Remote Control of Autonomous Robots via Internet

Masanori Sugisaka* and Mohd Rizon M Johari**

* Department of Electrical and Electronic Engineering, Oita University, 700 Oaza Dannharu, Oita, 870-1192, Japan
(Tel. 001-81-97-554-7831; Fax 001-81-97-554-7841; e-mail msugi@cc.oita-u.ac.jp; http://arib.cc.oita-u.ac.jp)
*The Institute of Physical and Chemical Research(RIKEN) at Nagoya
Anagahora, Shimoshidami, Moriyamak-ku, Nagoya, 463-0003, Japan
**Northern Malaysia University College of Engineering(KUKUM), Tarman JKKK, Kubang Gajah, 02600 Arau, Perlis, Malaysia
(Tel :604-9798285; Fax 604-9798292; E-mail: rizon@kukum.edu.my)

Abstract: This paper describes the method how to control an autonomous robot remotely using Internet. The autonomous robot that has an artificial brain is called "Tarou".

(1) It is able to move along the line on the floor based on processing the image data obtained from two CCD cameras.
(2) It is able to understand dialogs between human being and it and is able to take actions such as turn right and lefts, go forward 1m and go backward 0.5m, etc.
(3) It is able to recognize patterns of objects.
(4) It is able to recognize human faces.
(5) It is able to communicate human being and to speak according to contents written in the program.

We show the techniques to control the autonomous robot "Tarou" remotely by personal computer and/or portable Phone via Internet. The techniques developed in our research could dramatically increase their performance for the need of artificial life robot as the next generation robot and national homeland security needs.

Keywords: Autonomous robot, artificial brain, internet, mobile phone, next generation robot, national homeland security

1. INTRODUCTION

The picture of autonomous robot "Tarou" is shown in Fig.1. The specification of Tarou is given in Table 1. The height is 1300mm, front width is 450mm, and side width is 500 mm. The tasks mentioned in the abstract (1)-(5) are performed by the software articial brain[1]-[4], or the hardware artificial brain[5]-[8] developed at the Artificial Life and Robotics Laboratory of The University of Oita.

In this paper, the software artificial brain is explained to achieve the above tasks in Section 2. A technique how to control Tarou remotely by mobile hone or computer at anytime using the public internet system is introduced in Section 3. Also, the brief description of the technique to operate a group of autonomous robots that communicate each other is briefly given in Section 4. One of applications of these techniques for bio terrorism is demonstrated. Finally, the conclusions follow.

2. SOFTWARE ARTIFICIAL BRAIN

The hardware of "Tarou" is shown in Fig.2 where two CCD camera, two computer, two DC motors, one stepping motor, six ultra sonic sensors, and 5 LEDs are installed. One portable computer is used for voice recognition and command executing system (however, this computer is replaced by the above two computers later).

The artificial brain is able to perform vision based navigation, voice recognition, and face detection and face recognition. In Fig.3 the software structure of the artificial brain is shown In Fig. 4 behavioral table is illustrated.

2.1Vision based navigation

There are two types of landmarks used in the navigation based on two CCD video cameras which can capture nearly 24 images/s: one is the continuous landmark (guideline), another is the common landmarks (circle, triangle, etc). The guideline is used for positioning, and other landmarks can make the robot perform some specific action, such as turn, stop, etc. The robot moves at the least speed of 12cm/s. After one image was taken, the guideline and landmarks were extracted and recognized from that image. The robot will act based on the results of the image processing. And it has the capability to search its target as fast as possible when it is moving.

2.2 Voice recognition

Tarou has a voice recognition and command executing system, which are distributed on two computers on hardware and link and local network. The voice recognition system utilizes IBM ViaVoice SDK (Software Developer's Kit) for dictation and IBM ViaVoice TTS (Text to Speech) SDK for speech application.

