Discussion

Takanori Shibata

Q: About battery life of the Paro.

A: In the specification, it is about 1.5 hours. Of course it varies depending on the energy consumption. In the future, the Paro might be able to operate by some fuel cells with some alcohol drinks.

Q: You have been developing your robot as an engineer. Now you challenge to spread the technology.

A: There are two aspects of this research; to technically advance the robot and its evaluation.

Q: What kind of new technology are you trying for this robot?

A: This is the 8th version of the robot. So far I have been improving the robot in many points. For example, the first one is the tactile sensing technology. With it the Paro can react to the human's touch delicately. The second is about actuator. You rarely hear the motor's gear sound. It is very silent. This 8th version has been tested for more than one year. So far, no malfunction has been reported.

Q: About the Guinness Record.

A: I once exhibited the Paro in the science museum in London, where one of the researchers from the Guinness Company was interested in this robot and the related technical papers of my own. Later they created a new Guinness record category for "Robot Therapy" and certified it. In the robotics field of the Guinness record, the Paro was not the first. The AIBO got the one because they were sold in the rapidest time ever. And also the ASIMO got the one in the Humanoid type robot category.

Q: About the boredom for the robot.

A: I have been investigating the boredom of the Paro for many years. At least, in the elderly institution, the interactions between the elderly and the Paro lasted during the experiment. Of course they were not playing it for full day but they continued to play it sometimes a day. Even though they shortly got bored it, after that they got interested once again. These are findings as group users. Next year I will commercialize it to individuals. I'm interested in the results.

Q: Do you have more psychological evaluations for the experiments about the dog's tail moving in the movie?
A: No human is interested in just a mechanical bar's one degree-of-freedom motion, but in dog tale's movement. Moreover if the tale can react to the human's action, he/she might feel something emotional of the dog in the motion. This is the simple but basic way to study the psychological aspect.

Q: Are there any different findings between actions of the female and male?
A: I have some questionnaires for ordinary people. The results showed that there were some groups who gave the positive values. According to the questionnaires, a group with less than 20 years old and more than 50 years old showed the higher values. And we found that female had higher values than male. As shown in the video, an old man created a song for the Paro and was singing it happily. This is the typical behavior of the male user. Generally speaking, in elderly institutions, the ratio of the female is higher than one of the male, so I have female's data more.

Taisuke Sakaki

Q: How about regulation to introduce such a new technology for a practical clinical use?
A: I have no information about the regulation in the US. In my case it took about half year to get the regulation. This is not an invasive machine for human' body, so it is relatively easy to get the regulation.

Q: How about the safety of this machine?
A: There is a kind of assessment to ensure the safety of the robot. For this robot, there is triple safety mechanism. The first one is software to prevent the overload for the patient's lower extremity. The second one is a redundant electrical circuit to shut down the irregular current. The third one is a mechanical safety to ease the overload.

Q: I think for the human therapist it may be very difficult to move his/her arm with a very low speed for a long period. On the other hand, for the robot it is easy. Is this a big benefit of the robot?
A: Yes. One of the merits of the robot is that it can do repetitive task. And also the robot can do the task which human therapist cannot or does not want to do, such as monotony and repetitive action.

Q: In what point is the robot better than human therapist?
A: The robot can work better for simple and repetitive actions for a long period than therapist. On the other hand, human therapists can do more complicated, severe and important therapy than the robot. They have good points complimentary. This is a kind of work sharing.

Q: Is there any way to react to the patient's pain?
A: Yes. The machine modifies its motion to prevent the overload to the patient according to the load sensor information.

Q: Could you explain more information about the training experiment?
A: In the gait training machine providing information on the gait pattern timing, three hemiplegic patients joined the clinical test with gait training for twenty minutes per day, five days per week for two or three weeks. During the experiments, we have checked the safety and interface of the device.

Q: How quickly can the robot adapt patient's difference in such as size or test pattern?
A: Before the start of the training, therapist inputs the basic parameters of the patient's body size such as weight, size of the knee and so on. Using these parameters, the NEDO robot can automatically generate an appropriate pattern for the patient based on the standard pattern.

Q: Is the foot pressure data reasonable as normal subject?
A: Three pressure sensors mounted on the bottom of the foot cuff will shows three peaks in the case of normal subject. However, some different patterns were shown in the case of hemiplegics patients. Those data have been shown to the patients during the training.

Q: Could you tell us a future vision of the rehabilitation robot for home use?
A: Very tough question. This current version is too heavy and complicated to use in a home. But in the near future, I hope such a kind of rehabilitation machine will come into our home just like a current commercially available exercising machine for home use. Of course, we have to try the subject on size, weight, cost, and human interface to realize the home-use rehabilitation machine.

