RECONFIGURABLE INTERACTIVITY OF PET-TYPE ROBOT REHABILITATION SYSTEM

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Abstract: This paper addresses a pet-type robot rehabilitation system for aged people. The robot offers interactivity, which can communicate autonomously and communicate with others using Internet-connectivity, for being a partner. To avoid being satiated with conversation, we propose reconfigurable interactivity, especially focused conversation contents. In order to watch over aged people through the Net, we have furthermore developed auto-detection alert system for aged people by checking user logs, which is also reconfigurable.

1 INTRODUCTION

Recently, the rate of aged people is getting higher and higher and, in accordance with that, welfare facilities and tools using advanced technologies have been developed(Bolmsj et al., 1995; Clarkson et al., 2003). Many of them are, however, for aiding persons with manipulation disabilities, or for supporting physical works of carers and aged people, but for mental activities. Especially in Japan, single-resident aged people tend to be isolated with local communities, and that may lead loneliness of those. Thus it is very important to communicate those aged people with others on mental aspect. Pet-type robot system is one important candidate to solve those sorts of humane problems, and there have already been several researches(Matsukawa et al., 1996; Maeda et al., 2002; Ohkawa et al., 1998; Maeda et al., 2003), though they are not focused enough to single resident aged people. We here introduce a new pet-type rehabilitation robot system which consists of pet-type robots and the information center. Pet-type robots can treat as an autonomous pseudo-pet, which can talk to user(s), give information of the local communities, and watch over them and send some information to carers at the information center if needed. To avoid satiating with fixed conversations, we propose reconfigurability of the conversation contents which compensates limited storage space for conversation contents. The system measures satiation of user(s) in various ways.

In this paper we explain some concept and features of our system, and later we discuss some examination. We here have demonstrated and examined some features of this robot system for aged people, using some of the robots, and certified some effects of our system.

2 CONCEPT OF PET-TYPE ROBOT SYSTEM

Figure 1 shows the basic concept of our system. The robot should treat as an information terminal as well as a virtual pet for aged peoples. For realizing those requirements, the robot is net-accessible and that feature allows the people to communicate not only with carers, but also with relatives, acquaintances, and so on. That is quite important for aged people, especially self-resident, not to feel alone.

The robot has some functions, such as:

- Autonomous communication (conversation with user(s)),
- Voice mail via information center(s),
- Voice BBS (bulletin board system) on the information center,
- Telephone call with photo attachment,
- Image delivery for watching over, etc.

As described above, communication is very important for our system, and so we discuss those functions in details, in the following sections.

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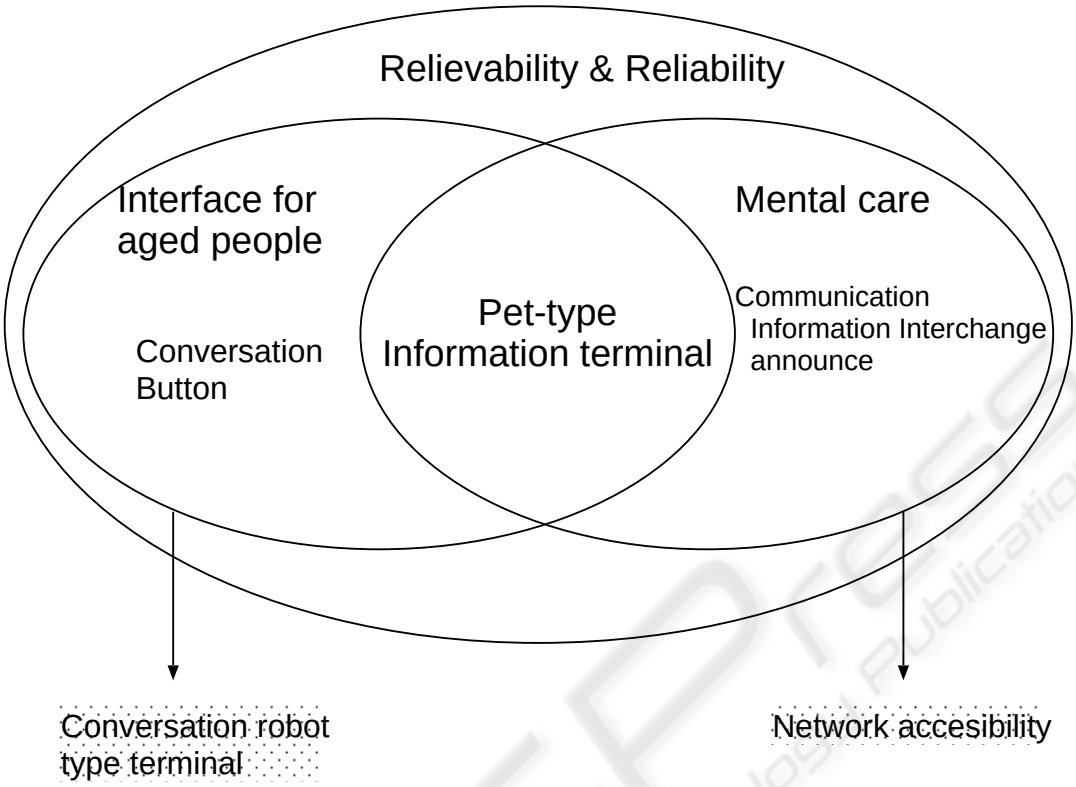

