Abstract: As robots are getting more important and personalize, the need for design in robot industry is increasing but not very many studies are done in design field. At the first part of this paper, the importance of design in robot industry is introduced. Fields in HRI (Human Robot Interaction) need to be studied which is an interdisciplinary study. HCI (Human Computer Interaction) and CSCW (computer-supported cooperative work) are the disciplines which share same domain with HRI. Therefore, these areas are reviewed in this paper. In the field of robot design, appearance of the robot is an important issue in robot design but there are other factors that need to be considered in robot design field. Unlike product design, robot design needs to have a serious consideration for its dynamic behavior which is one of the most important robotic factors. For designers, it is hard to experience this robot’s dynamic behavior and in order to overcome this problem, robot simulated prototype is required. Robotic factors like its interactive behavior and characteristics can not be fully shown by idea sketch or other design methods like design scenario. There are limits for expressing robot’s dynamic and interactive behavior. Also other issues like tangible feedback from the robots are need to be shown clearly for designers in order to express their clear design idea. Therefore in this paper, interactive tangible robot prototype system is introduced. The main purpose of the research is to construct a robot prototyping system for robot designers. Robot’s behaviors and its characteristics can be designed from this robot prototyping system.

Key words: HRI (Human Robot Interaction), Prototype, Interaction, Robot, Tangible

1. Introduction

Along with 3T (IT, BT, NT) industries, RT (Robot Technology) Industry is expected to be one of the new rapid growing industry. Robot industry can be divided into two different kinds of robots, industrial robots and personal robots. From the recent growth environment for robot industry in Korea, there is expansion of robot industry from the production field which includes mainly industrial robots to non-production field. From this non-production field, study about personal robot is rapidly progressing these days. Personal robot industry was initially started from toy robots, from then personal robots have been developed and studied to multi functional robots and in the future human like robots are expected. [6 ]

The conversion from its humbler roots in factory automation to that of a coveted consumer product was realized when SONY Corp. launched AIBO (ERS—10) in 1999. Early robot prototypes were merely an assemblage of parts and substantial design was not carried out until further advancements in their sensors and mobile parts made
its overall autonomy in movement relegated the robot’s function most suitable to the enterprise of mass production. 
A robot with independence of movement and a capability to act autonomously in accordance to its recognition of 
objects and surroundings has until now been developed for research purpose only. [2]

Robot is an interdisciplinary study. As the development of the personal robot increased the need for human robot Interaction became very necessity. This means that not just the function of the robot is the only factor for robot construction but also the need for ‘how robot should interact with human’ and ‘how should they be designed and how should these robots would be cognize to human’ are increasing. These studies have been studied from many different discipline including psychologists, sociologists, cognitive scientists, communication experts, human-computer interaction specialists and designers. [1]

Throughout the past involvement of design in the development did not exit or played minimum role. Robots were developed only for research purpose but as the robot penetrate into our daily life the need for the robot design increased. Nevertheless the necessity for the robot design is very crucial issue, the study on robot design is rare to find.

In this paper the needs for the robot design will be introduced and early stage of the robot design process will be introduced. Not like other product design, robot design has its own factors that need to be considered. At the first concept of HRI (Human Robot Interaction) will be introduced and from that, considerations of five different types of personal robots will be shown. Based on these studies, robot design prototyping elements, based on the tangible interface through computer, will be introduced. This will be base on dynamic behavior of robot.

2. HRI (Human Robot Interaction)

Human-robot interaction currently takes many forms. Dangerous tasks, such as urban search and rescue and hazardous material clean up, require a human operator to be removed from the physical location of the robot. Robot that assistant the elderly and the handicapped share the same physical space with their users, often transporting them through the world. Others, such as Sony’s Aibo, provide entertainment and companionship for people.

HRI is an interdisciplinary study which can be linked to many other fields. Human robot interaction is a subset of the field of human computer interaction (HCI). HCI has been defined in many ways. One example is the definition used by the Curriculum Development Group of the Association for Computing Machinery (ACM) Special Interest Group on Computer-Human Interaction (SIGCHI): “Human-computer interaction is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them.” Since robots are computing-intensive systems designed to benefit humans, HRI can be informed by the research in HCI. [1]

HCI does teach us important principles for understanding how a person might interact with a machine. Among the most important are that for a person to understand the interaction, the machine must project an image of its operation. The point is that people develop internal, mental, conceptual models of the way the device works, and they form those models from their expectations and experience with the device itself. For this reason, the device must project an image that is useful in developing this conceptualization.

Along the way, visible affordances and continual feedback are essential.