Stephen Intille

Q: The apartment you describe was for a single occupant. Have you looked at addressing spaces where there are multiple occupants and thinking about how you track multiple people in one living space?
A: It's a one-bedroom apartment so we can handle two people if needed, but the activity recognition is easier to do with one person, and it's a pretty hard problem to begin with. We're trying to focus mostly on a single occupant right now, but we're going to move to a second occupant at some point. When you have two people, certain problems such as interruptions become more significant, and you have multi-tasking of activities. In that case, the algorithms need to differentiate which sensor data maps on to which occupant's activity, and that's a challenging problem.

Q: What causes the difference in the detectability of activities?
A: It depends on how an occupant performs a particular activity and what sensors are used. This is fundamentally what we're interested in—understanding how the environment and the person's individual behavior impact how to design the algorithms that will work for those people.

Q: Is there any reason why you use only switching sensors? There are many different sensors, such as infrared sensors to detect motion and directional sensors.
A: The Place Lab uses computer vision to select video views, but I got tired of answering questions about privacy. A camera is very flexible—I call it an "optical sensor," which makes some people feel more comfortable. In theory, I can put one camera in the living room, and if computer vision worked as I would like it to work, it would be able to understand, like a person does, what you do and identify your activities. The problem is that the computer vision, like many artificial intelligence problems, is much harder to do than it appears. In reality, using a very flexible sensor can sometimes make the sensing much, much harder. In addition, some of the more flexible sensors are the ones that scare people the most and make them feel like they may lose their privacy.

We've purposely taken the opposite approach, which is to take the simplest sensor we can and embed it ubiquitously in the environment. As long as the sensors are easy to install and we can get them to detect the activities we are interested in, we feel like it is a good approach. But if another sensor comes along that will do the job, I'm happy to put it in the PlaceLab and try it. I'm focused at this point on creating systems that people can install themselves, because if a great technology requires an expert to install,

then the time to adoption is going to be substantially longer than if somebody can go to their local computer store, bring home the sensors, and install them themselves.

Q: From an implementation standpoint, do you work jointly with people doing research on the psychological side to help you understand human behavior, and then once you understand it, how to use computing technology to encourage people to modify their behavior?

A: In the last couple of years, I've learned a lot about behavioral science specifically to work on this problem, but also I have collaborators at Boston Medical, Stanford Medical, and other institutions. I've been working with those groups to figure out: How does the technology need to change in each stage to modify behavior? With exercise, for example, there's a certain percentage of the population that isn't even thinking about it. If their mobile phone can detect that they're walking or they're getting a brisk walk that's unusually long, what could it do? But then there's another group that are fitness nuts; they go to the gym all the time, so the type of intervention they need is different. We are trying to see how far we can go with this idea of "just-in-time" interventions, where the computer detects what the person is doing and then provides feedback.

Q: What I think you are actually doing is using Place Lab to make smart people, not smart homes.

A: Yes, if you have an idea for an intervention, say motivating physical activity or helping somebody change his or her diet, Place Lab can be used to study how that intervention impacts the person's actual behavior and how the person responds to that intervention. And it's the details that matter. The difference between an excellent product and one that's mediocre is often a very small observation that some designer made. That is what we need to create successful, proactive home technologies.

Q: In the Place Lab how much information is generated?

A: Most of the information is can be stored very efficiently. The switch data from two weeks is easy to deal with. The video and audio data for two weeks, however, is about 250 gigabytes. That's a lot of data to go through. When we have to annotate the video by hand, which is necessary for some studies, it takes about an hour for each hour of video, depending upon the amount of detail that must be marked. What is important to note, though, is that as more people use the datasets, more annotations get added and the more useful the datasets become over time.

Q: How much do cultural differences complicate the research in this area?
A: Right now we're focused on building systems for the U.S., but what's needed is for these types of labs and tools to be used in multiple countries. That would open up some very interesting research opportunities in looking at how behaviors and use of emerging ubiquitous computing technologies may be different between cultures. It's important to remember, though, that to make any of these proactive technologies work, at least the ones that motivate behavior change, the algorithms need to adjust to the particular environment and the particular situation. We don't know how to do that yet; we need to study it, and we need new tools to let us do that.

Margaret Morris

Q: What do you think about the potential for robots to fulfill a need for social connectedness for elderly people? At what point does it become a difference between a very fancy robot and a real live animal or human that would have the potential for spiritual connectedness that a robot may never really be able to provide?
A: I think I probably would have answered that question differently had I not spent much of the morning playing with the little robotic seal. Seriously though, I think these robots and technologies are most interesting insofar as they can catalyze social interaction among people. That's the most compelling usage model.

