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Japan is a true powerhouse in the realm of robotics, and robots for both industrial and social uses are an integral feature of life and work here. This issue focuses on the amazing technological advances Japan has made in robotics, how people here interact with robots, what changes those interactions have brought to the country, and what they can bring to the rest of the world.

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NEON GENESIS EVANGELION / Director Hideaki Anno © KharaProject Eva

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COURTESY CALL ON PRIME MINISTER ABE BY MR. WILLIAM (BILL) HENRY GATES III, CO-CHAIR OF THE BILL & MELINDA GATES FOUNDATION

On December 16, Prime Minister Abe received a courtesy call from Mr. Bill Gates, co-chair of the Bill & Melinda Gates Foundation, before the opening of the International Conference on Universal Health Coverage in the New Development Era, held in Tokyo.

JAPAN–AUSTRALIA SUMMIT MEETING AND OTHER EVENTS

On December 18, Prime Minister Abe hosted a summit meeting and other events for the Hon. Malcolm Turnbull MP, Prime Minister of the Commonwealth of Australia, at the Akasaka Palace State Guest House and elsewhere. First, the two leaders held a meeting in a tearoom at the Urasenke Tokyo Branch. Next, at the Akasaka Palace State Guest House, the two leaders received a salute and attended a ceremony by the guard of honor and then held a summit meeting. Following this, the leaders made a joint statement to the press.

UNVEILING OF THE OFFICIAL LOGO FOR THE G7 JAPAN 2016 ISE-SHIMA SUMMIT AND AWARD CEREMONY

On December 28, Prime Minister Abe unveiled the official logo for the G7 Japan 2016 Ise-Shima Summit, and an award ceremony was held at the Prime Minister’s Office. The selected logo was designed by Ms. Shiho Utsumiya from Oita Prefecture’s Tsurusaki Kougyou High School. Prime Minister Abe explained, “I believe that the work is a well-balanced design, combining the Japanese flag, cherry blossom petals, and the blue sea in the background, and expresses Japan’s natural beauty in a simple manner.”

COURTESY CALL FROM REPRESENTATIVES OF THE SHIP FOR WORLD YOUTH LEADERS

On January 20, Prime Minister Abe received a courtesy call at the Prime Minister’s Office from representatives of the Ship for World Youth Leaders, which is part of the Next Generation Global Leaders Program FY2015. Prime Minister Abe offered his wishes that the experience would be a precious asset for all of their futures, and that they would utilize it to fulfill roles as youth leaders in their respective countries.
Through its leadership in both annual shipment volume of industrial-use robots and number of units in operation domestically, Japan has earned its position as a principal driver of the robotics age.

This month we explore Japan’s state-of-the-art androids and the technology behind utility robots, which are flourishing in diverse fields and helping to cope with societal issues such as the declining birthrate and aging population. We also introduce ongoing research into artificial intelligence as well as how Japan’s globally popular robot anime has influenced robot technology here.
Please tell us about the path the robotics marketplace has taken so far in Japan, and the current environment.

In Japan, starting from the establishment of the Japan Robot Association in 1972, a number of corporate researchers explored practical applications for robots during the seventies. And since 1980, which is regarded as year one of the robot era, industrial robots have proliferated in everyday society here.

The robotics industry went into decline when the economy took a downturn, but it is once again flourishing. The Honda Motor Company caused a stir in 1996 when it devised the bipedal humanoid robot P2. In recent years robots that are useful in our everyday lives have been proliferating—Softbank’s communication robot Pepper is a hugely popular example—and anticipation about the development of robots in the field of livelihood support is growing.

Please talk about the industries that are working to incorporate robot technology and related trends.

As we can see from the advances made in existing robot technologies—such as the cleaning robot Roomba and medical robot da Vinci—we’re likely to see robots employed in a wide variety of familiar service fields, like the fully automatic driverless Google car and freight distribution drones such as Amazon’s Prime Air. In addition, communication robots that can draw emotionally close to people—like PARO, Pepper and JIBO—are anticipated to develop more therapeutic features, which are in huge demand in today’s society.

In Japan, where industrial robots are advancing at a rapid pace, cooperation between humans and robots has deepened. The incorporation of industrial robots will make huge inroads in the food, cosmetics and pharmaceutical industries. We can expect the arrival of robots equipped with artificial intelligence that can make decisions autonomously. With frameworks being established for certifying human safety, wearable

ADVANCES in robotics and artificial intelligence have created great expectations for their potential to make people’s lives more comfortable and convenient. We spoke to Dr. Kazuhito Yokoi, the director of the Intelligent Systems Research Institute—part of the National Institute of Advanced Industrial Science and Technology (AIST), in Tsukuba, Japan—about the path robotics has traversed in Japan and prospects for the future.
robot technology that increases contact between humans and robots—such as wearable robotic suits for caregiving support or autonomously running wheelchairs—is receiving wider support.

**How far has the development of next-generation robots progressed?**

After the disaster at the Fukushima Daiichi nuclear power plant in 2011, research into robots for fieldwork has progressed. AIST and Honda have joined hands to apply ASIMO’s technology toward the development of the High-Access Survey Robot, which has already been sent into Fukushima Daiichi. At AIST, a project with the New Energy and Industrial Technology Development Organization (NEDO) is working to develop disaster response humanoid robots that can function autonomously in unknown environments outside of prelearned movement patterns, and field robots that can provide infrastructure maintenance and update work through preventive measures and inspection duties. However, the practical applications for disaster response humanoid robots no doubt lie a bit farther into the future.

**What do you foresee happening in Japan’s robotics industry?**

While Japan is known as a “robot superpower,” the country faces many issues: a declining birthrate, an aging and deteriorating population, and a shrinking generation of workers destined to bear the weight of Japan’s primary industries. Because we are an advanced nation with such pressing issues, robots are viewed with great hope. The arrival of the age of the Internet of Things, where the “things” that comprise our everyday life from industrial machines to consumer goods are all connected by the Internet, is expected to be driven by big data and networks, and the shift toward robots possessing artificial intelligence is imminent. We hope that solving Japan’s societal problems and strengthening its international competitiveness will give rise to a society where robots generate added value, and make Japan the world’s number one culture in the integration of robots in society.