Figure 1: System concept.

3 COMMUNICATION ARCHITECTURE

Figure 2 shows the network diagram of our system. All robots, or terminals, are connected to Internet, which means the robots are regarded as Internet-accessible terminals. Furthermore, those treat a telephone if required. In the following subsections, these functions are described.

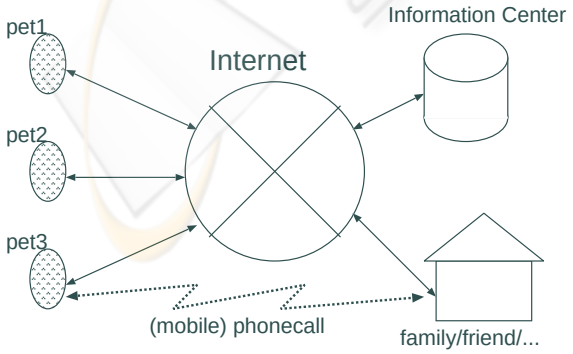

Figure 2: System network diagram.

3.1 Communication for surveillance

Each robot has a CCD camera to watch over user(s). Images can be taken by the camera, and are sent to the information center via Internet, which is connected by a mobile phone. Then carers can get informations easily for surveillance. If the user requires, the robot sends images in regular intervals, and that offers some of continual watching, which means a sort of lifeguard. That means, for instance, when the same images are sent for a certain period, the carers can get a situation such as the user may have some trouble (e.g. a sudden heart attack) and then go there to rescue.

3.2 Multi-modal interface

Speech techniques are, furthermore, used to some information exchange with the robot. That speech operation makes those people feel naturally and friendlily, and then improves usability much.

The current robot system supports the following invocation of communication;

- “Telephone button ON!”: by this speech command, a user can take a telephone call, or catch a call.

- “Tell!”: supports voice mails. At that time, a user can choose “(normal) mails”, or “special (messages)”.
- “Bulletin board!”: opens voice BBS. In the situation, a user can designate “Answer” for followup of others’ message, or “Question” for invocation of new a thread (theme or topic) in the BBS.

Those are mainly for communication with others through Internet and/or telephone networks, which helps user(s) to communicate with relatives and friends easily, as there are still some amount of people, especially aged people, who are not Internet-accessible.

3.3 Autonomous conversation

Besides networking communication, autonomous communication is strongly required for self-resident aged people, as the pet robot can be a partner and then that may avoid the user from loneliness.

Autonomous communication consists of speech recognition and speech generation. Speech media for operations are very useful for aged people, who are not accustomed to use computers straightforwardly.

The current version of robots can tell the user his name, current date/time. The robot can use around 200 Japanese words, including (translated in English);

- “Good morning!”,
- “Wake up!”,
- “Bye Bye”, and so on.

If a user talk to the robot “Wake up!”, the the robot talks the greeting back to the user, and gives one arbitrary health advice at random, which give user(s) some feelings of “live creature”. Furthermore, for the purpose of getting friendly, the robot can sing several short songs.

Note that those speech is not synthesized but just composed from parts of speech pieces, which were previously recorded and edited from human speech. This composed method found to be more natural to listen to, and that leads quite important characteristics for aged people to be easy to communicate rather than synthesized ones.

