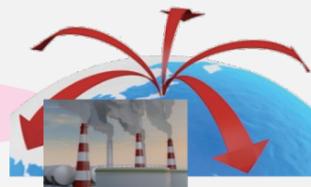


Skill and know-how of experts' as a strength of Japan
 ⇒Commercialize as contents, distribute over network.

Globalization of the manufacturing lines caused know-how of important skills in Japan to diminish.

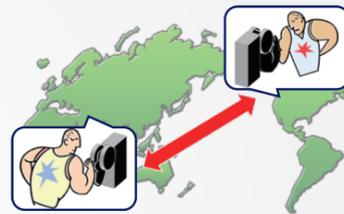


Making experts' motions into international competitiveness.

- ▶ Professional motion of the Japanese expert is commercialized and distributed in global market over the internet.
- ▶ Professional motion of the Japanese expert can be transferred by internet communication and exerted at international working sites.

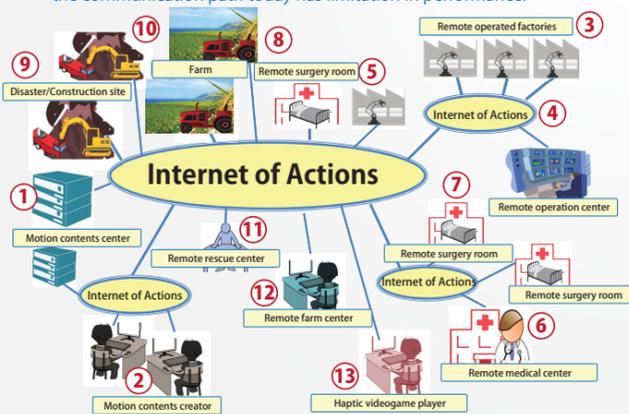
Haptics in virtual world.

- ▶ Extraordinary reality and intuitiveness in amusement application is possible by adding haptics to the conventional visual and auditory effect.
- ▶ Realtime haptics transmission in arcades makes player to face-off worldwide competitor in action dependent events. e.g. arm-wrestling.



IoA: Internet of Actions.

- ▶ Motion contents for realizing wide-range of tasks are commercialized and stored in contents center on internet. The contents are download when they are necessary and reconstructed at local.
- ▶ Hub centers are connected through internet and achieves realtime motion communication between centers.
 - To achieve high quality haptic sense transmission, high-speed network communication is very important. Unfortunately, the communication path today has limitation in performance.



▶On the left figure,

- Motion is commercialized into data contents, they are gathered and stored at the contents-center in internet cloud. They can be download and reconstructed when necessary. : ①, ②
- Manufacturing process can be tele-operated with highly realistic sensations. Experts need not to work in 3D environments. : ③~⑤
- Delicate medical operations become safe and dexterous by haptics. Remote medical operations could be performed from distant hospitals. : ⑥~⑧
- Haptics is installed into vehicles in construction, disaster restoration, and agricultural fields. Man-machine interaction becomes highly intuitive. Quality of the task can be improved and remote operation can be achieved. : ⑨~⑫
- Player of the video game can contribute against virtual competitor with experiencing tactile senses. Man-to-man match is also possible by remote haptics transmission with realtime communication. : ⑬

Haptics Research Center is about to begin the work to realize the IoA world.

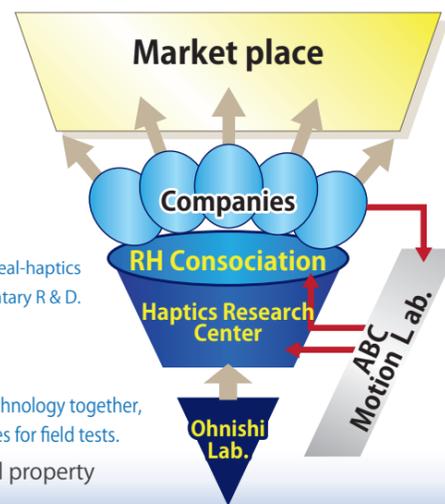
Promotion of the application development of real-haptics technology.

Ultimate objective of Haptics Research Center.