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**Robots—A Chronological Table**

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1954</td>
<td>American inventor George C. Devol, Jr. acquires a patent for Programmed Article Transfer, which becomes the basis for Unimate, the world’s first industrial robot.</td>
</tr>
<tr>
<td>1968</td>
<td>The introduction of new technology spurs the domestic production of robots in Japan.</td>
</tr>
<tr>
<td>1972</td>
<td>The Japan Industrial Robot Association is established.</td>
</tr>
<tr>
<td>1974</td>
<td>The International Symposium on Robotics is held for the first time in Japan.</td>
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<tr>
<td>1980</td>
<td>The year full-scale proliferation of robots begins in Japan; now known as “Robot Year One.”</td>
</tr>
<tr>
<td>1996</td>
<td>Honda announces the development of the P2, its bipedal humanoid robot.</td>
</tr>
<tr>
<td>1999</td>
<td>The U.S. firm Intuitive Surgical Inc. announces the release of its robotic da Vinci Surgical System.</td>
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<tr>
<td>2002</td>
<td>The U.S. firm iRobot Corporation announces the release of the Roomba, its autonomous robotic vacuum cleaner.</td>
</tr>
<tr>
<td>2014</td>
<td>Softbank Group Corp. announces the release of Pepper, its emotion-sensing humanoid robot.</td>
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</tbody>
</table>

Source: Japan Robot Association
THESE ARE THE DROIDS YOU’RE LOOKING FOR

Glory Ltd.’s futuristic production line employs next-generation NEXTAGE humanoid robots that work in companionable conjunction with human employees to build complex currency-sorting machines.

WE have visitors from around the world coming to see the production line. We once had a team from a French corporation here, and they kept saying, ‘This is crazy!’” recalls Akio Tobita, general manager of Production Engineering Dept. 2 at Glory Ltd.’s Saitama plant, with a smile. For technicians and engineers, being called crazy is the ultimate compliment, suggesting that their skills and ideas have made the unthinkable a reality.

The Saitama site features several NEXTAGE humanoid robots created by Kawada Robotics Corporation. Human technicians surround the robots and work in tandem with them on a production line covering nearly 225 square meters, assembling the coin- and bill-sorting mechanisms in cash registers. Prime Minister Shinzo Abe visited the plant in 2014 to observe its humanoid robots.

Glory began “robotizing” its plants twenty-four years ago. As
Japanese firms sought to slash costs and moved their plants overseas, causing a hollowing-out of industry, Glory chose a different route to maintain both costs and product quality.

“Starting with the introduction of robots with multiple articulated joints, we began to develop internal expertise in producing automated production lines,” says Tobita proudly. They discovered Kawada’s NEXTAGE robot at the International Robot Exhibition in 2009, he notes, and realized “it was a perfect match for our own goals of automation.”

The company brought in one unit for a pilot project in 2011, and after numerous trial-and-error efforts with processes such as producing small components and making peripheral in-house equipment, succeeded in its implementation. Today there are around three hundred employees at the Saitama plant engaged in manufacturing, with nineteen robots assisting them. The NEXTAGE model was specifically designed to enable safe and symbiotic work between humans and robots. It only outputs 80 watts and can hold no more than about 1.5 kilograms per hand, yet NEXTAGE excels at determining positional data and assembling precision components.

“The robots can perform fine work like grasping, peeling and inserting,” Tobita says, “but humans perform the more abstract and flexible work. In this way, robots and humans work together performing in their more skilled area. Robots are slightly slower than humans in movement, but they make up for this with their ability to work without stopping from morning to midnight.”

The robots sometimes require minute adjustments and must be shut down briefly, which is when humans step in and reboot them. By pursuing stable quality as well as high-level uptime and ROI, Glory has arrived at a combination that makes the most of the logical functionality of robots and the flexibility of humans, creating a synergetic production line.

Glory’s signature product is a machine for sorting foreign currency used by financial institutions, so they humorously decided to use world currencies such as “euro” and “dollar” on the robots’ nametags. The robots can perform different tasks independently with each hand, and their surprisingly lifelike actions are endearing. “We were a bit shocked at first, but they grew on us,” staff onsite have commented. “Work is faster and easier now. They’re cute, too—when they build something they don’t feel sure about, they place it off to the side on the table, showing you they need help. They wait and watch the other robots to learn from them. It’s quite charming.”

Tobita notes that Japan’s working population is shrinking, so robots are a must. “Still, improving their design, operating them, and handling more abstract tasks remain the domain of humans,” he says. “Even as robots evolve, there are still many tasks that only humans can perform. As we move ahead, we want to use not only NEXTAGE but a range of robots to further automate the line to enhance our productivity.”
A new, fully automated squid-fishing device uses computer control technology designed for industrial robots to faithfully replicate the maneuvers employed by expert fishermen. Customizable for ease of use and requiring less power to operate, the device is finding fans both in Japan and overseas.

“For environmental reasons, fishing for squid with nets is prohibited,” Hagiwara says. “Before the development of automatic control systems, they used to attach large reels to a handle and then manually reel the catch in, which required a huge amount of work. Someone had to man each reel, too, so the personnel costs were staggering. Since we deliver motor-based products to numerous firms, we had ongoing relationships with the fishing industry at the Port of Shimizu. We learned about the travails of fishing, the increasing age of the fishermen, and the lack of new candidates to fill their shoes. They also wanted to automate the process with minimal power consumption. We figured that we could solve all of these issues in one fell swoop with fully automated fishing devices.”

The decks of fishing boats are arrayed with squid-fishing machines equipped with reel drums. These are linked to wires leading into the water that have twenty needle-shaped lures. Traditionally, fishermen would tug on the wire to shake the lures in the water and simulate the movements of creatures such as small fish and shrimp. Attracted by a light shined from the boat, the squid would congregate nearby and then catch sight of the moving lures, seeing them as real prey.
To simulate this jerking motion, conventional automated systems used rhombus-shaped reel drums to create irregular motion in the wires. However, just repeating the jerking motion didn’t actually entice the squid into going for the lures. The system was also inefficient, as it took a great deal of time to unwind the wires, and it was easy for equipment such as the wires or lures to become damaged. A round reel drum was introduced to achieve more stable unwinding and retrieval of the wire, as well as greater durability by reducing stress on the equipment.