Implications for Robots. The strong, silent type is a bad model — for people, robots, and machines.
In interacting with others, it is essential to have a good model of how the other operates, with what it understands
it is about to do, and of the progress it is making. In computer systems, the need for feedback is well known. The
information required to yield a good, coherent conceptual model of its operation is not so well known.[3 ]

HRI can also be considered a subset of the field of computer-supported cooperative work (CSCW), “an
identifiable research field focused on the role of the computer in group work.” Often teams of people work with
one or more robots, clearly putting the human-robot system in the realm of CSCW. Even when a human-robot
system is comprised of only one human and one robot, this human-robot system can be considered to be engaged
in CSCW if the robot is viewed as an (unequal) partner to the human.

The robotic field also provides inspiration for taxonomy of human-robot interaction, as most robot systems are
interacting with human at some level. Some formal study of this interaction has already begun. Additionally, the
multi-agent robotics has been investigating issues involved with teams of robots and their interactions for many
years. [ 1]

From DARPA/NSF Study on Human-Robot Interaction divided five different types of personal robot concerning
with interaction between human and robot.

- Search and rescue robots,
- Personal assistants,
- Museum docents,
- Fleets of robots, and
- Physical therapy robots.

Specific, well-understood domains for HRI study are needed for several reasons. First, knowledge acquisition is
the foundation of modeling, yet it is a bottleneck. Participants expressed concern with the need to become
subject matter experts in complex application domains in addition to conducting the HRI research, and suggested
the inclusion of domain practitioners in the constitution of interdisciplinary teams. Domains for HRI can be
characterized in terms of the ability to capture and model relationships, the impact of interactions on performance,
the frequency of interaction between agents, the richness of interaction relationships (not simply "master-slave"),
the amount of communication, clear mechanisms for evaluation of usability, and the types of end-users included.
In our first application domain, robots for urban search and rescue have the humanitarian nature of personal
assistant robots and the challenge of working with "average" end-users. Search and rescue robots are interesting
because of the time pressure and the requirement that they must fit into the existing organizational and
information rescue hierarchy. Research is already underway in the HRI aspects of rescue robots at the University
of South Florida which will aid in modeling the relationships. The frequency of interaction between humans and
robots differs from personal assistants and docents: search opportunities are sporadic and short, often only three or
four episodes of activity, less than ten minutes in duration each over a twelve hour shift. The interaction is brief
and intense. The role of social informatics is an intriguing research question since it is uncertain as to whether
users should consider robots a tool to be sacrificed or should bond with them to get enhanced performance, like
dog handlers. The end-user is someone who can undergo only limited training and may have some resistance to
robots in the workplace.

Personal assistant robots also offer many opportunities for exploring HRI as well as making a contribution to
society. Personal assistant robots are already being developed by NASA to aid astronauts by carrying gear and
holding parts for assembly and by other institutions for aiding the handicapped. Other applications include military operations, where man-packable aerial robots can give an infantryman a personal "eye in the sky," and a carrier for search and rescue gear. Personal assistant robots are an attractive domain because humans must work side-by-side with the robots for large amounts of time. The robots' relationships with humans are servile, but personal. The tasks are limited enough that they can be modeled and evaluated. The end users are often ordinary people who cannot be expected to become robot experts. This domain has also been explored by the Swedish research team at the Interaction and Presentation Laboratory or the Royal Institute of Technology in Stockholm, and provides an opportunity for more international collaboration.

Museum docents are quite different from personal assistant robots. Docent robots offer a one-to-many relationship with humans, rather than one-to-one, and must get humans to do things that they may not do if left to themselves (such as interact with parts of a museum). At least two museum docents are already in existence: Minerva and Sage, developed by Carnegie Mellon University and Rhino in the Deutsches Museum in Bonn. The frequency of interaction is high and the robot must contend with a wide variety of people in differing emotional states.

The issue of the ratio of robots to humans is not well explored by the first three of these domains, prompting a call for considering swarms of robots. Applications of swarms include humanitarian demining, where multiple robots work under the direction of a single (or few) humans. Fleets of robots offer a set of different interactions, mostly that of interruption to the human and cooperation with other robots. Once the robots are tasked, they should perform their job autonomously until some anomaly occurs, then the human must be alerted. This may take the human unawares and generate an incorrect or delayed response because of not comprehending the context of the problem. While the robots have a near-peer relationship with the human, they have the possibilities of a range of relationships among themselves, depending on how the swarm is organized. They may be cooperative, have a hierarchy, etc. While fleets of robots score highly on interaction, the role of social informatics appears to be limited. The end users are expected to be highly trained.