By using this system, Tarou can now recognize the following commands in English and in Japanese:

1 Go ### meter(s)/centimeter(s)
2 Turn your head to the left/right
3 Straighten your head
3 Look up/down/straight
4 Turn left/right ### degrees
5 No (for canceling of a command)
(### means a number)

IBM ViaVoice provides a tool for building a personal voice model. For example, if a voice model is made by a Japanese people (who speaks English with Japanese accent), then, it will be easier for the voice recognition system to understand other Japanese people's speaking.

2.3 Face detection & face recognition

We have built a real-time face recognition system which is combined with face detection (based on a neural network) and face recognition (based on Embedded Hidden Markov Models (EMM)) techniques. It constantly takes images from the surroundings with the camera mounting on the robot's head, finds faces in them. If a face is detected, the system tries to recognize it.

The neural network is trained with many face examples

to get the concept of a face. It receives a 20×20 pixel region of the image as input, and generates an output ranging from 0 to 1, signing how close it is to a face. We use it to examine a sub-image subtracted from the input image whether it is a face.

For face recognition, we built a separate EMM model for each person in the face database. If a face is detected, it will be matched against each model in the database. The model, which yields the largest similarity value, is reported as the host. The system have achieved a detection rate of more than 85% for front views or slightly rotated views of faces.

3. REMOTE CONTROL OF "TAROU"

Remote control techniques via Internet have been developed. The remote control equipment used in Tarou is transmitter/receiver RDIS/LT-08 which has 8 input ports, 8 output ports, 2 analog input ports, and RS232 port.

The remote control is that the commands from the mobile phone or computer connected to Internet execute the different programs in the computers of Tarou, corresponding to the cases for Tarou to perform various tasks.

8 output ports of RDIS/LT are connected to 8 input ports of the I/O boad, IBX-2726C, in the computer of Tarou. The 8 input ports of RDIS/LT are connected to the corresponding ports to check the states of hardware equipments.

An example is shown in Table 2. When the signal number 2 is sent from the mobile phone, the output signal 00000001 of RDIS/LT is sent to the input ports of I/O board of the computer which activates the program of "Turn the head to the left". When the signal number 13 is received from the mobile phone, then Tarou measures the concentration of the poison gas using biosensor installed and sends the measured data via RS232 to the mobile phone. The other Tarou's action programs work similarly.

4. REMOTE CONTROL OF ROBOT GROUP

There are three types of communication and control methods in the remote control of a group of autonomous robots. The first method is to communicate between autonomous robots and ASP server. The second method is to communicate between robots, in addition to communicate between the autonomous robots and the ASP server. The third method is the combination of methods 1 and 2. We do not describe the details of these methods here.

The ASP server has the job scheduler for the autono mous robots. The server sends each robots signals that provide the contents of jobs. More complicated task oper ation system for a group of autonomous robots is a case where not only the communication between robots and the server but the communication between robots exists. This task operation system plays an important role in the construction of future robot task operation systems.

The application of the system developed for homeland security is illustrated in Fig.5. This figure shows that three mobile vehicles(Tarous) in hazardous field are controlled remotely by mobile phone or computer from operation center or an arbitrary point to measure the concentration of poison gas, anthrax bacteria, other types of bacteria which have ability to kill human being, radioactivity, and etc. Each Tarou sends the measure data and the notice to the mobile phone. The computer at the operation center has three softwares;

(1) software for detecting abnormal patterns,
(2) software for data analysis
(3) software for controlling a group of robots for tasks.

Performing the three programs mentioned above, the mobile vehicle robots team is able to perform their jobs instructed from human being by mobile phone. Each Tarou has their own artificial brain and therefore Tarou's team constitutes spatially distributed network system which enables to make a strong guard unit in order to protect the attacks from terrorists by various means. In this sense, the developed techniques and system are extremely effective for homeland security.

5. CONCLUSIONS

In this paper, the techniques developed to control remotely a team of autonomous mobile vehicles(tarou's) by mobile phone or computer via Internet are shown briefly. Also, one application of the remote control techniques is shown for homeland security.