In addition, the SX achieves the same maneuverability factory robots have when they determine the position of a component and stop at an irregular interval. This movement is used to jiggle the squid lure in a believable fashion just as the fishermen do, while also eliminating the inefficiencies earlier equipment presented.

“Each fisherman has a different method of manipulating the lure,” Hagiwara says. “Faithfully replicating those variations required us to board the ships and program the fishermen’s movements. While incorporating an advanced computer control system into a fishing device for squid and loading it aboard a ship might add a layer of complexity, the control panel can be customized to each fisherman’s specifications, so there have been no issues. In fact, we have fishermen between seventy and eighty years old—a demographic considered less than adept at operating computerized devices—using the SX with ease,” he adds with a smile.

“The domestic market for squid fishing was small to begin with, and now it is shrinking even more, along with the fisheries industry as a whole,” Shiokawa explains. “While imports of flash-frozen squid are on the rise, I don’t think the Japanese palate for fresh, raw squid is going to go away anytime soon, although that market has neared its peak. However, it’s a definite plus that orders from China, Korea, Taiwan and elsewhere are increasing, and we are proud to see that our technology is being recognized globally.” The company also hopes that, since demand for tuna in China and throughout Asia is also trending upward, securing squid—which serve as bait for tuna—should remain a key driver of demand for its machinery.

Achieving both an unflagging commitment to technical innovation and user-friendly considerations in one package is Sanmei’s strength, with its computer control technologies in wide use in various industries a testament to that ingenuity.
DENSO Corporation partnered with two universities and medical professionals to devise a revolutionary motorless surgical support robot called the iArmS that reduces the tremors from arm strain and fatigue surgeons experience as they perform procedures.

The motorless iArmS curtails hand tremors by 70 percent—a lifesaving improvement for patients undergoing microsurgery.

TAMI KAWASAKI

THE iArmS is a surgical support robot that reduces the fatigue and slight arm tremors of surgeons while they are performing operations. In addition, the robot helps surgeons assume unusual stances during procedures, especially for fine work like microsurgery, which involves suturing blood vessels and other tissue structures smaller than one millimeter in size while looking though a microscope.

DENSO Corporation—which developed the device in cooperation with Shinshu University and Tokyo Women's Medical University—is a major producer of automotive components and a leader in the Japanese manufacturing industry, boasting connections to overseas automakers and pursuing the development and manufacture of small industrial robots as well.

“We began this project with the goal of using DENSO’s strengths as a reputable provider of technology to develop a service robot and promptly bring it to market as a finished product,” says Toshihiko Koyama, head of the company’s healthcare business, who notes that surgical robots had begun to appear in the United States and were making quick inroads. “Robots were garnering praise in the medical sector, and we could see a new market taking shape. We felt this was a chance to use our existing expertise, so we set about developing this new device.”

Even so, these engineering experts were rank beginners when it came to the world of medicine. “We were told it was too late to enter that market, and since we lacked any connections we decided to contact famous doctors directly via e-mail. Despite the fact that this approach was
Surgeons place their arms on the device’s mobile platform, which moves smoothly as they do.

Although there were already robots being developed through partnerships between medicine and engineering, those projects were all long term, and none had come to fruition yet,” says Koyama. “We treated creating a practical robot as our absolute mission, and sought the most flexible and optimal solution to this engineering challenge in the context of the pressing needs of medicine. I think that really resonated with surgeons.”

DENSO representatives then met with Jun Okamoto of Tokyo Women’s Medical University, who had the concept for a motorless medical robot designed to reduce the fatigue and hand tremors surgeons experienced. As soon as they saw the demo unit, Koyama says, they knew “this was the way we could leverage our technology.” A system using motors requires significant development time to achieve safety guarantees, as well as time and effort to pass reliability verification tests. Opting for a fully motorless design that utilizes a system of weighted balance and friction alone to follow a surgeon’s movements exactly, they created a robot that curtailed hand tremors by 70 percent. Surgeons place their arms on platforms, and experience no resistance or heaviness; their arms move freely. Upon trying the iArmS for the first time, doctors could not believe the device had no motor. Their arms felt strangely weightless, they reported, and did not tire.

The robot emerged in an astonishingly short span of three years after further refinements were made in maneuverability, safety and practical use in a clinical context. The appearance of the motorless passive robot shocked the industry, but as Koyama adds with a grin, “It surprised us, too.”

With the collaboration of over one hundred stakeholders, the device later incorporated further improvements based on feedback from the operating room.

“When one of the surgeons we tested it with turned around to look at us during an operation, I tensed up, thinking he’d found a defect,” Koyama recalls. “But he just said, ‘I like it!’ For an engineer, that’s a thrilling moment—the pinnacle of your efforts.”

Since April 2015 when DENSO began taking orders for iArmS, the device has garnered praise in clinical contexts such as neurosurgery and endoscopic procedures in otolaryngology, with orders even coming in from abroad. Koyama is enthusiastic about the overseas market. “There’s a strong latent demand in the surgical world for this kind of product,” he states. “Surgeons feel they would be able to achieve even more precise results if they can limit hand tremors. We hope to find overseas sales partners and bring the product to a wider user base so that it can serve the real-world needs of surgeons everywhere.”

Toshihiko Koyama heads DENSO Corporation’s healthcare business.

highly unorthodox in the realm of traditional Japanese business practices, doctors responded favorably,” Koyama reflects.

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The Henn-na Hotel has garnered global interest because robots handle many of its services. The hotel’s management concept is also designed to trim labor costs and conserve energy, with an eye toward Japan’s future.

The Henn-na Hotel (literally, “Weird Hotel”), which opened last July, is located within the Huis Ten Bosch theme park in Nagasaki Prefecture’s Sasebo City, a destination that welcomes large numbers of guests from both Japan and abroad.

The first thing you’ll see when you arrive at the hotel’s entrance is the cloak robot. Normally programmed for tasks such as loading boxes in a warehouse, this industrial-use robot stores the luggage of hotel guests inside forty-nine cloak boxes. Inside at the front desk are three robot receptionists—one tiny bot, a dinosaur and a female humanoid—that handle check-in procedures. The female humanoid robot will look into guests’ eyes, smile, and at times even wink. The dinosaur robot is very popular with both children and adults of all ages, regardless of nationality.

