Motivated toward the revitalization of local communities, we have started an aggressive study on community support systems. In particular, we have studied a “community-centric system,” in which individual persons are tied to each other in a natural manner. In this paper, based on this community-centric concept, we introduce different robot operating interfaces, dialogue robots, and a telepresence system for generating human ties.

Keywords: community-centric system, robotics, communications

1. Introduction

One of the technical advances in the late 20th century has been the technique of human-centric design, which is aimed, for example, at finding solutions to the following questions from a human-centric point of view: How can we make easy-to-operate machines, and what makes a system untroubling, uncomplicated, and easy to use? Human-centric designs have led to the creation of the GUI, the advent of touch panels, and the nearly ubiquitous spread of mobile phones. Increasing endeavors in designing such machine systems that anyone can use at any time have contributed to the above-mentioned advancement of new devices. In the 21st century, people connect with each other through texting and social network services (SNSs). In current society, what connects people together is simply our so-called “weak ties.” Are we really satisfied with such “weak ties” in our networks? Or do we want to form and maintain communities with strong ties while taking advantage of such weak ties? In conjunction with the recent proliferation of studies on big data, we believe it is more important to focus on individual persons within communities.

2. Community-Centric System

As citizens of Japan, which sustained heavy damage during the 2011 Great East Japan Earthquake and the 2016 Kumamoto Earthquake, we have been engaged in studies on routine disaster prevention activities. Although the above-mentioned weak ties may be useful in certain types of emergencies, where a variety of means are used, for example, to inform the public through an SNS regarding the shelter status or to confirm important safety information, our studies have found that strong mutual assistance within neighborhoods is the most important element for making a town resistant to disasters. Nonetheless, what people can genuinely rely on for support during the several days that pass after the occurrence of a disaster has interrupted certain network functions, and up until the recovery of such functions, are their own local communities. Under the circumstances, community-centric systems that take clues from human-centered designs and are focused on individual members of the community are now attracting significant attention. Although human-centric designs are directed toward human-centered designs, community-centric systems are directed toward designs achieving human ties or designs for people to be tied to each other in a natural manner. Community-centric systems can provide venues where people can share not only certain locations and times with each other but also information and experiences.

Special collections of papers in IEEE Trans. IES have featured studies on spatial knowledge, and a number of international conferences such as IROS and ICRA have also held special sessions in this area. To study such human-centric systems, we participated in the development of image-recognition devices and modules through the NEDO project, which aims to develop a common foundation for next-generation robots sponsored by the Ministry of Economy, Trade, and Industry. In addition, through the NEDO project, we have also built a foundation for human-centric systems with robotic communications to develop intellectualizing technologies for next-generation robots. We also produced quality results in the development of watching robots during a project to promote the use of elderly support technologies, which was sponsored by the Tokyo Metropolitan Government Bureau of Social Welfare and Public Health.

Through participation with, and the promotions of, the above-mentioned projects, we have come to realize the
importance of acquiring living logs of users from studies on social robotics as social media forming a human-centric system, as well as the importance of using social big data to build user models by analyzing such acquired logs (social big data). In other words, to provide a support system meeting a variety of user needs for health, welfare, and care, it is important to build user models by analyzing social big data as a set of individual logs acquired through communication among social robots as social media and users. The above-mentioned method of thinking is an international trend, as represented by Softbank’s movements to acquire social big data through communications between the domestic robot Pepper3 and users, and through Google’s undertaking of studies on social robots and the use of social big data [a]. We can call such movements a paradigm shift from human-centric to community-centric systems.

Campbell et al. introduced a people-centric mode of thinking [1], in which any social information can be acquired by integrating information obtained from the sensors of individual smart phones and other devices. The use of individual sensors to obtain social information will prove important for studies on community-centric systems. In addition, we paid particular attention to the fact that the same person plays a different role in a different community. Although an individual person can be identified through various means such as facial recognition or fingerprint authentication, depending on the environmental information regarding who the person is with, where they are, and other types of information, the person’s role may be determined to be a father, chief manager, tourist, or host entertaining guests. Thus, it is important to take into consideration such changes in the roles played by individual persons in designing community-centric systems.

For community-centric systems to materialize, we have been engaged in developing social robots. Such community-centric systems, actually robot systems using social robots familiar with humans and societies, are expected to lead to a revitalization of communities based on human information obtained from robotic communications. In our view, a social robot system is composed of three steps, as shown in Fig. 1. In the first step, user logs are acquired by the sensors and analyzed for their personality, for which the latest sensing technologies enable us to obtain information on gender, age, and even feelings. Furthermore, dialogue logs may enable us to presume where their interests are directed and to what degree they are interested. The use of location information through GPS or other types of services, and big data through an SNS or other service types, will enable us to extract when, where, and what information users want to obtain. In the second step, extracting personal data from the acquired information while duly protecting their privacy and analyzing such personal data will enable us to predict information users want to receive. In the final step, robots offer information presentation services as well as serve as a bridge for tying people to each other. Some of the community-centric systems currently under development are introduced herein.