- ◆ Ultimate objective is to widespread the benefits of the real-haptics technology to the numerous fields fast and without exception. Manufacturing, disaster-restoration, construction, agriculture, and medicine are candidates.
- ◆ We believe supporting the advance of the existing robots is important.

Promotion of the application development.

- ◆ Promotion framework is depicted as figure shown right.
 - **Consociation for real-haptics technology:**Organizes companies aiming to develop practical applications of real-haptics technology. Manage to share the most recent information and responsible for collaborative and complementary R & D.
 - **ABC Motion Lab.:**Develops essential/standard technology for haptics applications. Also works for technological supports of R&D in consociation.
 - **Companies aiming to develop practical applications:**Companies that are active to develop real-haptics technology together, comprehensive to the practical issues in aiming fields of applications. Capable of offering experimental sites for field tests.
- ◆ For the effective use of the real-haptics technology in diverse applications, intellectual property charter had established to avoid unnecessary quarrel about patents



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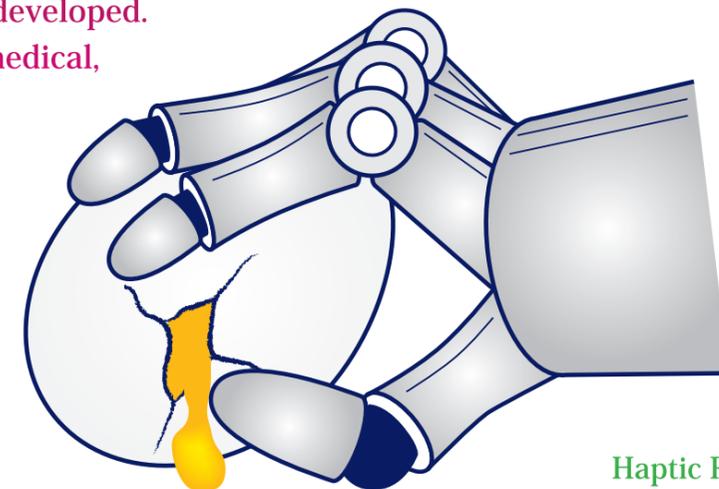
Haptics Explores The World of IoA



Haptics Explores The World of IoA

~Invention and innovation of Haptics Technology~

When we hold an object, we hold it with experiencing either it is a soft thing or a hard thing. The sensation we have just experienced here is "haptics", something not realized in robots today. An abandonment of haptics causes a difficulty in further advance in automated machine, or may even result in threatening the safety and security of the process. In addition, robots that are capable of supporting human with human-like motion in unstructured fields are hoped to be developed. In particular, rescue, medical, and construction are main fields.



An Inconvenient Action!

Haptic Research Center (HRC) introduces a simple method to install haptics to the automatic system and proposes a way to collaborate a man and a machine in more intuitive way. Superior motion dynamics of experienced persons can be digitalized into data contents with our technology. We aim to distribute those contents over internet cloud and develop the world of "Internet of Actions (IoA)".

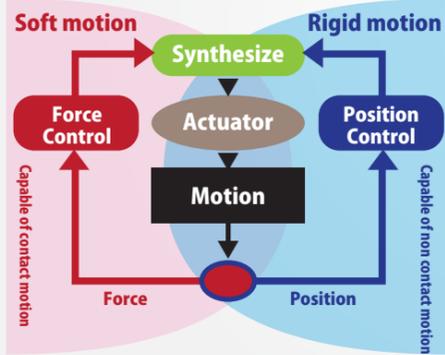
"Haptic sense", "Real haptics" vs "Haptics"

- ◆ Humans can identify the physical characteristic of the object in an instant just by touching it. The object is soft like a sponge, is rigid like an iron, has elasticity like a balloon, or is moving by itself. That sensation is ability of the human called "haptic sense".
- ◆ "Real haptics" is a technology to reconstruct haptic sense by acquiring dynamic physical information that is transferred bi-directionally in between surrounding environment and you.
- ◆ "Haptics", on the other hand, is a technology to realize artificial haptic sense. The world haptics conference defines it as "a technology to obtain cutaneous sensation feedback by force, vibration, displacement, etc."

