Scenarios Development of Pet Companion Robot for Visually Impaired Elderly

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Abstract—The concept of pet companion robot for visually impaired elderly is proposed. The pilot study and interview with elderly indicates that the primary problems are communication, feeding and emotion reception between pet and elderly. The proposed concept serves as the middle person to feed, detect, trash collect and communicate between the elderly and the pet. Several kind of interaction mode was also proposed to fulfill the ability and living characteristics of the elderly. Although only part of function can be implemented by information technology today, it shows the pet companion robot is helpful for visually impaired elderly.

Keywords: pet, robot, visually impaired elderly

I. INTRODUCTION

Pet and Elderly

Impact on mobility of visual impairment highlights the concerns with regard to spatial restriction and loss of ability to move [1]. Other people have pet care-taking needs as well. For example people from time to time need to travel to other places for a short period of time, and often it is not possible for the owner to take the pet along. At this time a robot can take some of the task of care-taking the pet.

Dog and Elderly with Physical Disability

Assistance dogs are specially trained to help people who are blind, deaf, or physically disabled. Their lives are devoted to the serious task of providing security and independence to a person with a disability. There are now three basic types of assistance dogs [2]: Guide dogs, Hearing dogs and Service dogs.

Guide dogs help people who are visually impaired to navigate on the road. Although the dogs can be trained to bypass various obstacles, they are partially colour blind and are not capable of interpreting traffic signs [2].

Hearing dogs are sensitive to special sounds like doorbells and smoke alarms, and will warn the owner about it. The dogs can even be trained to recognize the name of their owner, making communication with others easier.

Service dogs help people who have physical disabilities like pulling wheelchairs or opening doors. It can also provide stability for someone who can’t balance very well.

Some surveys also [3] show pets enhance the lives of their owners. Pet-facilitated psychotherapy can increase social interaction, provide comfort, and reinforce feelings of independence. A one-year longitudinal interview was conducted [4] to collect the following data: social network activity, current number of selected health problems, pet ownership status, physical health and psychological health. It is indicated that the ownership of a pet significantly changes the relationship between social support and psychological well-being.

Previous study [5,6] surveyed the variables in the elderly-animal friendship bond. The study focused on self-perceived criteria by the old people regarding their intimate association with their dogs. Results indicated self-perceived variables of companionship, emotional bond, usefulness and loyalty. If we can reduce the problem between visually impaired elderly and dog, we can certainly improve the relationship in between.

Interaction between owner

Interaction between the owner and the pet are affected by personalities and gender. A research was conducted between twenty-seven pairs of owner and the dog. Each pair works as a team in a fun-agility parcours. Results show that the gender and personality of both partners affected the performance. Different personality means different ways of interaction: neurotic owners use verbal communication more, while extroverted owners treats the dogs as companions. The human-dog dyads can be separated into high and low performers. And there was an indication that owners, who saw their dogs as children, were worse than teams where the dog was seen as a companion [7].

Even though dogs have been human’s best friend for hundreds of thousands of years. A preliminary investigation on canis behavior was conducted on sixty people [8,9] with different levels of hands-on experience with dogs. Among them are dog-owners, veterinarians, dog trainers and non-owners. They were asked to classify the behaviors of nine dogs, shown in different video clips, ‘friendly’ and ‘aggressive’. The tail movements were the most common cues used by participants to interpret dog behaviors and that, even if they were not instructed to do so, observers tended to give ‘holistic’ descriptions of dog behaviors, such as ‘the dog wants to…’ or ‘the dog feels…’ [10].

Assistive Technology

Simon [11] designed a framework to allow haptic discovery of location data, helping visually impaired users to get to know the location around them. The system is
designed for single-handed interaction and can select available points of interest near their location. Wireless-charged RFID sensor [12] is used to collect outdoor data from an RFID reader. The capacitor can be wirelessly recharged, and data can be acquired whenever it is near a reader.

Maps can be presented to the blind using a combination of tactile mapping layer with a touch tablet. The user can feel the map using the fingertip and by pressing at special places a corresponding audio clip will be triggered. A portable navigator could be a book of these tactile maps with audio commentaries, and a battery powered pen.

The team at Tohoku University developed a robot that can dance by following a human dancer’s lead [13]. The robot predicts the next move by analyzing the hand pressure applied to its arms, and can then turn at the appropriate speed. Another robot called the ‘walking partner robot’ utilized same techniques as the dancing robot, by perceiving the intended movement and force of human footsteps. The result is a machine that can perceive its surroundings and provide walking assistance to the elderly and physically disabled.

