Preparation of Basic Robot Technologies –Expending Future Robot System Construction-

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1. Introduction

Various kinds of robots have recently emerged. For example, maintenance robots for nuclear facilities (Fig.1), humanoid robots for human life support , pet robots (Fig.2), remote operation robots in communication networks (Fig.3).
The reason why we can build up these robots is because of element. Since 1970, we have been researching element technologies; arm/leg mechanisms, fine motion control for manipulation, autonomous control, task planning, machine vision, speech recognition, and so on.
This paper describes an example of construction method and design procedure of a robot system, and finally proposes an open architecture for robot controller. The proposed PC-based open robot controller allows you to easily build up your robot systems. [1]

2. A robot is a useful working machine for human life

Each person percieves robots in adifferent way. Thit can cause some confusion.
We would like to classify them into the following 3 groups:
1) Useful working robots; For welding, painting, assembling and so on.
2) Remote operation robots; For aged-person care, nuclear facility maintenance and so on.
Robots in 1) and 2) are defined by working tasks.

3) Humanoid robot; human and a animal. Like robots.
Robots in 3) are defined mainly by shape.
Our robots, which are discussed here, are 1) and 2). An aim of our robot research is to make useful working machines for human life.

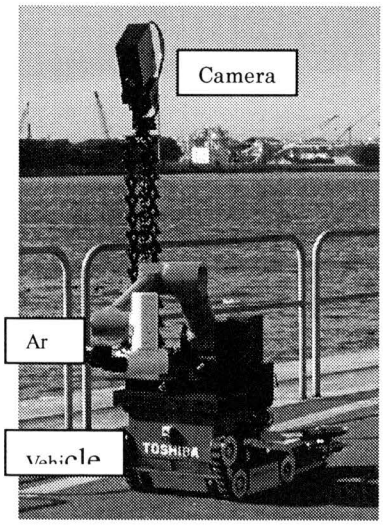

Fig.1 Robotic system for nuclear facility emergency preparedness

Fig.2 Pet robot

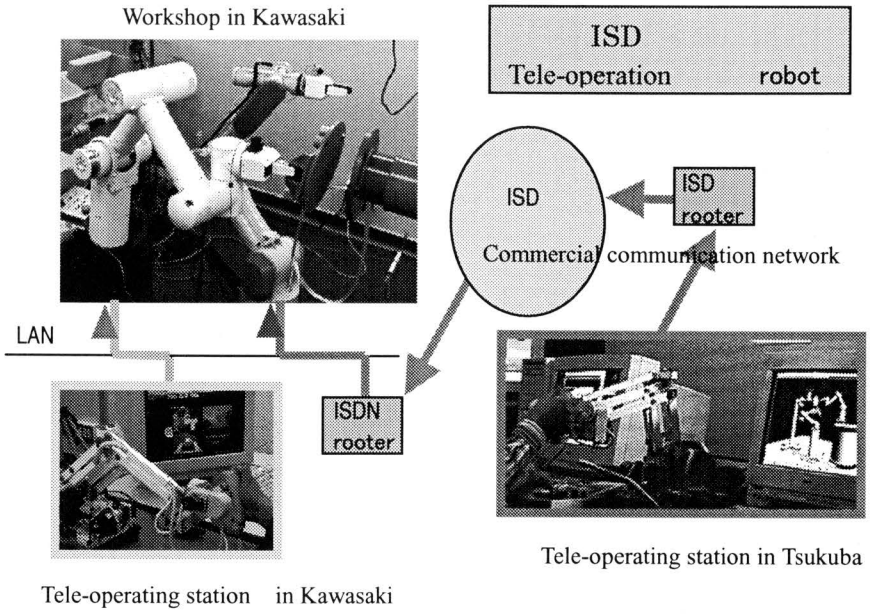

Fig.3 Collaborative multi-telerobot system

3. Subsystem of robot system

We can build up a robot system with the following subsystems as shown in Fig.4.

The robot system is composed of subsystems: Brain which makes task planning and system administration; Vision which recognizes a working circumstance and measures the 3D-position of a task object; Acoustic sense which allows us to communicate with the robot; Arms which manipulate task objects and many kinds of tools; and Locomotion system which carries the other subsystems and task objects.