3. Safe and Secure Mobility System

Safety and security are important elements for humans when dealing with machines. It is also important that machines not psychologically damage human users, and that they provide a sense of security. To ensure such safety and security, we first need to consider what aspects of the machine cause anxiety in users, and what aspects provide a sense of security. Therefore, we have focused on the so-called personal space and developed a mobile robot. In this paper, we introduce the effects of the robot’s approaching patterns, as well as the added sense of security achieved through an intuitive finger-pointing robot operation.

3.1. Robot Operating Support Considering Personal Space

We can often see guidance robots placed in shopping malls or other locations. Most are only capable of voice interactions, and can move only their heads or hands. Their mobile mechanisms are not fully used, probably owing to a sense of unease with mobile robots. To effectively use the mobile mechanisms of a robot, we need to review its approach method to provide users with a sense of security during use. Therefore, we studied the changes in user impressions regarding telepresence robots approaching through different patterns. Telepresence robots equipped with a mobile mechanism, and recently developed as an extension of video conferencing, include Double 2 of Double Robotics, Inc.4 In the above-mentioned study, we used a concierge robot of Vector Inc. for our experiments as shown in Fig. 2 [2] in which we checked the effects of a robot approach in the personal space of a standing subject through different patterns, i.e., at different moving speeds, with deceleration methods, and with and without uttered sounds. The experiments showed that a robot can approach closer to a standing subject in a smaller personal space by vocalizing when it starts moving than it can by abruptly approaching the

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subject without saying anything (Fig. 3). We are proceeding further with studies seeking the relationship between such personal spaces and personal traits (using the Big 5 model) [3].

3.2. Interface Using Finger Pointing

The above-mentioned study was concerned with a scenario in which a robot approaches a human subject. We also studied some operator-support systems, such as information presentation to car drivers [4] and wheelchair operational support [5], and we are currently proceeding with studies on gesture-operating systems using a wearable device [6]. The proposed operating interface can automatically move a robot by pointing a finger at the desired destination. We need to take individual users into consideration when deciding how to avoid obstacles and how to accelerate and decelerate. To make the operations as close to human operations as possible by having the robots learn by themselves the more comfortable traveling speeds or turning methods, we plan to incorporate a sense of unease in the user as represented by their heartbeat and facial expressions (Fig. 4).

4. Development from Dialogue Robots to Human Dialogues

User needs, hobbies, and adherences can be obtained through a variety of methods, such as questionnaires and analyses of their action logs. We have been aggressively engaged in extracting information on users through their dialogues. Therefore we consider a dialogue system essential for users to feel like continually using the system and we have proposed to acquire users’ dialogue contents from their utterance histories. In addition, we have studied how to recommend appropriate information to various types of users such as tourists and how to collect social big data on them. We hope such studies will lead to the development of systems supporting the building of co-occurrence and mutual assistance relations within local communities. Our studies are briefly described in the following subsections.

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**Fig. 2.** Tests on changes in personal space with approaching robot.

**Fig. 3.** Effects on personal space by approaching robot with and without vocal utterances: Model 4, without utterances; and Model 7, with utterances (excerpted from [2]).

**Fig. 4.** Robot operations through finger pointing.
4.1. Acquisition of Dialogue Contents from Dialogue Histories

Dialogue robots, capable of making online interactions, have been aggressively developed. One of the most familiar dialogue robots may be Siri, which can conduct searches or control telephone calls through vocal interactions. A business model for Pepper that can introduce products or work as receptionist is also available on the market. How to generate contents for such dialogue robots is one of the issues we need to address. Text dialoguing methods using Twitter or Wikipedia contents have been mainly proposed in the field of natural language processing. We proposed a method through which some of the user dialogue histories collected in a cloud are reused for robot utterances, as shown in Fig. 5. The study results show that daily updates of the dialoguing data help to maintain or increase the number of dialogues [7]. Fig. 6 shows the results of the experiments we conducted using a total of six subjects. During the first experiment conducted in June, the dialogue contents of all six subjects were updated every day, and during a second experiment conducted in July, dialogue contents of only three subjects were updated. The subjects whose dialogue contents were updated (framed with rectangles) maintained or increased their dialoguing times, whereas the subjects whose dialogue contents were not updated decreased their dialoguing times. The above-mentioned experimental results tell us that dialogue contents should not remain static but should be updated dynamically. We are now engaged in studies on how to collect information on users while protecting their privacy, as well as on automatic data selection.