II. SURVEY

An interview was conducted with a visually impaired elderly (88 years old). His favorite exercise is swimming. Two years ago, he slipped down when walking on the wet floor. During the slip and fall, his arm was broken. He usually goes to hospital with his caretaker. He uses voice alarm clock and walking aid cane. He abandoned his pet, due to the limitation of mobility and caring.

Usually those who became blind during the older age lack sufficient training such as using the cane. Assistance is indeed important to them and will prevent them from possible dangers. Visually impaired elderly are often alone, so it is good to have pets as their companions. On the other hand, they often can not take good care of the pet.

A second interview was conducted with a 35 year’s old visually impaired person with guide dog in school (Figure 1). During the observation, the dog can lead with normal walking speed. The handler bar transfers the force and allows the user to adjust speed based on the situation. The owner seldom uses white cane.

Dog loves the open field and enjoys the opportunity to be with other dogs. They frequently have body contact with the owner too. Most guide dogs is owned by the younger generation. Sometimes the owner worries about the health condition of the guide dog, so they often try to have regular exercise together.

III. SCENARIOS DEVELOPMENT

A common definition of creativity is the ability to generate new useful things that are characterized by being original and imaginative. Conceptual design is the central stage in product design; it determines the principles that govern the product. Decisions made in this stage have major impact on the final product.

All design involves a developmental process. The design ideas and eventually the artifacts that stand for the ideas move from one developmental stage to the next. Having desires motivates people to engage in just-in-time learning to achieve their project goals.

Scenarios are commonly used to solve design problems by visualizing a concrete situation. Scenario can either be described in detail or the focus can be more on the context of use [14] (Keinonen, 2000). By making use of a specific story to both construct and illustrate design solutions, scenario building is a good way to generate design ideas for new products and to identify the possible users and contexts of use.

The related concepts will be developed by scenario-based design approach [14]. In these studies, the use of scenario is a tool for visualizing a possible way to act in a particular situation. It helps potential users to understand imagined applications of new technologies. The concepts are describing in following figures.

Figure 2 shows the scenario of pet companion robot:

Owner tries to interpret the pet’s emotion.

By putting the flexible wire gesture sensor on tail of the dog.

The vibration frequency and magnitude can be translated to dog’s emotional status.

Detects and performs faeces collection while needed.

Filtering and monitor dog’s social targets by RFID tag detection and drive away these targets.
As shown in Figure 3, the pet companion robot can assist the master in several ways. Figure 3 shows the container for pet feeding and the detectors in front side. The RFID reader of pet companion robot can identify the specific dog through the tag. When the location of the garbage is known, it can pick it up by a trash collection mechanism. By the communication and computing abilities of the smartphone, the facility can perform as a walking guidance vehicle.

The scenarios were then discussed with elderly people. After the interview with elderly people, the major needs are summarized as the following:

Feeding: based on preset amount or particular signal from the pet, the pet companion robot can provide small amount of food.

Guidance: the GPS and RFID based tracking module can provide location information.

Feces collection: the robot will help to collect pet feces in the public area.

Outdoors activities monitor: to maintain physical health. Pet companion robot can take the pet for a walk given the preset route and time. It can monitor the pet's condition in a distance, and issue commands using a voice pager.

Pet's emotion interpreter: visually impaired elderly cannot see the pet, therefore he or she lose many ways to perceive the emotion of the pet. By building a database of pet's different body languages, it can encrypt the pet's emotion and inform the owner and enable a better communication between the two.

Custom response to simulate the habits of the owner: a response mode that can reward food, give movement or LED signal. These can be set by the owner.

Detection of dangerous target: the dog can be identified through the RFID tag. If the unwelcomed dog approaches, the pet companion robots will drive it away using noise or movement in order to protect the owner's pet.

IV. CONCEPT DESIGN I

Basic Components

From the scenarios of pet companion robot, the next step is the technology evaluation. The purpose is to find possible solutions and possible problems with these kinds of situations. As summarized below (Table 1), many creative concepts were suggested, but we found that there are many problems and technology barriers too. By scenario-based design, it reveals both opportunities and challenges. More research is still needed in order to solve these problems.