“The female reception robot is so real that some children are afraid of her,” reports Takeyoshi Oe, the hotel’s general manager. “Because she’s a humanoid, she has been built to re-create the smooth movements of a person without mechanical noise. Her natural-looking facial movements, such as smiling, are generated through the compression and expansion of air in her facial structure. We’re scheduled to get another robot in March of this year, and we plan to increase language compatibility from the current two languages of Japanese and English to four by adding Chinese and Korean.”

In the lobby, a concierge robot offers information about the hotel and Huis Ten Bosch, and a porter robot is on hand to guide patrons to their room. The highly mobile porter robot has a motion sensor to detect people, allowing it to avoid colliding with guests or accidentally abandoning those following it. Outside, a grass-cutting robot maintains...
the hotel lawns, returning automatically to a recharging station whenever it finds itself low on power.

All guest rooms feature a robot—nicknamed Tuly—so that guests exhausted after spending the day at Huis Ten Bosch can accomplish tasks such as adjusting the room lighting or arranging wakeup calls through voice commands without ever leaving their beds.

“We’ve improved the precision of this robot so that it responds to any voice, regardless of sex or age,” Oe notes. “Some rooms even feature Tulys that ask riddles. They’re very popular, since they help guests staying alone avoid feeling lonely.”

The hotel offers a wonderfully offbeat new kind of guest experience, and as the world’s first low-cost hotel, subverts existing concepts of how such establishments operate. “Huis Ten Bosch is teeming with five-star hotels, but it takes significant labor and energy to maintain services deserving of a star rating,” Oe states. “That’s how the idea for the Henn-na Hotel came about—to create an energy-efficient smart hotel unlike anything you’ve seen before. By incorporating robots and using radiant panels as an air-conditioning system, we were able to drastically cut labor and energy costs. We’ve also reduced guest room amenities to a minimum by offering them for purchase in a vending machine in the lobby, and with the exception of our deluxe rooms, instead of installing televisions, we’ve provided tablets for guests to enjoy movies and other forms of entertainment. A 72-room hotel would normally require a staff of about 22, but we have less than half that number, with 10 staff members always onsite.”

While the incorporation of robots has merits such as standardizing the quality of service and lowering labor costs—not to mention the entertainment aspect—there are still concerns that need to be addressed, such as emergency support. The Henn-na Hotel has solved this particular issue by ensuring that guests can speak with a human staff member through their in-room tablet, and a human monitor observes much of the hotel’s public facilities via security camera twenty-four hours a day. Considerable research has gone into determining which services only humans should perform and which ones robots can provide, creating a neat division of labor between the two.

“I believe we’ll see a polarization in styles between the five-star hotel services and those like the Henn-na Hotel,” Oe says. With a goal of opening another hotel in Tokyo by the time the 2020 Tokyo Olympic and Paralympic take place, the Henn-na Hotel provides an enjoyable experience for its guests, who receive the best in omotenashi (Japanese hospitality) from both robots and human staff.

**GUEST ROOMS (As of January 2016)**

**Standard Type**

- Size: 21.32 m²
- Price: ¥39,960 (roughly $340) per room for two guests in a room, including tax and service fees. Cleaning, bedmaking and other services are available for an extra charge.
Experts believe that fully automated robot taxis will help solve Japan’s social needs and represent a step toward maintaining a more convenient and intuitive environment for foreign residents as the country globalizes.

RIEKO SUZUKI

In increasingly depopulated rural areas throughout Japan, local bus and train services are shrinking in scale or being scrapped altogether, and the elderly are running out of transit solutions. In addition, there is a growing shortage of drivers for nursing service vehicles, and accidents are on the rise. For these reasons, unmanned vehicles known as robot taxis are drawing attention because of their potential to solve these and other dilemmas. Robot Taxi spokesperson Tomonari Kuroda outlined the situation.

DeNA Co., Ltd. and ZMP Inc.—a leading startup in the automated driving space—entered into a joint venture to create Robot Taxi, Inc. in May 2015. “The response both within and outside of Japan has been great, and we really feel its potential,” Kuroda reports confidently. “We’ve paired the advanced automated driving technology ZMP developed with our own expertise in Internet services, and we believe we can bring new innovation to the transit infrastructure.”

Unmanned vehicles use what is known as “deep learning” to assess their surroundings and movement. The vehicle must be able to make accurate determinations about its constantly changing environs to select appropriate maneuvers. Using camera footage, objects are “learned in” to the machine through a layered neural network, allowing it to detect and interpret the positions of vehicles and pedestrians in real time. Multiple sensors scan the surroundings and synchronize with GPS-based coordinates to precisely evaluate complex environments and ensure safe driving.

Local trains are increasingly being phased out in sparsely populated areas and the elderly in particular find themselves in crisis, left without alternate means of getting around. Robot taxis could potentially be the key to revitalizing Japan’s local regions by aiding the elderly as well as meeting transportation needs.

“It’s said that bus and taxi companies typically
spend 50 to 70 percent of costs on personnel,” Kuroda states. “This means they can’t turn a profit even if they shrink their operations. Some find themselves expending costs on cabs that are simply shuttered in storage. Robot taxis will dramatically lower personnel costs and enable the unmanned operation of inactive cars.

“Another pressing issue is the lack of drivers for nursing care vehicles, as well as a growing number of accidents,” Kuroda continues. “Robot taxis may prove to be an economical solution to Japan’s super-aging society.”

Kuroda is also convinced that even when robot taxis become a reality, they will not rob taxi drivers of jobs. “There will be a bifurcation of services—simple transit at low cost with robot taxis, and the more flexible and value-added services human drivers provide, such as conversation, assistance with luggage and other perks,” he predicts. “Compartmentalizing the services in this way will give consumers more choices.”

Trials to test the roadworthiness of these vehicles have just begun. The company’s goal is to have robot taxis cruising the streets in time for the 2020 Tokyo Olympic and Paralympic. This will require maximizing the technology’s benefits while doing away with any problems, using an iterative experimental process to ensure that the numerous untold circumstances that may occur on the road are accounted for.

“Our goal for the Tokyo Olympic and Paralympic is to have robot taxis in the city that support the languages of all participating countries,” Kuroda says. “If robot taxis allow foreign guests who can speak neither English nor Japanese to travel using their own language, don’t you suppose it will make them happy?”

All eyes will no doubt be trained on robot taxis as an alleviator of the burdens of an aging society and a key agent of international support in a global city.