Q: Is there a point where we as engineers and scientists should be bothered by pursuing the objective of replacing human relationships with robots?
A: As a clinical psychologist, I greatly value social connectedness, so my bias is to try to use technology to foster rather than replace human interaction. The elderly often have less access to other people and it is sometimes argued that robots should be used for social support. Robots can hopefully provide some of the instrumental assistance for the elderly that is currently offered by people, but for emotional and social connection I think robots should be designed as catalysts rather than surrogates.

Q: As engineers, we like to see lots of sensors and complex systems, but are there some simple systems with voice recognition equipment and recording systems that can serve as prompts to users? Is that type of technology available or being developed?
A :(Abowd): You're talking about prospective memory aids, and the problem that has really motivated their development is medication compliance. There's also some AI research based in planning that tries to help people who have schedules of activities but

have a hard time remembering the sequencing of activities. This has led to the development of simple devices that can remind them what the next task should be. These prospective memory aids are not very high tech, and they don't need to be.

Q: I'm curious about the relationship you have with engineers in terms of how much is application pull and how much is technology push? In the prior speaker's discussion there were some questions about how to make this applicable for a broad user base without being too specific. And here it looks like these particular applications can require a very specific technology depending upon the individual's needs. How are you going to drive this into a design process? Will this be a one-size-fits-all kind of approach, or is it going to be very customized?
A: One clarifying point is that Intel is not trying to develop these prototypes into products. But, yes, our goal has been to examine whether there is a match between proactive computing capabilities and health needs. We try to use off-the-shelf sensors, and while these items are not customized, the way that we arrange them is specific to each household. For example, in the social health trials I spend a lot of time with people trying to understand their social dynamics and then develop hypotheses about how computing systems could improve these dynamics. These hypotheses guide our placement of sensors and analysis of data.

Q: How do you design your research?
A: I should clarify that this is highly exploratory and primarily qualitative research. The naturalistic experiments we are doing now (i.e., our in-home trials) were shaped by 18 months of ethnography and concept-feedback studies. In these in-home trials, we are using a baseline—intervention design to evaluate the effectiveness and feasibility of our prototype systems. During the baseline period, sensor and journal data are collected to build an index of the elder's average level of social interaction. During the intervention period, these data continue to be collected and are reflected to the elder and the caregiver in three displays: a dynamic social network visualization that gives real time behavioral feedback about social activity, a "presence lamp" that signals availability of a caregiver, and a "context ID" application connected to the phone that shows the elder images and reminders about callers. In this design, each elder-caregiver dyad is treated as a case study. To control for the tremendous variability among households, comparisons are primarily within subject or repeated measures. There are two main hypotheses: First, that there will be agreement between sensor- detected and self-reported social engagement, and second, that the interventions will motivate social

activity. There are also case-specific hypotheses based on the social dynamics and environments of each household. In addition to these hypotheses about this particular health domain, we are studying (through ethnographic observation and analyses of technology usage) the ways in which participants adopt and work around these systems.

Q: This question is addressed to both speakers. You both have "ubiquitous" in your titles, and as a technologist, I couldn't help but think about the scenario where—of course, the sensor networks and so on are all designed for the good and to help people—the information fell into the hands of the wrong people. For example, what about an employer who wants to probe an employee's lifestyle or even something like a big company that wants to change your behavior so you buy their product everyday?
A :(Morris): The streams of data we get are not terribly revealing, for example, numbers about whether you're in the house, out of the house, whether you're in the kitchen, etc. It's not the richest data; it's the sense that you make out of that data that is the challenge. The other point is that there are trade-offs that people will make at some point and in different ways, and probably those decisions will be based on their culture or their age group, but there are trade-offs between privacy and autonomy. Privacy is not just one issue; it's grounded in specific scenarios, and for a lot of people giving up a little bit of privacy is something that they're willing to do to live on their own. However, I don't think it's an easy question.
A: (Intille): Answering the second question first, people already are trying to motivate change all the time, and they're actually doing a very good job at it. To some extent technology can be used to counteract that; part of the obesity epidemic is due to the effectiveness of the advertisers. So, what information others have access to is going to depend upon what people are willing to release and what has value to them.

This question is a hard one to answer because our community is trying to demonstrate the value now, and those of us who work in this area are pretty convinced that there is value. However, we're in the early stages, so when the technology is presented without people being able to see the benefit, initially they'll look to see what the negative is. But once they see the benefit, then they'll make these trade-offs about whether they want to let people have access to it or not.

Ultimately when we demonstrate the value of these technologies, particularly to the medical community, then people will say, "You know what? This helps me communicate with my family. It makes me feel good. I understand my health situation better than I did before." And whatever risk is associated with it, people will just accept, as they do with any other technology.