Redefinition of RO-MAN Scope
-Message from the founding period-

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Abstract— **In this study, we try to define a new scope for the RO-MAN conference, which will celebrate its 20th anniversary in 2011. The original concept remains effective; however, a clearer elucidation and additional interpretation may be useful to society.**

I. Introduction

IN 1990, we discussed the importance of interactive communication between humans and robots.

In this study, we define robots as computerized high-tech equipment. The rate of innovation of high-tech equipment is higher than the rate of evolution of human beings' intellectual capabilities. In addition, the rate of progress in new research fields is less than the rate of innovation of high-tech products. Therefore, we believe that this is the right time to start investigating communication between robots and humans.

The RO-MAN conference was established with the objective of investigating the relationship between human beings and high-tech machines. As expected, several remarkable technological innovations have been introduced thus far, especially with regard to computers, mobile communication devices, MEMS application sensors, and power devices. The performances of such devices are beyond the scope of human cognitive perception; therefore, intensive investigation of high-tech machines is necessary. We discuss the essence of the RO-MAN conference on the basis of advancements in high-tech machines over the last two decades.

II. Definition Of Robots

Before we describe the scope of RO-MAN, we must clearly define a robot. In the RO-MAN community, a robot must be defined as follows:

A. Hardware Definition

The definition of a robot is subjective; it has evolved over the years, owing to technological developments and the influence of science fiction. The RO-MAN community should adopt the following general definition.

A robot is a form of artificial intelligence (a computer) comprising receptors (sensors) and effectors (actuators).

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The computer acquires information by using its sensors autonomously, and it processes the acquired information. Then, on the basis of the processed information, it performs some physical actions by using its effectors.

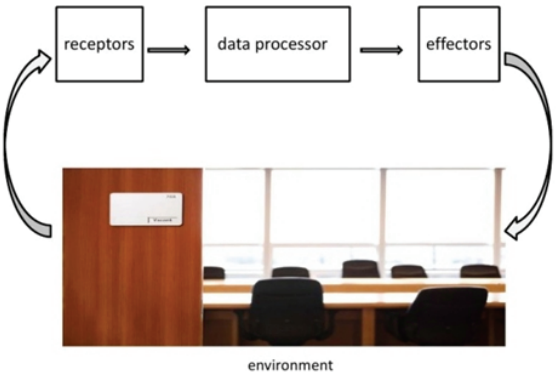

Fig.1. Hardware definition of robots

B. Social Definition

Robots may be socially interpreted as follows:

Robots are social agents that extend internal human consciousness

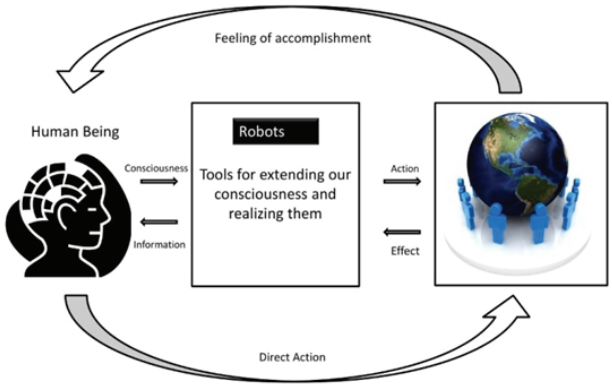

Fig. 2. Social definition of robots

In other words, robots can retrieve internal human consciousness on the basis of their interactions with humans, and they can realize that consciousness (or desire) by using their actuators.

III. Interaction

Let us reconsider "interaction problems" between a robot and a human being; on the basis of this consideration, we describe the new scope of RO-MAN and review previous papers presented at RO-MAN conferences.

3.1. Mental Models

What constitutes "interaction" between humans and robots? "Interaction" between two entities is based on the "mental models" of each entity. Before we discuss the interaction, we must consider two mental models.