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1 People with limited transportation options—especially in rural areas—will benefit from robocabs
2 The doors of the unmanned taxis close and open automatically
3 The robocabs use multiple sensors to monitor their surroundings and ensure safe travel
4 Robot Taxi spokesperson Kuroda says the goal is to have robocabs roadworthy in time for the 2020 Tokyo Olympic and Paralympic
“Can a robot get into the University of Tokyo?” That’s the question the team led by National Institute of Informatics seeks to answer with their similarly-titled project as they prepare the artificial intelligence robot To-Robo-kun to tackle the entrance exam at Tokyo University, designed to be the most difficult entrance exam in Japan. We spoke with project director Noriko Arai about the significance and goals of the project.

The real aim of this project is to use To-Robo-kun to demonstrate in an accurate fashion to society just what artificial intelligence can and cannot do, and suggest to what extent an AI can take on white-collar work,” Arai states. “We focused on university entrance exams because we feel they are representative of the intellectual labor that Japanese white-collar workers engage in. The actual quantity of data used in the entrance exams is quite small, but compared to big data—with its vast, unsorted quantities of information online—it is exceptionally ‘clean.’ In other words, it has very precise parameters. By exploring how well an AI can learn the test content, we may be able to differentiate ourselves from AI research in other countries, such as in the U.S., which focuses on big data.”

What benefits will the average person see from this experiment’s progress? One potential answer is found in To-Robo-kun’s strongest subject, world history.

“On the latest mock test, the robot scored a 76, 30 points over the average score,” Arai relates. “One of the key reasons is that we fed the AI several thousand examples related to the commonsense knowledge that the test presumes humans know, such as that humans cannot facilitate events after death, that religion is propagated not by objects but
“In this way, the theoretical research that NII and the universities have developed can be rolled with untold speed into the manufacturing practices that our corporate partners excel at, letting us quickly implement AI theory,” Arai continues. “This lets us rapidly forecast in concrete terms how and where AI will be used in society, and practically test the return on investment. In a broader context, this can stimulate the growth of Japanese industry and extend GDP.”

What obstacles does To-Robo-kun have to overcome to contribute to the growth of Japanese robotics? “Without a doubt, it comes down to physics,” Arai says. “For example, we might have vehicles with automatic driving functionality trying to avoid suddenly falling rocks, or an emergency response robot working to pull out people trapped under rubble. In these situations, the size, quantity, location and weight of the rubble differs, so statistical determinations based on past cases cannot be used to make judgments. This requires the AI to have an understanding based on actual physical laws. Assessing to what extent To-Robo-kun can clear the questions about physics on the university entrance exam is a valuable first step in that direction.”

The current exams administered by the National Center for University Entrance Examinations will be scrapped in 2019. In 2020, the current system of a knowledge-based fill-in-the-blanks format will change to one emphasizing free response and thinking.

“I believe the emergence of To-Robo-kun influenced this change in educational policy,” Arai notes. “By 2020, our research will be farther along, and the strengths and weaknesses of AI will become much clearer. We believe this feedback will allow the educational sector to determine in which domains human test-takers can demonstrate their abilities best. If they are willing to explore that further, it will present positive returns for our research as well.”
Japan has envisioned numerous robots over the last half century, primarily through its colorful manga and anime culture, and the history of Japanese robot anime is one reason for Japan's global reputation for being “robot country.” Anime and film critic Ryusuke Hikawa explains.

TRANSFORMERS, the action film series featuring humanoid robots, have become global hits, but they trace their roots to the Japanese genre of robot anime,” says Ryusuke Hikawa, an anime and live action film critic who is also a visiting professor at Meiji University’s Graduate School of Global Japanese Studies. A researcher of Japanese animation technology and culture, Hikawa delves into this subgenre and what he says is its central role in Japanese culture and a reflection of Japanese sensibilities.

Robot anime emerged in Japan over half a century ago in 1963, when Osamu Tezuka’s Tetsuwan Atomu (Astro Boy) appeared as the first anime program on television. Mitsuteru Yokoyama’s Tetsujin 28-go debuted the same year. These two shows marked the beginning of Japanese TV animation, which now boasts over two hundred titles broadcast each year.

While Astro Boy is a life-sized autonomous robot with free will like humans, Tetsujin is a massive remote-controlled automaton. Interestingly enough, these two styles typify the two main kinds of robots found in Japanese industry today.

Robot anime took off following the late 1972 broadcast of Mazinger Z, based on a graphic novel created by Go Nagai with the intention of making it into an animated TV show. In this series, a vehicle merges with the robot’s head, and a human rider directly controls the robot, resulting in a new style of human-powered “mecha.” This can also be considered an advanced version of the “transformation” seen in live-action programs like Ultraman and Kamen Rider, and it entranced children.

Partway through Mazinger Z’s run, zinc alloy toys of the character went on sale under the “Super-Alloy” brand, riffing on elements from the show. The toys were a smash hit. These metallic figures had a cold feel and notable heft, as well as a spring-loaded contraption and mechanical switches that controlled the signature “rocket punch” maneuver used to take down villains in the TV show. Refined industrial technology succeeded in making the fantasy of the anime world a reality.

In 1979, a new, epoch-making program was born: Mobile Suit Gundam. Developed by director Yoshiyuki
Tomino and his team, the Gundam series had a unique worldview. Its story targeted audiences of middle and high schoolers or older, and for that reason toy merchandise sales struggled during its initial run. However, the 1980 release of the build-it-yourself Gundam plastic model, or *gunpla* for short, proved to be its turning point, and sales continue to hold strong to this day.

The success of the Gundam series led to the production of countless original animation series, which in turn inspired a new generation. In 1995, a new robot anime aimed to succeed based on the merits of its story alone, becoming a social phenomenon: Hideaki Anno’s *Neon Genesis Evangelion*. The show emulated *Mazinger Z* with a narrative structure in which humankind’s science and technology were used to intercept mysterious monsters, yet it adopted biotechnologies and hybrid components that allowed an external suit of armor to be connected to the internal operator’s nerves and spiritual energy.

The evolution of children’s robot anime remains strong. *Little Battlers eXperience*, first aired in 2012, employs the concept of small-scale robots guided with a mobile telephone-style controller. This approach resonates with youth in today’s mobile era, and the show became a hit.