Another proposed domain is physical therapy robots, combining many of the attributes of personal assistants with strong humanitarian contributions. Physical therapy robots, however, are expected to work in constant direct physical contact with the human and must respond to subtle social informatics signals. The authority relationship is challenging because such a robot must make sure the patient receives the care even if he/she does not want it, yet be sensitive to the patient's needs and fears. [1]

This paper will deal with the interaction between human and personnel assistant robot from the five divided types of robots above.

3. Robot Design in HRI (Human Robot interaction)

It is important to design the interaction between human and robot. Such as, how should robot interact with human in each case and also the behavior needed for the personal robot in certain situations. Robot’s physical appearance is also an important issue in robot design. The first recognized area when a human meets a robot will be the image of overall appearance, especially face area before looking the scope of motions or the sophistication of function. [11]

Industrial design as it exist today, is the design of fundamentally static objects. The structure itself hardly changes. The freedom of movement afforded by a robot differs fundamentally from the staticity of existing
industrial products. The continuance of movement with its plural mobile parts presents several obstacles in pursuit of form amid these restrictions. As in the case of all industrial product design must be realize amid severely restrictive conditions. The body of a Formula 1 racing car is realized on the basis of aerodynamics, engine installation and so on. These restrictions are even more conspicuous in the case of robot design. We need to recognize that robot design is not simply the design of an objective but the design of a whole range of dynamics.

4. Development of Human Robot Interaction Assessment System

This study focuses on the early stage of robot design. Based on the fields of HRI (Human-robot Interaction) and characteristics for robot design, interactive robot prototype can be developed. Since robot itself need many mechanical elements in order to operate its behavior, it is hard for designers to have the perception of robot’s dynamic movement.

From the fact that have been studied above, robot design needs to have serious consideration of a whole range of robot’s dynamics and also behavioral exchange between human and robot. These issues can be limitation for robot designers. In the concept generation process which is one of the most crucial steps over all design process, the conventional 2D drawing or 3D drawing turned out to have limits in visualizing the complex interface on robots. The virtual Prototyping technology is one of the concept generation and explication methods among the newly developed tools. Despite this VP technology, there are limitations such as having no tactile feedback or not having physically simulated.

In order to overcome these problems in some extend, virtual robot prototype with tangible input device is developed. The main purpose of this prototyping tool is to have better robot simulating system and having solving the problem with limitations in visualizing the complex interface on dynamic robots. Also having the assessment for the robot that has been designed.

4.1. Requirements for the interactive prototype

In order to accomplish the needs for interactive prototyping tool, simple test was practiced. Simple hand game with the character on monitor through using tangible interface was designed. The sensors and the hardware used in this case study are in fig.1. Also the structure for this system is in fig. 2. [10]

![fig.1 Sensors and the hardware for interaction](image)

Software used in this system is Macromedia Director and input device for this system was optical sensor and output device was vibrating motor. From this test, the systematic structure for human and tangible device was tested. Robot tangible prototype can be easily adapted from this system.
4.2. Interactive Tangible Robot Prototype

From this case study we were able to understand the basic manipulation of tangible interaction through computer and interface Board (K8000) with the virtual feedback and also auditory feedback. Based on the case study above, we were able to construct tangible robot prototyping system.

Basic framework is with conceptually designed robot prototype, designers can give ‘physically’ made robot prototype. Some basic sensors are embedded in the physically made robot prototype in order to receive designer’s behavior. From the received behavior of the designer, robot’s dynamic behavior is shown through virtually on the monitor. This is where designers can modify the robot’s behavioral design or the appearance of the robot in order to have sufficient human robot interaction.

5. Evaluation

This Tangible Robot Prototyping system is suggested for designers. There have been many existing robot simulating tools or prototyping tool for engineers, but it was hard to find a prototyping or simulators for designers. In this paper, suggested prototyping system focuses on designer’s perspective view and it is constructed from
designer’s needs. This gives a great opportunity for designers to experience robot design idea more sufficiently and also makes it easier for designers to visualize their robot design ideas. Since robot is very interdisciplinary area, tangible robot prototyping system would give a better chance for robot designers to cooperate with other fields’ researchers.

6. Further Study

There are certain limits to this tangible robot prototyping system. One of the limitations that this system has is that robot’s behavior is not fully shown physically. Its virtual behavior might have full understanding for the robot’s dynamic behavior and better and simpler way to construct the robot prototype need to be studied.

This tangible robot prototyping system can be developed for robot usability test for end user. From this system, collecting user’s behavior data can lead to user participatory design where efficient human robot interaction design can be possible

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