We have already acquired the element technologies for these subsystems. We will be implementing the element technologies in the PC-based open robot controller.

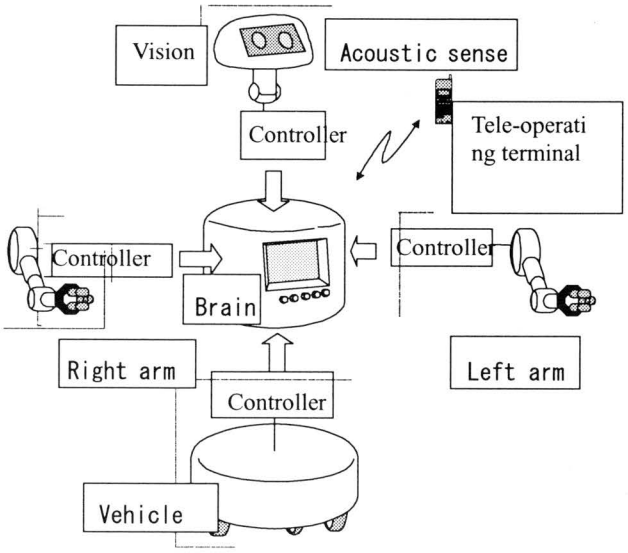

Fig.4　Example of subsystem structure and robot system

4. Design method for a robot system

We will explain our design method using Fig.5. Fig.5 shows a structure of basic technologies for robot systems. We divide these technologies into task knowledge and basic functions. Some of them are dependent on tasks and some of them are independent on tasks.

In our design method, there are top-down steps and build-up steps.Top-down steps:

1) Define a robot by the tasks and the functions it has.
2) Draw images of the robot and the environments, and describe tasks (motion of the robot) with illustrations like comic pictures.
3) Divide tasks into primitive tasks, for example, pick and place, grinding and so on, and describe motions for the primitive tasks with motion parameters (positions, velocities, and forces/torque)

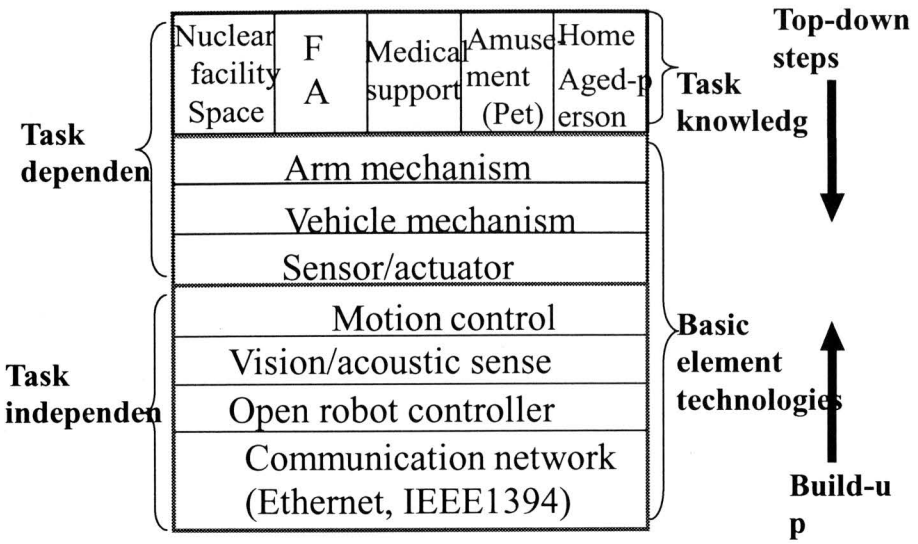

Fig.5 Basic functions and design method for robot system

or sensing quantities (colors and shapes of task objects, etc.)
Build-up steps:
1) Design Mechanisms including actuators and sensors for arms, mobile vehicle and tools.
2) Prepare PC-based robot controller hardware.
Design software for robot motions for primitive tasks.
3) Assembling the target task with the primitive tasks
4) Build a robot simulator and animate robot the to verify the design.