“Japanese people have a good track record of ‘hybrid thinking’—combining conventional ideas with new concepts—and evolution through modification and refinement,” Hikawa says. “And throughout history, these processes have brought new breakthroughs. The way robot anime imbue precision machinery with the presence of massive gods is like a mythological retelling of Japan’s early modern industrialization. There is a near-inevitability to the way robot anime came about in Japan, of all places. This is a media and art product we have much to be proud about.” In these ways the history of Japanese robot anime is closely related to the growth and development of robotics, and the two have evolved together.
MICROSURGERY involves operations on narrow blood vessels, nerves, lymph ducts and other delicate tissues. Suturing narrow blood vessels around 500 micrometers wide requires a needle just 100 micrometers in diameter or smaller. But with conventional needles, surgery on tissue elements smaller than five hundred micrometers used to be impossible.

To answer the demands of medical professionals for thinner needles, a Japanese manufacturer rose to the challenge to create the world’s smallest needle—just 30 micrometers in diameter and 800 micrometers long. This was Kono Seisakusho, a manufacturer of needles for timepieces and other implements. The company holds a 60 percent share of the microsurgery needle market in Japan, and almost all surgeries involving tissue structures under seventy micrometers are performed with its products.

These ultrathin needles made previously impossible operations feasible. In suturing the severed fingertips of babies, for example, it allowed the fragile blood vessels and nerves to be sewn together, restoring the finger’s functionality with the most minimal of incisions. Surgery for moyamoya disease, a cerebrovascular condition that involves blocked arteries, also became possible.

A thirty-micrometer needle, of course, is so thin as to be more a steel thread than a needle. This required engineering a way of giving the tool enough strength to both pierce living tissue and suture it. Moreover, an actual suturing thread must pass through the needle, and the needle’s tip must be pointed. Kono Seisakusho selected a stainless steel that could withstand precision machining and engineered a process in which the jigs, grinders and other machinery involved are operated entirely by hand. The bottom of the needle
is actually split in half, creating a channel for the thread to pass through.

Kono Seisakusho’s pride in craftsmanship is evident in the way it relies on more than the handiwork of veteran machinists. “Many of the processes involved in machining superfine surgical needles are done by hand, but we wanted to devise a uniform process so that anyone could achieve a consistent result,” says Junichi Kono, the company’s president and CEO. “We consider the creation of such machinery part of the craftsmanship process.”

Mass production offers one way of keeping costs down, but the company also maintains a separate production line for fully customized products so that it is possible to manufacture a specialized product even if there is only a single patient in need.

Kono Seisakusho also draws on specialized technology that Japan’s small to medium enterprises (SMEs) boast, as well as research results generated by university engineering departments. The company has developed a deep understanding of the needs of the medical field, and combines that knowledge with Japanese technology to create products of real use to medical professionals.

In 2011, Kono Seisakusho obtained a license for the sale of medical devices in China, and is making significant inroads in that market. The company is also exploring new markets in Southeast Asia and Europe. “This is about more than just making and selling Japanese products overseas,” Kono notes. “We want to utilize Japanese technology to create products that these respective medical sectors need.”

As regenerative medicine and transplants gain ground, microsurgery is moving into the realms of gynecology, ophthalmology, otorhinolaryngology and other areas beyond traditional surgery, with ultrathin needles drawing ever more attention. Beyond mere market growth, however, Kono is enthusiastic about using craftsmanship to contribute to real medical needs. “We want to make items that have never been available,” he says. “Our biggest driver is helping patients and doctors.”
THOMAS BERTRAND

Packed with Style

Thomas Bertrand’s firm Bento&co markets Japan’s signature bento boxes and related products in about ninety countries. He’s helped fuel consumer fascination with these containers, particularly in France, to the extent that French dictionaries now include the word “bento.”

TOMOKO NISHIKAWA

Thomas Bertrand, a native of France, first came to Japan in August 2003, entering the country as an exchange student at Kyoto University.

“Japanese anime was very popular during the 1980s in France, especially shows like Dragon Ball and Captain Tsubasa,” he says. “And home video game systems like the Famicom (Nintendo Entertainment System) were also trending, so of course my generation grew up very familiar with those things. Naturally I had a great interest in Japan, and I came here so that I could study the country’s history, culture and economy.”

Bertrand started a blog in 2005, mainly about Japanese culture and his life in Kyoto. As the blog became popular, he developed connections with a great many people, including French journalists and other French nationals living in the Kansai region, which spurred him to consider starting a business. Although he began with the idea of introducing things unique to Japan to the rest of the world, he couldn’t decide on what he wanted to share.

In 2008, however, he heard from his mother in France that Japanese bento boxes were being featured in a French magazine. Bertrand was instantly convinced that this was it. He discovered that while plenty of websites were introducing bentos, few were selling bento boxes. The next day he ordered catalogues from manufacturers, and soon after acquired an inventory of ten different types of bento box at a cost of about 50,000 yen. He got friends he had met through the blog to help him with the website’s construction.
and design, and launched his site Bento&co about two weeks later.

France is a country with a rich and bountiful food culture. Many people attend cooking classes there taught by three-star chefs, and the Japanese bento box aligned perfectly with the esthetic souls of the French people, who love to enjoy beautiful and delicious meals. Furthermore, with the effects of the 2008 financial crisis still fresh, many people were bringing their lunches instead of dining out at expensive restaurants. Bento&co has enjoyed better-than-expected results ever since.

Thanks to being mentioned in an English-language blog, Bento&co also began receiving orders from North America and the UK, and in 2010 Bertrand launched an English-language version of his website. The company now receives orders from ninety nations; although most of them are from North America, Europe and Asia, orders come in from countries like Israel and Togo as well. In addition to ongoing wholesale distribution to overseas department stores and restaurants, Bento&co opened a bricks-and-mortar specialty store in Kyoto in 2012.

The current product lineup features over a thousand varieties and fifteen original products. Bertrand’s standard for selecting products is simple: “Whether or not I like it,” he says. In many cases, he adds, he has succeeded in presenting manufacturers’ bento boxes in ways that “revive” them as hit products.