A. *Human's Mental Model of Robot*

The first issue is a human's mental model of a robot, i.e., a human's conception of a robot. These mental models are very subjective; they depend on experience, education, age, gender, preferences, specialty, job, etc.
The following problems need to be included in the scopes:

- ✓ The acquisition of a human's perception of a robot.
- ✓ The changes in mental models because of human-robot (H-R) interactions.
- ✓ The identification of mental models developed by humans to represent robots.
- ✓ The symbolic representation of mental models.
- ✓ The types of human traits that characterize mental models.
- ✓ The degree of variation among the mental models.

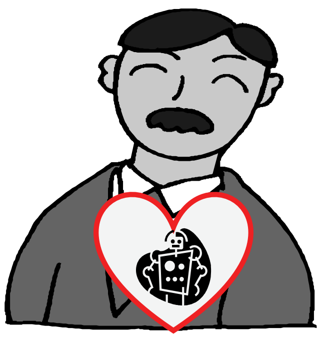

Fig. 3. Human's mental model of robot

<u>*Current Research Topics*</u>

An accurate description of mental models of robots is not available; however, several papers on related topics have been presented at previous conferences. Some of them include aspects of the mental models of both robots and humans. The research topics are classified using keywords as follows.

Long term interaction between H-R [5],[15],[60]
Engagement of user with robots [27], [46]
User experiences in HRI [6],[14],[30],[31],[32]
Cognitive psychology in robot/human interactions [16],[29],[45]
Emotional communication [4],[28],[44]
Multi-modal robot-human communication [1],[3],
Dialogue and multi-modal human robot interaction [58]
Methodologies for HRI studies [2]
HRI fields study, Knowledge representation [57]
Robot and human personality [18],[43]
Robot as a Social Agent [42],[46],[56],[58],

B. *Robot's Mental Model of Human*

The second issue is the mental model of a human, which is implemented in a robot. This mental model is a purely artificial model. Any type of mental model can be installed into a robot. The owner of a personal robot may install a mental model of himself or herself into the robot. The mental model is a set of behavior patterns or preferences that can enable a robot to assist its owner.

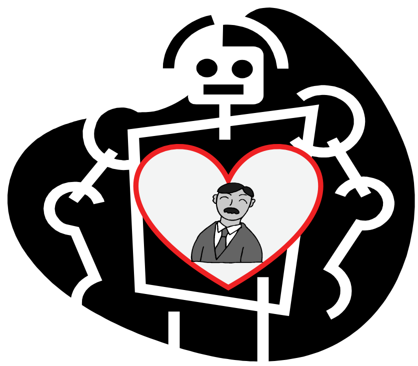

Fig. 4. Robot's mental model of human

The followings problems need to be included in the scopes:

- ✓ The description of human mental models implemented in robots.
- ✓ The possibility of representing the mental models mathematically.
- ✓ The need to customize the mental models for each individual or to generalize them such that they can be adapted to each individual.
- ✓ The types of learning algorithms that are suitable for general mental models, and the types of interactions that are effective for adapting the general models to each individual.

<u>*Current Research Topics*</u>

Related research topics that have been presented at previous conferences are

Interactive virtual environment [34],[61]
Cognitive sciences for socially interactive robots [21]
Measurement and evaluation of Kansei information, [7]
Developments to robot companions [23]
Human aware robot perception [10],[48],[62]
Robot architecture for socially intelligent robot [43],[63]
Expressiveness in robots [19],[33]

Personalizing robots [34]
Socially adaptive robots [20]
Affective and cognitive sciences for Social Robot [36]
Context awareness, intention understanding [9],[65],
Learning, adaptation [22],[47],[49],[50]
Human robot teaching [8]
Robotic interface for human communication [64]

3.2 Purpose of Interaction

The purpose of interaction, which is a research topic for RO-MAN, may be classified as follows.

✓ To develop good mental models.
✓ To retrieve human consciousness.
✓ To execute H-R collaborative work

As mentioned above, RO-MAN mainly concerns interactions and mental models. Interactions are necessary to develop a good mental model.
According to their social definition, robots are social agents that can extend human internal consciousness (intention or desire). Interactions are imperative for robots to retrieve human consciousness. If both the robot and the human have good mental models of each other, the robot can easily retrieve the human consciousness. To develop a good mental model, a learning process (adaptation process) that involves interactions is required.
If robots perform tasks as co-workers of humans, interactions are necessary to accomplish the tasks.