In 1970s, many of machine tools have abandoned to install haptics in order to achieve automatic and clever task execution.

Machine/Robots without haptics manipulates objects by sensing position displacement, cannot even recognize that they are hurting the objects. →Not capable of safe contact motion

Mar. 2011: "Fundamental Patent on Real Haptics Core Technology" Japan Patent 4696307, US Patent 7672741B2.

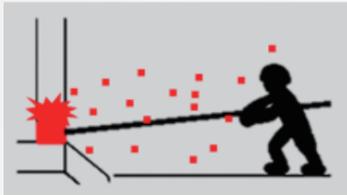


- ▶ Prof. Ohnishi is the inventor of the technology.
- ▶ Soft motion by force control and rigid motion by position control need to be achieved simultaneously for vivid haptics. "Acceleration based bilateral control: ABC" achieves both position and force control at the same time without contradiction.
- ▶ Do not require special sensor. Haptics sense is estimated from acceleration in output axis with high performance computation and communication.
- ▶ Haptic sense is transmitted along the motion. Rigidness/softness, elasticity and displacement of the object can be experienced by haptic sense.
- ▶ Motion with gentleness and high flexibility is achieved by real haptics technology. Soft motion by force control and rigid motion by position control is integrated in real-haptics.

In many automated working fields, robots are in charge of achieving structured tasks, while helps of humans are inevitable in unstructured tasks.

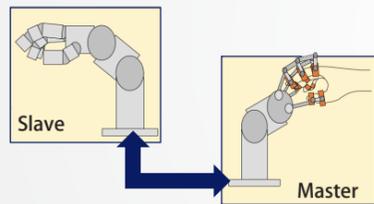
Although multiple sensors and analysis technologies have enhanced cognitive performance, there is a limitation of applicable fields in machines/robots without haptics.

Improving the working environment (in 3K fields) with real-haptics.



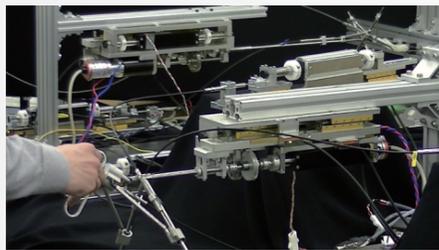
- ▶ In many fields, humans are taking care of "Dirty, Dangerous, and Demeaning" 3D tasks because those tasks tend to be fundamental. Those tasks require haptics capability and intuitive decision making by humans. Real-haptics can relocate working environment for human to more comfort cites.
- ▶ At the same time, haptics can multiply human ability and ease the task. Diversity in the labor can be achieved as a result.

Working in chaos fields and untracked fields.



- ▶ In rescue and reconstruction fields, situation appraisal is difficult. In addition, living things, harmful objects, and objects that are hard to deal with are expected to be scattered randomly at the site.
- ▶ Realtime observation and flexible motion by haptics for human are essential in such field.
- ▶ Real-haptics technology achieves remote motion and/or amplification of the motion with haptic sense.

Sharpening the sense and improving safety in medical applications.



- ▶ In minimally invasive surgery, surgeons need to acquire the situation, operate safe and quick under restricted information in such surgery. Robotic supports are necessary to operate beyond the human ability.
- ▶ For the safety, surgeon must recognize the softness of organ even with surgical instruments.
- ▶ Real-haptics technology not only achieves remote operation of the forceps, but also prevents damaging patients body during contact motion in the operations.

Realization of real-haptics.

Return of haptic sense.

Integrates human and machine work.
Precision and high-output of machine.
+
Flexibility and decision-making of human.

Visualization.

Comprehend expert's skill.
Train young worker
Install skill to automated machines.

Enhance human ability.
Macro-size, Micro-size,
emphasize, etc.

Data contents of motion.

Reconstruction of action.
Flexible and adaptive motion.
Synthesize and reconstruction of motion as contents.
Now under R&D.

The world of IoA.

Starting to work in R&D.

Return of haptic sense.

Comprehensive visualization of motion.