His clients include manufacturers who now enjoy overseas sales ratios in excess of 10 percent, which has helped Bertrand gain deeper levels of trust in his business relationships. He has even begun to accompany manufacturers’ representatives to trade fairs such as “Maison & Objet” in Paris—the largest of its kind in Europe—as well as major gift fairs in Sydney, Australia.

“Anytime something new is born, it is always because of connections to people,” Bertrand observes. “Our bestseller is the Hakoya double stack bento box, and that came about from a casual conversation I had with a manufacturer after looking at a kokeshi doll. I said, wouldn’t it be fun if we could have a bento box like this?”

Bertrand has been developing paper-based bento boxes for use in catering and at hotels and restaurants. He’s also expanded his product lineup to include stationery, food items and cookware. In February and November of 2016, he plans to widen his scope of activity, opening a pop-up shop in Paris, among other endeavors.

Bento&co’s theme is “to bring Japan closer,” according to Bertrand. “Starting with bento boxes, I want to deliver the wonderful things that Japan can offer to people all over the world,” he states, “and I want to make them as easy as possible to order from anywhere, anytime, and deliver them smoothly to our customers.”
Imagine seeing an array of vividly colored shooting stars streaking across the night sky—a manmade meteor shower created here on Earth and delivered via satellite to enthrall audiences on the planet’s surface. This is the brainchild of Lena Okajima, who holds a doctorate in astronomy from the University of Tokyo. She and her team at ALE Co., Ltd. are working to realize Okajima’s dream of launching artificial shooting stars in the stratosphere, and someday even beyond that.

“Seeing a shooting star is an amazing experience,” Okajima says. “A person is lucky to see two shooting stars coming in sight at the same time. I’ve always dreamed of seeing them coming down like a rain shower.” In 2011, she gathered people with a similar vision together to form ALE.

Interested in science from a young age, Okajima become captivated by outer space during junior high school when she learned about black holes, the creation of the universe and the Big Bang theory. While dedicating herself to studying astronomy at the University of Tokyo, Okajima discovered that Japan was investing large amounts of public funds in scientific research and equipment dedicated to outer space.

Okajima, however, had another aspect of space exploration in mind. Her approach focuses on connecting everyday people with astronomy and the sciences, using the manufacture of artificial shooting stars as the basis of a commercial enterprise. “People often think astronomy is not a useful science, but I think it can be used to encourage people to find enjoyment in outer space while also supporting scientific research,” Okajima notes.

ALE has completed roughly half of the necessary research into making its shooting stars. Working with professors and researchers from various universities, the team has already created shooting-star-source spheres, and has now started developing a cube-shaped satellite roughly fifty centimeters in diameter that holds about a thousand of these small spheres. The spheres...
Performing maintenance on equipment that replicates the release of artificial shooting stars

A prototype of the device to be mounted on an artificial satellite, installed in a test apparatus

Scientists and artists involved in Project Sky Canvas are considering how Okajima’s artificial meteorites can be used

Natural shooting stars only appear for a second; Okajima’s will be visible for three times that long

will be ejected from a satellite, burning brightly as they enter the earth’s atmosphere. The composition of each sphere can be altered to produce a range of different hues, and there is no virtually no environmental impact, since the spheres burn up completely in the process.

“Naturally occurring shooting stars can only be seen for under a second,” Okajima adds, “but ours can be seen for about two to three seconds. They can also be viewed from a range of two hundred kilometers.” That’s about four hundred times the area in which conventional fireworks are visible.

Now that the research behind making these artificial meteors is moving toward its final stage, Okajima is focusing on the aesthetic aspect behind the spectacle. She’s working with various artists to plan a time and place for people to wish upon her shooting stars. Under the project name Sky Canvas, scientists and artists have come together to share their ideas.

“In many projects, having too many people with too many different ideas can be a problem,” Okajima says. “With Sky Canvas, though, more is better. The ideas may be diverse, but everyone is working toward the same goal.” The proposals so far include local promotions like Light Up Nippon, which supports the Tohoku region, as well as larger international events such as the torch-lighting ceremony of the 2020 Tokyo Olympics. And with the night sky as the canvas, there are undoubtedly many opportunities waiting outside of Japan. “We have always thought of the world as our customer,” Okajima says.

If things go according to schedule, ALE’s manmade meteors should be lighting up the cosmos by the end of 2017 or early 2018. Meanwhile, the company will develop a prototype, reserve space on a rocket, and expand its support base through promotion. When asked about future projects, Okajima insists that Earth’s low orbit is only a first step. “With space entertainment, I want to go farther and deeper into outer space.”

1. Performing maintenance on equipment that replicates the release of the artificial shooting stars
2. A prototype of the device to be mounted on an artificial satellite, installed in a test apparatus
3. Scientists and artists involved in Project Sky Canvas are considering how Okajima’s artificial meteorites can be used
4. Natural shooting stars only appear for a second; Okajima’s will be visible for three times that long
Citrus production is big business in the regions bordering Japan’s Seto Inland Sea, and two tiny hamlets in the area yield mountains of the fruit. *Yuzu* and *sudachi* are the varieties prized most, thanks to their refreshing taste and fragrance—and several positive effects on health.

CATHERINE S THORBECKE
CITRUS fruits are popular ingredients in kitchens throughout the world because of their tart, refreshing juice, peels and pulp, which boast a flavor and fragrance suitable for everything from main dishes to cocktails to desserts. Lemons and limes are probably the most prominent citrus fruits in Western cuisine. Japan has its own array of zesty citrus: Hiroshima Prefecture is known for its lemons, for example, and Ehime Prefecture for sweet, luscious tangerines. Oita Prefecture’s kabosu, a fruit similar to a lime, has many fans as well.

Yuzu and sudachi are two other popular choices in Japan, appreciated for their culinary versatility along with their unique and delicious flavors. Shikoku, the smallest of the archipelago’s four main islands, is one of the country’s biggest producers of these Japanese citrus fruits. The picturesque isle lies west of the main island of Honshu, across the Seto Inland Sea, and its climate, similar to that of Mediterranean countries such as Italy and Greece, is ideal for all kinds of citrus production, especially sudachi and yuzu.