3.3 Interaction Media

Interaction can be described by using a variety of media. There are numerous interaction media: basic interactions are physical interactions, including haptic/tactile interactions. Interactions at a slightly higher level include signs or motions. The top-level interactions include symbolic code exchange. “Media approach” is a research topic for RO-MAN.

✓ What type of media can be used and for what purpose?
✓ How to use the media?
✓ How to process/analyze/characterize the media data?
✓ What type of hardware can be used for the media?

3.3.1 Interaction Hardware/Software

Hardware plays a very important role in realizing a good interaction. The hardware and implemented software is an important research area for RO-MAN. Research topics include
✓ Interface Design
✓ Sensor/Motor coordination
✓ Robots’ appearance
✓ Robot internal state expression
✓ Learning Algorithm
✓ Artificial Intelligence/Creature/Psychology

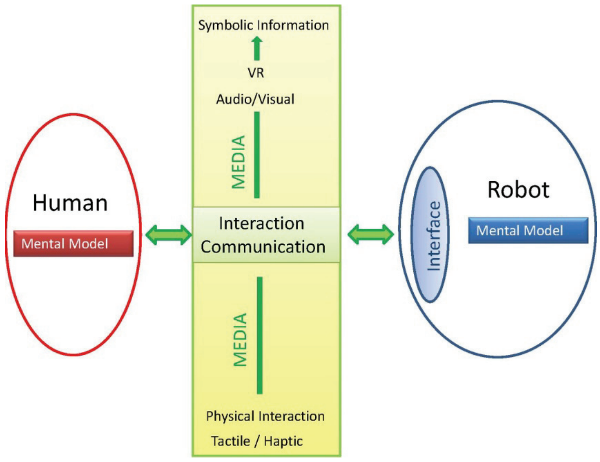

Fig. 5. Interaction media for H-R communication

3.3.2. Environment of H-R interaction

We also need to consider the environment (external conditions) for H-R interaction. The interactions must occur in real society; that is, they must be safe, legal, and ethically acceptable. The following issues should be investigated.

✓ Legal/ethical/social aspects of H-R interactions.
✓ Safety/security aspects of interactions with networked robots.

3.4 Design Portfolio of H-R Interaction

At the RO-MAN conference, we welcome discussions on the challenging academic research topics mentioned above. However, it is difficult to address these issues analytically; it involves a considerable amount of trial and error. Moreover, we have not clearly determined the scope of the research area thus far.
For the time being, portfolios of creative design (application) will facilitate the development of the research area significantly.
The creations need not be academic novelties; moreover, theoretical evidence of the creations is not required. Creations such as paintings and sculptures may be used. However, they must be in complete form and they must function properly.
The types of creation include

✓ Personal/pet robots
✓ Service Robots
✓ Interaction Robots
✓ Actroids/vocaloids

<u>*Research Topics*</u>

Related research topics that have been presented at previous conferences are
Actuators and materials for socially interactive robots [40],[55]
Appearance design of interactive communication robots [41]
Application case studies of interactive communication robots, for education, and so forth, [28],[37],[53]

Interactive robotic arts [69]
Robotic Maids, Service Robot [25]
Toys, Robotic Friends, Robot in personal care, Child Care, (for the Elderly or Autistic) [12],[24],[38],[51]
Virtual Training, Rehabilitation, Entertainment, Gaming with robot [39],[66],[67],[68],[70]
HRI fields study [26]
Robot assisted therapy [13],[52]
Robot as companions [54]
Robot as assistive technology [11]

IV. Concluding Remarks

In conclusion, we describe three areas that have considerable scope from the viewpoint of future RO-MAN conferences.

4.1. Education: Meta cognition of H-R relations.

As expected, there have been several remarkable technological innovations, especially with regard to computers, mobile communication devices, MEMS application sensors, and power devices. The performances of such devices are beyond the scope of human cognitive perception. Moreover, many people are unaware of the essence of such high-tech machines; in other words, they are not educated enough to develop a good mental model of a robot.