4.2. Tourist Information Robots Using Cloud Data

We have focused on how to acquire utterances for the above-mentioned dialogue robots. From a robotics perspective, for humanoid robots such as Pepper, we need to generate not just vocal utterances but also actions, voice intonations, and facial expressions in conjunction with the contents. To analyze the contents and dynamically generate actions and facial expressions while maintaining natural dialogue speeds, we need high-performance computer specifications. Therefore, we proposed a cloud system for possible application to the robotics field, as shown in Fig. 7. Humans can create dialogues regarding the current weather, for example, based on commonly understood tacit knowledge that is not expressed in words. Therefore robots should also be able to generate dialogues based on such tacit knowledge regarding the weather and other types of subjects. Conventional methods, however, often analyze the HTML or RDF data of the web pages that human users have browsed for use in robot dialogues. Such analyses take a lot of time and effort. In addition, the clients themselves have to generate the data on their actions, facial expressions, and other elements. Robot services are standardized, as represented by the Robot Service Network Protocol (RSNP) [8]. In the future, more secure communications using such standard protocols may become necessary. However, we believe that the development of robotic applications as an extension of much simpler smart phone applications can lower the threshold for robots. Our proposed cloud servers publish data on weather forecasts and other elements in the JSON format, and thus, users can obtain weather information, living indices, and so on using generally available HTTP access and the JSON API [9]. Of course, RSNP contains so-called weather information profiles [10]. Compared with such weather information profiles, the characteristics of our cloud servers lie in the feeling codes assigned in cor-

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respondence to the living indices. The information “No umbrellas are necessary” is deemed as positive, and the information “Be careful to avoid a heat stroke” is considered negative. Of course, the information “An umbrella is necessary” may be judged as positive in certain cases. The assignments of such feeling codes on the cloud side will not create unnatural dialogues because they are specified within the “travel guide” domain. We also collect user logs while paying due attention to user privacy, allowing us to recommend more appropriate information.

4.3. Matching System Based on Co-Occurrence and Mutual Assistance

Robot-human dialogues can be applied to a variety of services in our daily lives, such as information or viewing services. We have learned from disaster-prevention related projects that mutual assistance among people is of most importance. In building disaster-resistant towns, regular human ties among residents within a neighborhood are very important. Therefore, we studied the development of certain systems to discover and build such human relationships. What we aim to build are not merely conventional co-occurrence relations, or so-called resemblance, but also mutual assistance relations (Fig. 8). We proposed a method through which individual characteristics are first extracted based on dialogues or questionnaires, and any co-occurrence relations are then discovered from such individual characteristics, as are mutual assistance relations such as the “things one is good at” and the “things one is not good at but is interested in” [11]. Using the proposed method, we actually conducted dialogues by presenting some co-occurrence and mutual assistance topics, and found some synchronous trends in their heartbeats between both types of topics. A simulation analysis of the proposed method shows that it is important to mutually assist with not only those things one is very good at, but also those things “one is only slightly good at” [12].

5. Telepresence for Human Ties

In the preceding sections, the interfaces connecting humans to robots, as well as the foothold for shifting from human-to-robot dialogues to human-to-human dialogues, are described. We have been engaged in developing telepresence robots as a part of our more forward-looking studies on community-centric systems. One such system supports the transmission of non-verbal information that is more likely to be missing in video dialogues. Another is a video conferencing system focused on visual line information through which, based on shared material, we can determine who is paying attention to what information.

5.1. Telepresence Robot Synchronized with Head Motions

Information provided interactively can be largely divided into verbal and non-verbal information. Video interactions and telepresence are likely to lack the dialogue counterpart’s non-verbal information. In particular, using a compact tablet device, the dialogue counterpart’s face displayed is so small that slight motions are likely to be overlooked. Therefore, we focused on the head motions, which we observed using a Kinect to build a robot capable of simulating head nodding (nods and Aizuchi responses) and shaking (denials) motions, as shown in Fig. 9. We conducted experiments using such a telepresence system on a pair of individuals who match the above-mentioned co-occurrence and mutual assistance relations [13]. As the phrase “a harmonious combination of two persons” suggests, when people get along well with each other, their heartbeats are also synchronized. Pairs of people with co-occurrence and mutual assistance relations were also shown to have synchronized heartbeats when using the telepresence system. To support the building of co-occurrence and mutual assistance relations, we are now engaged in studies on robots that can intervene in telepresence dialogues and dynamically present items of mutual interest.

5.2. Multi-User Telepresence

Telepresence systems are considered effective not only for video dialogues but also for many-to-many dialogues such as video conferences, for which, however, we may need to prepare dedicated lines because many participants and connecting terminals can apply a heavy load to the network. Our proposed system does not transmit video images as they are, but uses virtual reality to transmit a limited amount of information such as facial information, visual line information, and feeling information (Fig. 10). For visual line information in particular, we use Kubi6 to extend the system’s movable range allowing it

Fig. 9. Telepresence robot synchronized with head motions: the dialogue counterpart’s robot simulates head motions such as nods that are synchronized with the head motions of the user.

Fig. 10. Multi-user telepresence system.

References:
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