4 HARDWARE FEATURES

4.1 Robot structure

To reinforce interactivity, including communication with user(s), more naturally and friendlily, the robot has some sensors and motors.

Figure 3 shows a skeleton of the robot.

Figure 3: The robot skeleton.

Those components enable the robot to behave much more like a real (living) pet, which afford to be more friendly and easy to contact (Gibson and Walk, 1960).

Sensors work for catching some signals of friendliness, which makes the robot cheer up / down, as well as for interrupting its action, speech, etc.

Considering necessity and sufficiency, the robot has four motors; one for both ears, one for both eyes, one for the nose, and one for the neck. Motions generates by those motors symbolize emotions of the robot, which is essential for our object. For instance, the head, followed by neck, can move vertically, which imply the emotion of bowing, and horizontally, which imply negation, or “No, not at all.”.

Figure 4 denotes motions of the robot.

4.2 System structure

Figure 5 shows one of our prototype robots.

At the moment the robot consists of two units, stuffed toy unit and control unit, and those two are connected by a serial line. the toy (doll) part has motors and sensors, and motion commands and sensed signals are sent to the control unit.

To afford user(s) to use easily, or pleasantly, several components are set as follows;

- A camera is embedded into a toy camera.
- Microphones are set at both ears.
- A speaker is set just under the mouth.

We at the moment use a laptop computer for the control unit, and the control system (softwares) is programmed on Linux.

To and from the information center, communication, or information interchange is done through the Internet, with TCP/IP protocol of course. Telephone

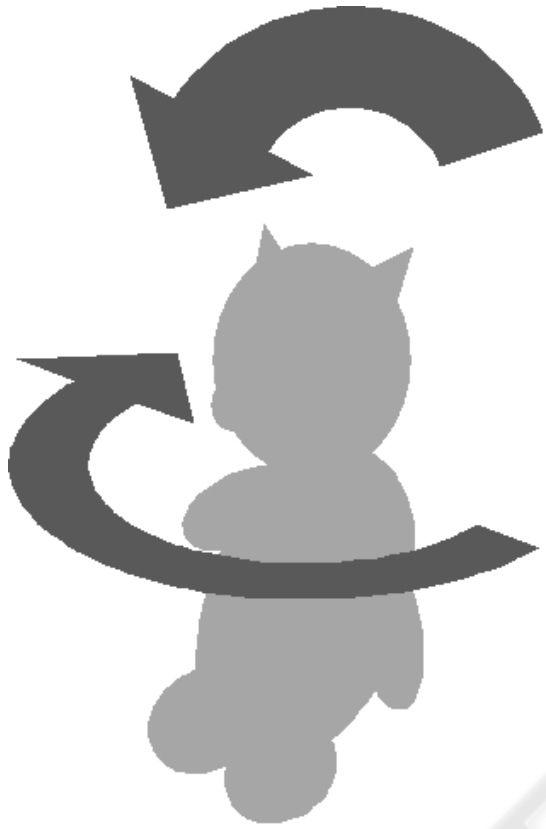

Figure 4: The robot motion.

calls are not to use VoIP protocol, but done using facility of (stand-alone) PHS, through public telephone network.

5 RECONFIGURABILITY OF INTERACTION

5.1 Interface Usability

Pet-type robots should satisfy following requirements with view of aged people's usability:

1. They should not give a feeling of machines, or electronic equipments. For aged people, those "Hard" equipments are very tough to touch, and that leads not to use frequently.
2. They should be able to give some conversation with contact and/or speech, that let user(s) be kind, or easy to communicate.
3. They should not force user(s) to use.

Figure 5: The prototype robot.

To solve above problems, we install the following features:

1. We designed a robot body as a stuffed toy bear. That enables the robot to be more emotional, which is essential for pet-type robots(Fujita, 1999).
2. We have developed speech input (recognition) and speech output (synthesis or conjunction), and other multi-modal interface for conversation (explained below). Those techniques realize behavior of pets, and also offer affordance(Gibson and Walk, 1960).
3. We designed user interface as easy and simple as possible. For instance, a user does not need to operate any mechanical equipment for telecommunication such as making a telephone call (discussed below).

5.2 System Reconfiguration

Figure 6 shows a diagram of reconfiguration system.

