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Inclusive Design: Task Specified Robots for Elderly

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Abstract. In order to improve aging populations' living quality, this paper mainly provides a broader overview of aging-care robots design. We first study the physical condition, mental health, and living habits of aging users. Then, base on safe, simple, and sustainable design principles, we propose a design strategy for aging-care robots from the aspect of robotics functioning, appearance design, human-agent interaction model, and technical analysis.

Keywords: aging-care robots; inclusive design; aging in place.

1. Introduction

The World Health Organization predicts that from 2000 to 2050, the proportion of the world population age 60 and older will double from 12% to 22%[1], a huge challenge for all the countries. According to AARP, nearly 80% of the elderly in America want to remain in their current home as they age[2]. Aging in place is more affordable, and allows the elderly to retain a familiar setting, but as the health decline maintaining independence can be increasingly difficult and the lack of socialization can also cause some psychological problems. Therefore, aging care robots that provide health services and meet communication requirements could play an important role in aging in place. The robots may not be able to observe the exact status of the target but must be supportive both physically and mentally, by means of understanding, parameterizing, and processing instructions from the elderly.

2. Analysis of the characteristic of aging users

2.1 Physiological characteristics

Aging is a complex physiological and pathological phenomenon. As people age the most common phenomena are the calcification of soft tissue, bone, and blood vessels, the decrease of cardiac output decrease, the increase of blood pressure, and decrease in vital capacity, and slower expiratory flow rates. Those physiological phenomena will cause a physical decline in sensory, cognitive, and motor abilities, all of which should be carefully considered when diving into the design process.

2.2 Psychological characteristics

Switching from working to retirement could possibly cause an enormous gap psychologically for older people since they lose the daily pattern they stuck for years and need to adapt to another lifestyle without any preparation. In family networks, their position transformed from family supporter to dependent, and meanwhile, in social relations, they are included in the group that requires special attention. These factors will influence the self-perception of the elderly, and the difficulties or malfunction of being understood by close people or communities lead to elderly suffering from loneliness and results in increasing the mortality risk[3]. Hence, the robot's design should take the fragile and psychological characteristics of aging people into full account, providing them with psychological counseling and guiding them to a positive attitude to life.

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2.3 Living habits

The development of the digital age widens the gap between the elderly and the outside world. Due to the physical and mental factors, learning new technology can be increasingly difficult as they age. Technology products such as smartphones and The Internet can be adapted by some elderly, but most of the aging people are still isolated from the smart life.

3. Design strategy

3.1 Robotics function design

The functional design is carried out from three aspects: safety monitoring, life service, and companionship. In addition, the robot should be associated with external health care centers, emergency centers, and guardians of the elderly.

Safety monitoring is the fundamental function. Robots should monitor the elderly's physical condition such as heartbeat and blood pressure, thus can connect the most updated physical information to the medical center. When emergencies happen, medical services and the family members of the elderly should be notified immediately.

For life services, the elderly care robot is the center of the smart home, which can assist the elderly to manage other smart homes in the home, such as adjusting the temperature of the air conditioner, turning the lights on and off, and changing the TV channel. In addition, he is also a good memo, which can solve the life problems caused by the memory degradation of the elderly, remind the elderly about their daily arrangements and medical examinations, and record the time and dosage of medication. The robot is also a mobile life assistant that can grab items or deliver them to a specific place in the home.

The development of technologies such as voice recognition systems and depth cameras has made the communication between robots and people more emotional, and can realize the functions of chatting with the elderly, playing news, videos, and playing simple games.

