsukuba City was introduced by Mayor Ichihara to many participants from other countries. The 4th forum is due to be held at Tsukuba City.

Prof. Neugebauer of Fraunhofer (left) and Dr. Chubachi (right)

In front of Fraunhofer Institute for Applied Solid State Physics

Scene from the panel discussion of the High Level Forum

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