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Fig.1 The picture of unmanned ground mobile vehicle "Tarou"

* 2 driving wheel (I/O card, D/A converter, DC motor driven by PWM control),
* 2 incremental photo encoders,
* 2 caster wheels,
* rotation of neck (rotation by stepping motor),
* 2 CCD cameras (Sony VISCA protocol control, zoom, pan, tilt possible),
* 4 conditional LEDs,
* 6 ultra sonic obstacle sensors,
* touch panel,
* keyboad,
* Speaker, microphone,
* 3 computers connected by Ethernet,
{2 on board computers (for robot control and image processing),
1laptop computer (for voice processing and mobile phone)}

Table 1 Specification of Tarou

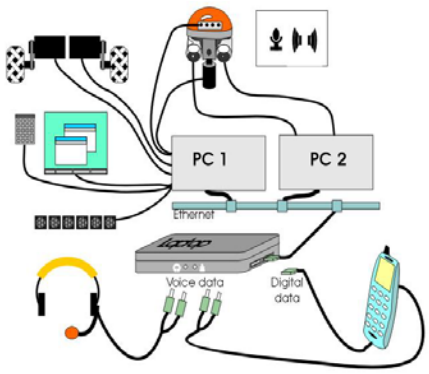

Fig.2 Hardware structure of Tarou

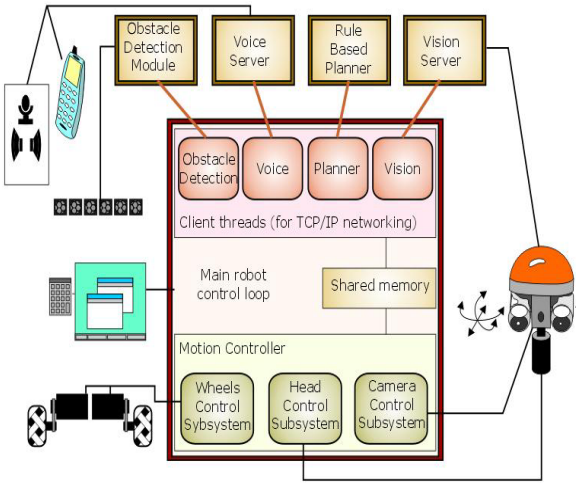

Fig.3 Software structure of artificial brain for Tarou

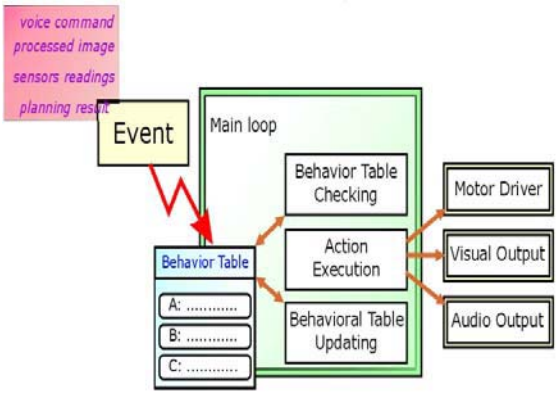

Fig.4 Behavioral table

Output signal from RDIS/LT	Signal number	Tarou's action programs
00000000	1	Initialization
00000001	2	Turn the head to the left
00000010	3	Turn the head to the right
00000011	4	Turn the head to the front
00000100	5	Turn the CCD camera up
00000101	6	Turn the CCD Camera down
00000110	7	Turn the CCD camera forward
00000111	8	Landmark recognition program
00001000	9	Line tracking
00001001	10	Speech recognition and synthesis
00001010	11	Face tracking and recognition
00001011	12	Measure the abnormal poison gas
00001100	13	Measure other types of bacterias
00001101	14	Measure Radioactivity
00001110	15	open
00001111	16	open
others		

Table 2 RDIS/LT output signal and Tarou's action programs in indirect remote control by mobile phone