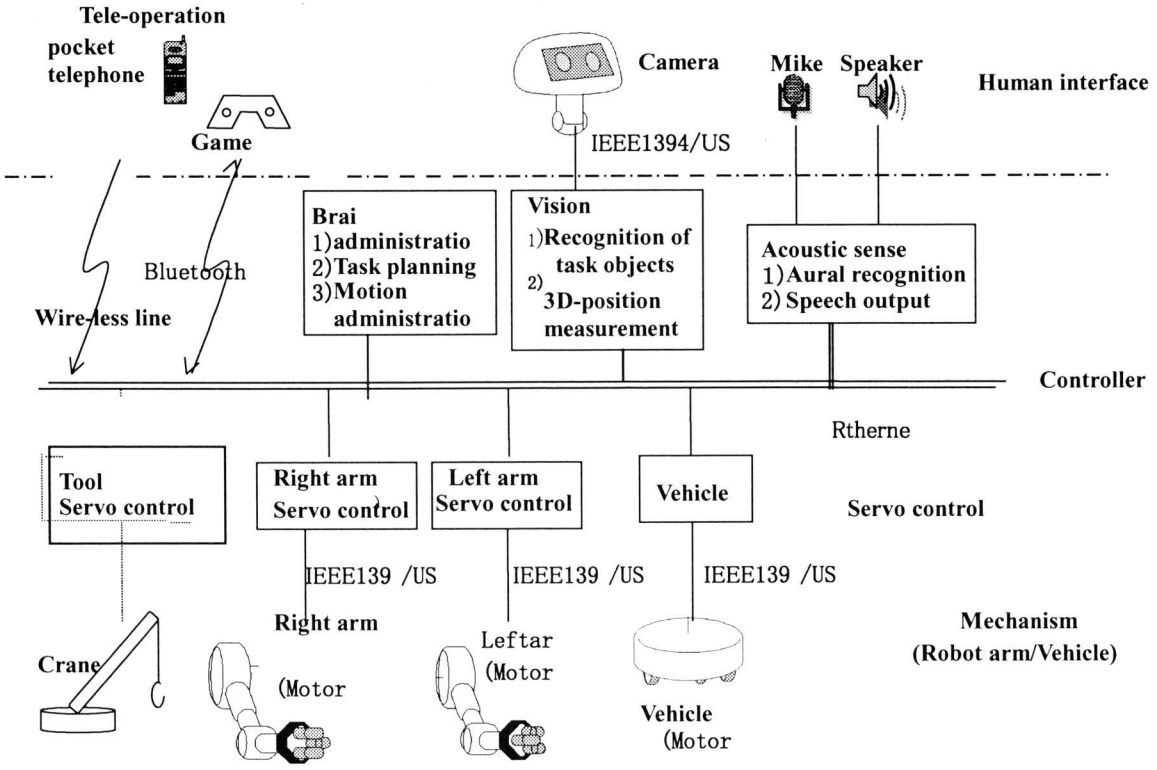

Fig.7 Architecture of an open robot controller

5. Proposed PC-based open robot controller

In the above design method, the robot controller has an important role. In a robot controller, we describe a target task by programming many functions.

Fig.8 shows our proposed architecture of a PC-based robot controller. This architecture meets with the concept of the open NC(Numerical Control) controller. The features of the architecture are the followings:

1) Each subsystem block in Fig.7 corresponds to 1 PC-board.
2) Ethernet connects the subsystems.

Many engineers and researchers accept PC and Ethernet because they are wide-spreaded.

3) Mechanisms, actuators and sensors are connected through IEEE1394 or USB.

By this serial communication line for sensors/actuators, we can easily combine mechanisms and controller. It is a key point of this architecture.

4) Robot can be operated through commercial communication network. For example, we can operate a robot by wireless phone.

We can build up robot systems using the open robot controller, which have many basic functions.

6. For the future

By the end of the 20th century, many machines and apparatuses changed our lives: Electric washing machines, electric rice cookers, electric refrigerators, electric cleaners, automobiles, electric trains, airplanes, televisions, radios, which change daily lives. [2]

We want to successively develop useful machines for human life in the 21st century. One of the machines is a robot, I believe.

References:

[1] Special Reports, Robot Technologies Supporting Human Society and Daily Life, Toshiba Review, Vol.56, No.9 (2001,9)

[2] Japan Society of Mechanical Engineers: Innovation Technologies for Human Life, Gihodo Publishing (1997.11)