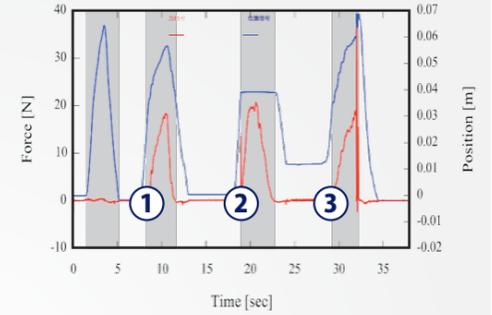
Transition of position and force through the motion can express the physical characteristic of the motion→Advanced comprehension of professional skill.

Motion is identified from using real-haptics from two signals; position and force. The motion is quantized as trajectory of the signals.

Comprehensive visualization of motion.

- Compressing soft object 1.
- Pushing rigid object 2.
- Compressing soft object and breaking it 3.

In Newton physics, velocity (position) and force provides the energy to the system. From the fact, velocity and force is necessary and sufficient for "Comprehensive visualization" of the motion.



Comprehension and distribution of human skill.

Implicit knowledge of the expert can be apprehended by analysis of expert's motion from comprehensive visualization.

- Implicit knowledge is characterized to explicit knowledge. Skilled motion can be explained and trained to unskilled person.
- Control strategy of the automated system can be integrated by observed skilled motion information.



Prevent decrease and diminish of expert to sustain efficiency, safety, and security in manufacturing.

Enhanced performance by haptic signal processing.

Inserting signal processing function in between haptic sense communication can enrich the applications.

- One workforce can be multiplied to ten, hundred times.
- One workforce can be micro-sized to one-tenth, one-hundredth.
- Multiplication/micro-sizing of position information is also possible.
- Important frequency information is enlarged to emphasize the sensing experience.



Task in macro/micro-size can be performed intuitively as if human is macro/micro-sized.

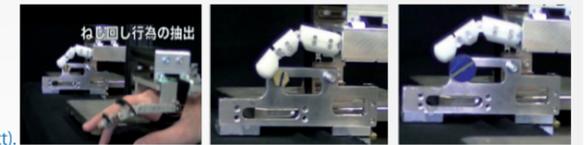
- Gigantic object handling in chaos-site/ support in microsurgery, micro material manufacturing, etc.

Surface smoothness and distortion can be estimated from high-precision haptics sensing.

Reconstruction of the motion

The same motion can be reconstructed by replaying the stored position and force signals.

- Screwing motion is stored in left figure (teach).
- Screwing motion is reconstructed to the same object in middle figure (reconstruct).
- Different-sized object is unscrewed in right figure (reconstruct).



Force signal based reconstruction is soft motion. The motion is capable of adaptation to slight initial position difference.

Motion is translated into data contents

Stored motion contents can be reconstructed into another motion contents.

- Right figure expresses rehabilitation support system with haptics sense. Motion contents are switched according to the progress of the patients rehabilitations.
- ▶ Complicated tasks in mult-degree of freedom motion can be generated by connection of series of motions.
- Synchronization of the motion needs to be preplanned or achieved dynamically. Contents synthesizer is necessary.

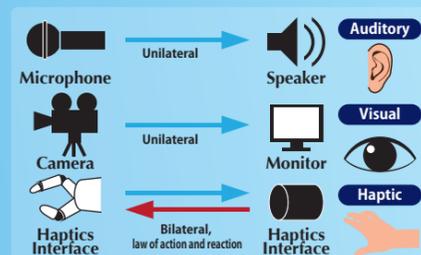


Fundamental technology for contents expression is developed. Complicated contents expressions are now under R&D.

Translation to data contents.

Difficulty in haptic sense

- ◆ Visual and auditory senses are one directional communication. The communication is completed by sending sensed information from sender to receiver.
- ◆ Haptic sense is transferred as a result of the physical interaction between target object and effector. Operator sends force information to the effector to fulfill a task. Effector applies force to the object that is the same amount from received signal. Reaction effect must be sent back to the operator to complete the communication.



Based on Newton's theory...

- ◆ Physical motion in the world is ruled by Newton's theory.
- ◆ Under the theory, energy can be provided to the system through two dual quantities; force and velocity.
- ◆ Real haptics controls force and velocity (acceleration and position) precisely and achieves transmission, store, reconstruction, and processing of the haptic sense.