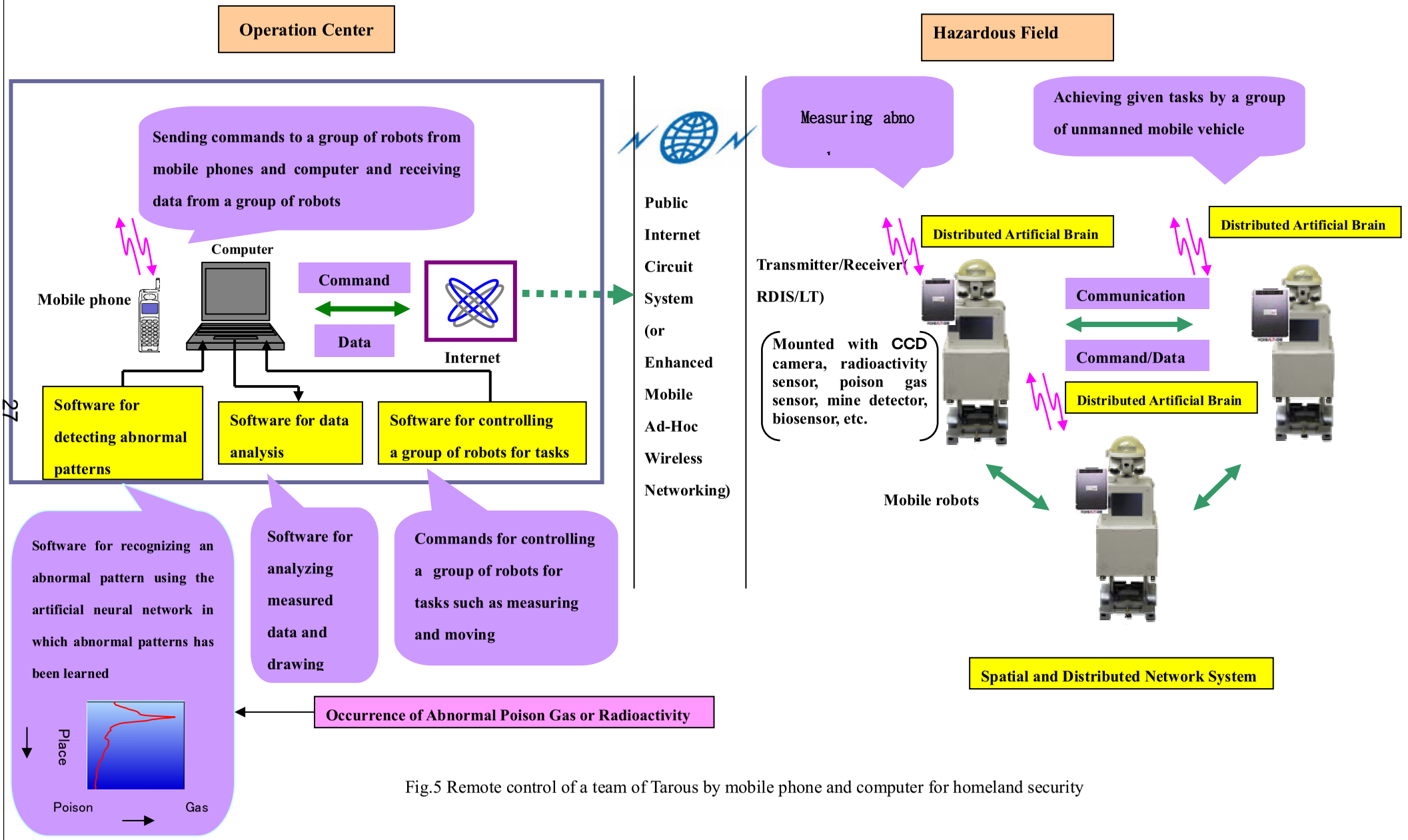

Fig.5 Remote control of a team of Tarous by mobile phone and computer for homeland security