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 of information technology today, it shows the pet companion robot is helpful for visually impaired elderly.

Keywords—pet, companion robot, visually impaired, elderly, interaction

1. INTRODUCTION

1.1 Pet and Elderly

Impact on mobility of visual impairment highlights the concerns with regard to spatial restriction and loss of ability to move [1]. There are also many elderly who acquired diabetes which lead to blindness after the age of seventy.

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 the task of feeding and monitoring the pet. The related concepts will be developed by scenario-based design approach [2].

1.2 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. Dogs are selected based on their temperament and size. There are now three basic types of assistance dogs [3]:

- Guide dogs
- Hearing dogs
- 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 [4].

Hearing dogs alert a person who is deaf or hearing-impaired to sounds like doorbells, smoke alarms and baby cries. The dogs can even be trained to alert to the name of their owner, making communication with others easier.

Service dogs help people who have physical disabilities. They can pull wheelchairs, open doors, and retrieve dropped items or provide stability for someone who can't balance very well. Service dogs can also be trained to help people with seizure disorders or other medical problems.

A survey also [5] shows that pet facilitate rapport and enrich the treatment milieu. 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 [6] 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.

The dog day care needs to provide a safe and healthy atmosphere full of interaction with other dogs and with people. Dogs can participate in group play, gnaw on a favourite toy, or just lounge on a couch and watch television. Previous study [7] 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.

1.3 Assistive Technology

Simon [8] 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.

A smart-camera network was proposed to tackle the target tracking and multi-object tracking problems. In such a network, a method for tracking people in 2D world coordinates and acquiring canonical frontal face features were proposed. The recognition of human faces can lead to a number of applications, including personal assistants, smart monitoring and surveillance systems.

Wireless-charged RFID sensor [9] is use to collect outdoor data from an RFID reader. Its capacitor can be wirelessly recharged, and data can be acquired whenever it is near a reader.

Tactile mapping is either vacuum moulded or printed on an embossing printer, then placed on the touch tablet. The skin can feel the map and by pressing it the user can trigger corresponding audio clips. 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 [10]. The robot predicts the next move by analysing 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.

2 SCENARIOS OF PET COMPANION ROBOT

2.1 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.

Fig 1 Interview with visually impaired elderly

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 years old visually impaired person with guide dog in school. 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 favorite the open field and enjoy the opportunity of mutual activities with other dogs. They frequently have body contact with the owner too. Sometimes the owner worries the healthy condition of the guide dog, so they often try to have regular exercise together. Mostly guide dog is owned by the younger generation.

![Figure 2 Observation of visually impaired with guide dog](image1)

### 2.2 Scenarios and Concept Design

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.

The scenario is commonly used to describe a method of design problem solving by

![Figure 3 Scenario of pet companion robot](image2)
As shown in Fig. 3 and 4, the pet companion robot can assist the master to take care of pet. After the interview with elder people, the major needs can be described as the following:

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

2. **Guidance**: the GPS and RFID based tracking module can provide location information (Fig. 5).

3. **Faeces collection**: the robot will help to collect pet faeces in the public area.

4. **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.

5. **Pet’s emotion interpreter**: visually impaired elderly can not see the pet, therefore he or she lose many ways to perceive the emotion of the pet. By building a database to of pet's different body languages, it can decrypt the pet’s emotion and inform the owner and enable a better communication between the two (Fig. 3).

6. **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.

7. **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.

### 3. Technology Consideration

#### 3.1 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 problem with these kinds of situations. As summarized below (Table 1), many creative concepts are suggested, but we found that there are many problems too. By scenario-based design, it reveals both opportunities and challenges. There are a lot of puzzles that needs solving before the whole concept can be used in the real environment of elderly people. More research is still needed in order to solve these problems.
### TABLE 1
SUMMARIZED FROM CONCEPTS

<table>
<thead>
<tr>
<th>Approaches</th>
<th>Sensor/actuator parameters</th>
<th>Problem arises</th>
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</thead>
<tbody>
<tr>
<td>four bar mechanism</td>
<td>force sensor</td>
<td>handle soft part of faeces detection</td>
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<tr>
<td></td>
<td>infrared sensor</td>
<td></td>
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<tr>
<td>remote call for dog</td>
<td>remote speaker and microphone</td>
<td>use specific code to generate command with lower bit rate</td>
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<tr>
<td>know where the dog is.</td>
<td>zigbee wireless node</td>
<td>spatial resolution</td>
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<tr>
<td>preset amount to</td>
<td>sound from dog</td>
<td>determine the pet situation</td>
</tr>
<tr>
<td>promote interaction</td>
<td>intension</td>
<td>strategy of pet control</td>
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<td>between pet and robot</td>
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<tr>
<td>understand vocal</td>
<td>sound frequency spectrum</td>
<td>complexity of mathematical calculation</td>
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<td>language</td>
<td>amplitude</td>
<td>location sensitivity of microphone</td>
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<tr>
<td>understand body</td>
<td>vibration of dog</td>
<td>correlation between vibration frequency and emotion</td>
</tr>
<tr>
<td>language</td>
<td>tail</td>
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3.2 Initial Prototype
The initial prototype is currently under development. The robot's structure has a lower centre of gravity. The basement contains main circuit board and battery. The main circuit board (Fig. 6) 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 rule database. The input sensors include collision sensors and the leading edge infrared module for obstacles avoidance. The physical structure is shown in Fig. 7. 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 unwelcomed dog can be detected and driven away.

![Fig. 6 System block diagram of the main controller](image)

![Fig. 7 Perspective view with front side LED display panel and trash collection container open](image)

4. 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 interaction with the robot.
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 getting to the exact location. Outdoors activity monitor can be implemented through wireless node. 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. Prof. Aggarwal [13,14] started with the study of motion of rigid planar objects and gradually progressed to the study of human motion. But it still needs a lot of research to extend to the world of pet. There are a lot of puzzles that needs solving before the whole concept can be used in the real living environment of elderly people.

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