<table>
<thead>
<tr>
<th>Approaches</th>
<th>Sensor/actuator parameters</th>
<th>Problem arises</th>
</tr>
</thead>
<tbody>
<tr>
<td>four-bar mechanism</td>
<td>force sensor infra-red sensor</td>
<td>Detection of softer faeces</td>
</tr>
<tr>
<td>feeding</td>
<td>sound</td>
<td>supply amount</td>
</tr>
<tr>
<td>defense</td>
<td>RFID reader, keep away of unwelcome dog</td>
<td>Effective approach</td>
</tr>
<tr>
<td>remote call for dog</td>
<td>remote speaker and microphone</td>
<td>generate command with lower bit rate</td>
</tr>
<tr>
<td>know where the dog is.</td>
<td>zigbee wireless node</td>
<td>spatial resolution</td>
</tr>
</tbody>
</table>
Initial Prototype

Figure 4 is the initial prototype of concept I currently under development. The robot's structure has a lower center of gravity. The basement contains main circuit board and battery. The main circuit board (Figure 5) has the processor, memory, I/O unit and high-capacity battery. The main chassis has one guiding and two driving wheels which can be driven at different speeds. The speed-controlling unit adjusts the outputs based on sensor input and the simple rules. The environmental sensors include collision sensors and the leading edge infrared module for obstacles avoidance.

Detection of dangerous targets can be implemented through existing RFID technology. The detection range of high frequency (HF) RFID reader is 30cm. By utilizing this capability, unwelcomed dog can be detected and driven away through physical contact or electrical discharger from the tail of the pet companion robot.

Figure 4 Perspective view with front side LED display panel and trash collection container open [16], by Ming-Ching Jan.

V. CONCEPT DESIGN II

Concept I provides feeding and feces collection functionalities. Some difficulties arise while following the pet in an irregular environment. Concept II focus on outdoors activities monitor and communication functionalities. Pet companion robot is placed on the back of the pet, it automatically follows the route of pet. It can monitor the pet’s condition in a distance, and issue commands using a voice pager.

One function is pet's emotion interpreter. Although visually impaired elderly lose many ways to perceive the emotion of the pet, the related body sensor can decrypt the pet’s emotion and inform the owner and enable a better communication between the two.

Basic Components

Figure 6 is the parts placement of the emotion communication concept. The system has a flexible solar cell belt on the dog's back. The control chassis, which hanged at the edge of the belt, consist of battery, charger circuit and zigbee module (Figure 7). The main circuit board (Figure 8) has the processor, memory, I/O unit and battery. The emotion communication unit decides the emotional status of the pet through the body sensor and can send voice and gesture information to the owner.

After the owner received the emotional signal, he or she can respond remotely through the main command unit. The main command unit sends voice or haptic commands based on sensor input and the owner’s intentions.

The system flow chart is shown in Figure 9. Location acquire module can detect relative distance between the owner and the dog. It can be implemented through existing GPS or Zigbee technology.

Emotion detection module analyze pet’s emotion. It can be implemented through analyzing dog’s sound and collecting G sensor signal placed on the tail. It required more computing power to classify proper emotion. It can be placed on body of the owner to reduce dog's burden.

Remote command module can contact the pet through remote voice signal and haptic display device placed on the body of the pet. It can be implemented through existing vibrating actuator. To reduce the communication bandwidth, the command can be coded in a certain protocol, it allows mutual communication easier.

Figure 5 System block diagram of the main controller

Figure 6 Placement of the major components and main controller, picture modify from [3]
VI. CONCLUSION AND FUTURE WORK

The scenario of pet companion robot for visually impaired elderly is proposed. The interactive modes and functional module were discussed, and structure diagrams are provided to show the interconnection of different modules. The pet companion robot concepts can be helpful to visually impaired elderly in many ways. It can help the elderly to feed the pet, detect its emotions and enhance the communication. Several key functionalities have already been implemented by other products, such as feeding and guidance. Part of the pet’s emotion interpretation also has been achieved through sound signal analysis, but body language interpretation has not been implemented yet.

Owing to the complexity of real world situation, there is still a gap between the concept design and the current technology. For example, the task of faeces collection faces a great challenge of determining the exact location. Outdoors activity monitor can be implemented through wireless nodes. Pet companion robots can then receive that information and translate it to the owner. Several kinds of interaction modes can be programmed to respond to pet’s different emotions. But it still needs a lot of research to extend to the world of pet.

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