In each robot, the storage is limited and so we cannot install enough amount of interactivity procedures at one time, especially for conversation contents. In this paper we focus on conversation interactivity, which is essential for our rehabilitation robot system. When user(s) use the robot more and more, user(s) may get boring more for that reason. To avoid

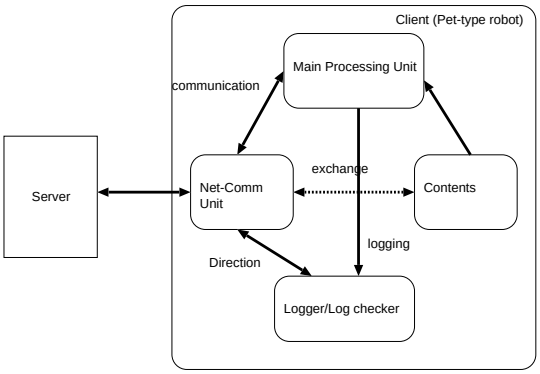

Figure 6: Reconfiguration diagram.

satiating with robot interaction, we propose reconfigurability of Interactivity.

The system measures satiation of user(s) in various ways;

1. The system analyzes the usual usage of the user by active usage time at the first time, and
2. the system checks the logs where which contents are selected more often, and
3. if some of them are selected over a certain threshold value, or one of other ad-hoc rules matches, a trigger event occurs.

Ad-hoc rules are, for instance, “If a sentence was invoked frequently at past, and are not used recently, then the sentence may be boring to the user”, and so on. With that trigger, the system reinstalls the contents through the net from the server. For instance, if a user often ask the robot to sing a song, contents of songs are limited (at the current system only 10 songs are involved) and the robot system exchanges songs if all songs are sung three times at the current configuration.

6 AUTO-DETECTION ALERT SYSTEM

In order to watch over aged people apart from their residences, automatic alert system is a very useful function. The server has logs of usage history of each user(s), and so system can check the frequency of the pet-type robot. The system watches logs continually and the alert is generated when the user has not use the robot during a certain period, 24 hours at the current configuration.

Table 1: Questionnaire results (%)

Q	V	G	N	B
How frequently do you think the robot understand you?	33.3	33.3	14.3	19.1
Do you feel the design of the robot is good?	31.3	62.5	6.2	0
Does the robot speak well?	33.5	43.8	22.7	0
How do you feel by listening to the delivered messages from the center ?	62.5	31.3	6.3	0
Do you feel friendliness with the robot?	57.1	33.3	9.6	0
Do you think you feel lonely without the robot?	23.1	53.8	15.4	7.7

7 DISCUSSION

We have examined a field test, and targets are 73 single-resident aged people. Each person use the pet-type robot averagely 62 days, and in that period we have done 4 interviews and 2 questionnaires.

Table 1 presents questionnaire results, where “Q” stands for Questions, “V” for “Very good”, “G” for “Good”, “N” for “Not so good”, and “B” for “Bad”. It actually shows our system can be used quite well, though it is not complete. Especially, the item of “understanding” is not of good point which may cause from insufficiency of speech recognition, and thus the function of speech recognition and autonomous conversation should be improved.

Table 2 shows statistics of conversation data, derived from log-messages in the center (server). The system is used approximately each two days, which seems to be moderate. User(s) turn on the switch twice a day, which may causes from mail checking on morning and evening. Conversation time is about 6 minutes, and it may be enough for get and give information.

For the auto-detection alert system, we focus 60% of the testers who periodically uses the robot. During the experiment period, alerts occur almost every 6 days, all of which are not serious, or mis-alert. From questionnaires, even though mis-alerts happen, most of user(s) feel safe by watching over.

As for the reconfigurability of conversation contents, we have just implemented the modules and not enough experiments are done yet.

Table 2: Usability statistics.

Item	Average
Active rate (actual used days per monitored days)	53.5%
Power-on frequency (per day)	2.05 times
Conversation time (per one conversation)	5 minutes 47 seconds

8 CONCLUDING REMARKS

We developed a pet-type rehabilitation robot system including the information center, and certify some of our system's effect.

We need more field tests for analyzing our system more precisely, as we have not done enough amount of examinations. Furthermore the contents, which consists of conversation sets and speech programs, should be reconsidered for the more comfortable and pleasant interaction.

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