This is a serious problem. Education for all people, which will be known as RO-MAN education, is necessary.

If a person does not have a proper mental model of a robot, he or she cannot deal with high-tech machines.

Moreover, it may be extremely dangerous to involve such persons in decision-making groups for high-tech machines. Unfortunately, many highly ranked managers do not have proper mental models of robots.

If such a person is the head of an industry (society), he or she may commit serious mistakes, resulting in the development of defective products. This may adversely affect the reputation of the society or company. From this viewpoint, awareness of the proper RO-MAN concept is imperative. In particular, society must have a common consensus that only people who are aware of the RO-MAN concept can be elected as leaders.

Intensive investigation of recent accidents related to high-tech machines reveals that people related to the accidents, especially the heads of groups or persons who made the basic decision, were not aware of the RO-MAN concept. For example, they may believe that machines are completely accurate and secure. With proper mental models, they would understand that there is no such thing as complete security. They may also believe that human engineers can work with 100% security and efficiency. On the basis of this assumption, they may make numerous plans and other decisions. This may have a disastrous cumulative effect, resulting in serious accidents.

There are several instances of such accidents in the recent past, such as the financial institute case and power plant case. We must ensure that people nominated as top managers are aware of the RO-MAN concept.

4.2. Multi-disciplinary research

In order to pursue RO-MAN research, collaboration among various research areas is imperative. Discussions among specialists may provide a new direction. However, such collaboration is not achieved easily. There are two main reasons.

A. Researchers like to pursue their own interests in fields of their choice, and they may not be interested in other research fields.

B. Each research field has its own terminology and train of thought; owing to cultural and linguistic differences, it is not easy for researchers from different fields to communicate with each other.

International multidisciplinary conferences provide researchers from various fields with opportunities to communicate with one another; nonetheless, it is difficult to launch a multiple-disciplinary project.

As stated earlier, society may face serious problems in the near future, which can be solved only by a multidisciplinary approach. Thus, we must patiently await the emergence of such collaboration.

RO-MAN conferences have been providing such opportunities over the last twenty years, and such collaboration may be realized soon

4.3. Ethics

Ethics, i.e., the basic concept of the proper relation between a human being and a robot, should be elucidated and shared among people in society. The discussion should be held among people from various fields, irrespective of gender, nationality, and age. A typical topic is Networked robots, keywords of which are ‘character,’ ‘personality’ and ‘anti-trust.’ Computer networks are susceptible to cyber-attacks. If robots are involved in computer networks, they may become extremely dangerous entities.

For example, there is a plan to standardize network devices that can control home appliances (electric and electronic) using a smart-home application.

Such smart homes may be considered as networked robots. It would be dangerous for all robots to have the same access protocol with the same security holes. Hackers or crackers who exploit such security holes can cause serious damage. For example, a cracker could turn on all the air conditioners in a network at exactly the same time. This may result in a large-scale power outage because the initial (inrush) current is 6 times greater than the steady state current.

To avoid such a situation, all devices should have different characteristics such as hardware structures and protocols; thus, it would be virtually impossible to control multiple devices using the same protocol.

In summary, robots involved in a network must be handled cautiously. As mentioned earlier, cyber-crimes are far more serious than conventional network hacking.

Such awareness does not exist among most people. Only people who have the proper RO-MAN concept can share this idea. Therefore, we must promote RO-MAN education.

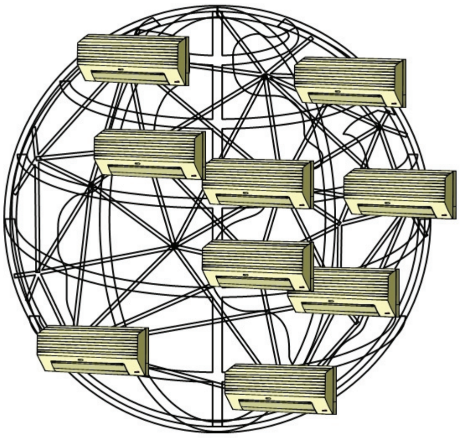

Fig.6 Networked air conditioners

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