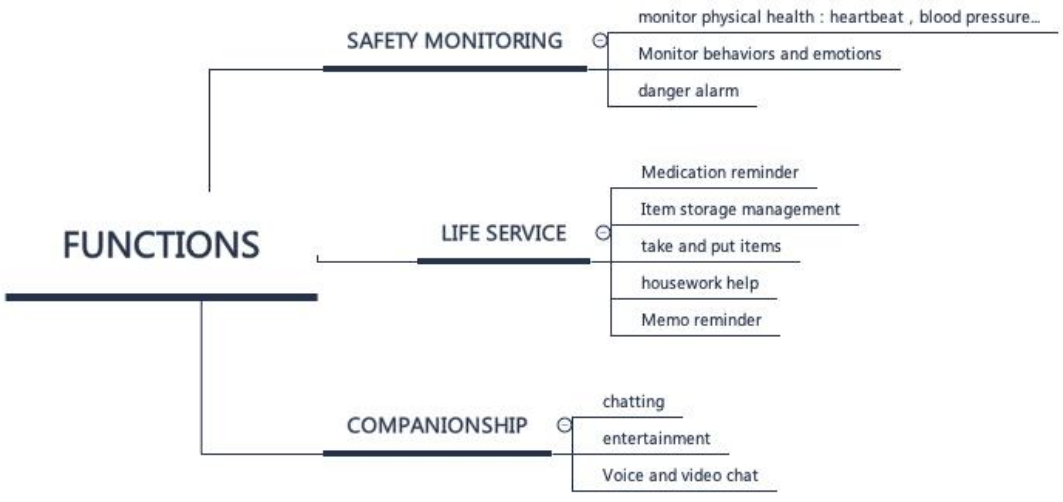

Fig. 1 function analysis

3.2 Human-agent interaction

The essence of human-computer interaction is the interactive cycle of human information input and machine output feedback. With the technical support of artificial intelligence, some new sensors have been added to the input port, such as depth cameras, microphone arrays, etc., so that the machine has the ability of natural language understanding and image recognition, and the output

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interface has also increased more feedback channels. With the development of these technologies, human-computer interaction has developed in a more natural and emotional direction.

Due to the decline of sensory, cognitive, and motor abilities, sensory enhancement and multisensory compensation design approaches will be used to enhance the experience of the elderly. The research results of the cognitive theory of multimedia learning show that the information fusion of visual channels and auditory channels is better than separate visual channels and auditory channels [5]. Therefore, we use both of them. Voice interaction is the primary interaction model for this program, but considering the characteristics of auditory function deterioration in the elderly, visual information will exist as a supplement.

A set of better responsive speech and character identity designs can make users expect an emotional communication experience between people when using the intelligent voice interaction system. We hope that through the design of the voice system, the robot can bring a better emotional experience to the elderly while executing the commands of the elderly.

3.3 Technical analysis

3.3.1 Knowledge graph

The agent stores item information by creating a knowledge graph, that is, a network representation that connects all elements in the room [5], with a detailed description of property information. Each object is associated with an ID and a set of attributes, including location coordinates, item size, nutrition information, functioning guidance, and we use treelib to implement the spatial information of the room. For instance, under the category of the kitchen, the agent has a collection of cuisine utensils, such as spoon, fork, chopstick, knife, and frying pan. The specific object will be extracted when processing the command from the elderly end-to-end to the agent.

The agent starts with an empty knowledge graph and will add items when randomly exploring the room. When the agent picks and drops objects, the related item in the position of the knowledge graph needs to also be updated. Any item that is consumable should be removed from the knowledge graph once being discarded.

3.3.2 Computer vision

We should address the question of how the agent has the capability to identify objects when providing the instructions. Computer vision techniques should be configured inside the agent, that is, a technology that can recognize the object by using feature matching algorithms [4]. The core idea is that the agent carries sensors and cameras while making movements. Those devices can collect the surrounding information, such as the distance between the agent and furniture to avoid a collision or the distance between the target object and the agent. Agents collect the inputs from devices, extract the feature representation in vectors of each object and calculate the mathematical distance between the feature and pre-calculated features' dictionary, to recognize the object in text format.

3.3.3 Natural language processing

The most common scenario that should be considered is that the elderly express their needs to an agent in casual conversation. The contextual query is a formal language for representing queries in a structured manner. Each class of contextual query corresponds with a task parameterized by a goal. The agent parses the contextual query and maps it to a valid sequence of parameterized subtasks. We use NLTK [6] to tokenize and tag the queries, then analyze the sentence. composition to extract the goal parameters. We implemented custom transformations mapping from each contextual query class to a goal-parameterized task. For example, the elderly can say: I am hungry, I want to eat something that's sweet or sour. The voice command control converts the voice to text sentence as raw input, then uses NLTK to extract keywords: "eat"," sweet". The agent will look up all the items in the knowledge graph that has the attributes of "edible" and "sweetness", and then check the location of the elderly (We assume the location is the bedroom). The contextual query will be

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generated as: bring the apple to the bedroom. The agent will generate a sequence of actions by analyzing the contextual query.

The agent can provide a service of chatting as a means of entertainment. Apart from sending commands to the agent, a casual talk should be given during the chat and general questions in a common sense should be answered. For example, when the elderly ask for common information like the weather report daily or the president of the United States, the agent needs to provide concrete answers from searching from Google, respond in appropriate format via voice output.

4. Summary

Aging-care robots based on the elderly have a significant project value in recent years, thus it is worth researching the design details. We analyzed the physiological characteristics, psychological and living habits of the elderly, and then introduced a recommended design strategy. We discussed the function design, the interaction between humans and the agent, and the technical challenges. Future work will address the following issues: How to design the sequence of actions after receiving the instructions from humans? How to design the agent efficiently and economically?

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