Kamiyama-cho, a small town nestled in the mountains of Shikoku in central Tokushima Prefecture, harvests 1,300 tons of sudachi annually—the biggest crop anywhere in Japan. Sudachi, which resemble small limes, were once hard to find except at luxury restaurants, but have been used lavishly and with pride in the local cuisine, and can now be found even in casual restaurants all around Japan. Although large-scale cultivation did not begin until 1956, sudachi trees over two hundred years old have been found in Kamiyama-cho, pointing to the region’s long tradition of cultivation. Refrigerating sudachi after they’re picked allows them to retain their flavor for a long time, and Kamiyama-cho made a point of acquiring refrigeration technology that has helped sudachi production flourish to meet increasing demand throughout the land.

The tiny fruit is packed with antioxidants and vitamins, and locals in Shikoku praise sudachi for health benefits such as reducing fatigue, aiding in calcium absorption and preventing blood sugar spikes. Sudachi also contribute to a healthier overall lifestyle by reducing sodium intake when used in place of salt or soy sauce.
For those unfamiliar with its taste, the *sudachi* has a mild flavor and high acidity, making it an ideal partner for countless other ingredients. Cooks will tell you that *sudachi* coaxes out the flavors in other foods. In addition, most of its pleasant, fresh scent resides in the peel, which is ideal because it will not overpower the fragrance of other ingredients when its juice is added to dishes.

The Mizuki Teahouse, a restaurant and traditional inn in Kamiyama-cho, takes great pride in serving dishes incorporating local ingredients. Mitsuru Yamada, the head chef, explains that *sudachi* subtly adds value to whatever it is combined with, making the dish better—such as the hint of complexity it lends to the teahouse’s delectable sashimi and *kara-age* (Japanese-style deep-fried chicken). The *kara-age* is even made using chicken raised on *sudachi*, which is then marinated in salted *sudachi*, deep-fried and seasoned with grated *sudachi* peels, making it a great way to appreciate the quality of Kamiyama-cho’s signature fruit.

Local farmer Junichi Hashimoto has been growing *sudachi* for sixty years, and takes great pride in his work. Still full of energy, the 83-year-old shows off his perfectly manicured orchard of *sudachi* trees, and lights up with passion when he talks about his work.

His favorite way to eat *sudachi*, he says, is squeezed plentifully over tofu and fish.

Another local specialty, *sudachi* cider, is remarkably refreshing and full-bodied, not too sweet and not too sour. *Sudachi* even enhances the flavor of pilsner beers. For creative chefs, the culinary uses for the fruit are virtually boundless.

About three and a half hours away from Kamiyama-cho over winding mountain roads is Umaji Village in Kochi Prefecture. Often cited as one of Japan’s most beautiful villages, Umaji has a population of just under a thousand people. Despite its size, this hamlet is a huge producer of *yuzu*—a Japanese citrus fruit with a strong and distinct flavor as well as high acidity—and almost everyone here is involved in its production. In recent years *yuzu* have exploded in popularity, and the demand for the fruit has also grown substantially worldwide, especially as Western chefs discover its unique flavor profile.

Eisaku Okabayashi, a *yuzu* farmer in Umaji, spends hours pruning his trees. The more time you put into taking care of your *yuzu* trees, he explains, the better your produce tastes. Work for *yuzu* farmers is therefore virtually year-round, because they can always find ways to improve their crops by trimming overgrowth and keeping a watchful eye out for...
harmful weeds. Okabayashi takes immense pride in his yuzu, which he displays by eating one raw right off the tree.

At the restaurant in Umaji-mura Onsen (a combined public bath, guest house and community center) the chefs incorporate yuzu in virtually every dish, proving it can be just as useful as salt. The yuzu sushi and yuzu sherbet here are especially delicious. Even the water they serve is infused with yuzu juice, and at the baths the locals bathe in yuzu-infused waters because it contains vitamins that benefit the skin.

In Umaji Village’s center stands a beautiful riverfront building called the Yuzu Forest Factory, which produces yuzu drinks. The Forest Factory also houses a yuzu research laboratory, where resident academics conduct research on the various benefits of the tart fruit. Another feature of the factory is a design studio where designers create graphics to promote Umaji Village and yuzu to better share them with the world.

In recent years, yuzu have become extremely popular in contemporary Western cuisine, which may be a sign of the positive impact of Umaji Village’s research and marketing. The Forest Factory alone employs about 10 percent of Umaji’s population, and the people here take great pleasure in their work, hand-packing boxes of yuzu merchandise that include yuzu juice and cooking sauces.

Umaji Village also produces a popular drink called Gokkun that has only three ingredients—yuzu, water and honey—but tastes absolutely wonderful.

Shikoku’s citrus fruits are special because of their high standards, as well as the hard work and passion that local farmers invest in producing them. While some countries require medical inspections of imported Japanese citrus fruits, Japan’s peerless quality control procedures have earned the trust of its export partners. For skilled and inspired chefs, these citrus fruits can enhance virtually any dish. Those unfamiliar with this gorgeous part of Japan can get a taste of it through these citrus fruits local farmers and workers produce and share.

6 Sashimi topped with sudachi at the Mizuki Teahouse
7 Mitsuru Yamada, the Mizuki Teahouse’s head chef
8 Yuzu-related products and souvenirs at Umaji Village
9 The Yuzu Forest Factory came up with this refreshing yuzu-infused drink, called Gokkun
10 In the Yuzu Forest Factory’s lab, researchers focus on the health benefits of the tart fruit
11 Boxing up products at Umaji Village’s Yuzu Forest Factory agricultural coop and research lab
12 Yuzu adds flavor to meals and also replaces salt, making it a healthier alternative for cooking
13 Yuzu sherbet, served at a local sweets shop in Kochi, is an especially delicious dessert
Hari-Kuyō is a memorial festival for used sewing needles in which they are honored in a ceremony at a shrine. The dates for the festival are generally February 8 in eastern Japan and December 8 in western Japan.

Needles are valuable tools, typically used to make kimonos when Japanese people wore them as everyday clothing. The festival reportedly spread during the Edo Period (1603–1868) as a way to acknowledge the burden the needles had endured, and to pray for better sewing skills.

On this day, any labor involving the use of needles is halted. Broken or rusted needles are inserted into rice cakes or blocks of konnyaku (konjac) or tofu, and then either wrapped in paper and memorialized as an offering at a shrine or sent floating down a river. The reasoning is that during their “lifetime” the needles were used to stitch hard materials together, so they should be allowed to enjoy themselves in the afterlife by piercing something soft.