Chapter 8
Characterize a Human-Robot Interaction: Robot Personal Assistance

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Abstract In the last years, the development of robots is entering a new stage where the focus is placed on interaction with people in their daily environments. With the improvement of more and more complex robots to be used in rehabilitation, heath care, service or other applications, robot-human interaction is a rapidly growing area of research. This chapter explores the topic of human-robot interaction. Finally, we presented a proposed framework design that will operate with a person. The system considers the person attitudes level while interact with. The goal is to propose an architecture that monitoring person attitudes in real scenario, and detect patterns of behavior in different occasions. The robot will interact with a person and its training a decision support system that in a real scenario that provide the robot to makes interactions with a person.

8.1 Introduction

The Websters Dictionary defines a robot in three different ways and one of the definitions is "any machine or mechanical device that operates automatically with human-like skill" [1]. Through popular interpretations, these definitions already draw associations between a robot and man.

During the last century robots have operated around humans within industrial and scientific setting. And in the last years, their presence within the home and general

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society becomes ever more common. Frequently robots are used in environments that are inaccessible or unsafe for human beings. Robotic operations include, for example, planetary exploration, search and rescue, activities that impose menacing levels of workload on human operators, and actions requiring complex tactical skills and information integration [20, 27].

The interaction between humans and robots come into physical contact under a variety of circumstances. In the last years, the development of robots is entering a new stage where the focus is placed on interaction with people in their daily environments. The concept of communication with robots has rapidly emerged. The robotics communication will act as a peer providing mental, communicational, and physical support. Such interactive tasks are very importance for allowing robots taking part in human society where many robots have already been applied to various fields in daily environments.

The human-robot interaction is the interdisciplinary study of dynamics interactions between humans and robots. From the point of view of researchers human-robot interactions include a variety of fields, like engineering, computer science, social sciences, and humanities. However, they research subjects are very different: in the field of engineering, the research of study are electrical, mechanical, industrial, and design; in the field of computer sciences, are human-computer interaction, artificial intelligence, robotics, natural language understanding, and computer vision; in the field of social sciences, are psychology, cognitive science, communications, anthropology, and human factor; and in the field of humanities, are ethics and philosophy [13].

From the increasing number of research in this field, it is convenient to distinguish some concepts: such human-robot interaction, social robots, and personal assistance. This chapter deals with the issue of human-robot interaction in personal assistance, with the aim of proving robot, which helps people in their working routines. This chapter is organized as follows. In the next Section the theoretical foundations where scientific literature is reviewed. Section 8.3 contains the proposed design, and finally in Sect. 8.4, discussions and conclusions of this work are presented.

8.2 Theoretical Foundations

Normally, the field of human-robot interaction (HRI) investigate: the development of new techniques for knowledge transfer from human to robot; designing effective tools for human control of a robot; anticipating of the growing presence of robots within general society; and human friendly interface for a robot control.

The goal of HRI is to create teams of humans and robots that are efficient and effective and take advantage of the skills of each team member. An important target of HRI is to increase the number of robotic platforms that can be management by users. For that its necessary have a knowledge of: type of interactions between robots and humans; information that humans and robots need to access, in order to have desirables interchanges; and software architecture that its necessary to accommodate these needs [30].

Table 8.1 A schema of robotics for anthropic domains: main issues and superposition for HRI

Domain	Issues
Design	Lightweight
	Compliance
Control	Safety
	Performance
Sensors	On-line fusion
	Dependability
Biomimetic	Interface
	Human metrics
Software	Open architecture
	Dependability
Planning	Real time
	Consistency

Another target that is keys to the successful of introduction of robots into human environments are safety and dependability. In the field of physical assistance to humans, robots should reduce fatigue and stress; increase human capabilities in terms of force, speed, and precision; and understanding for a correct task execution [10].

In Table 8.1 is presented the fundamentals anthropic domains and the main issues concepts of robotics for anthropic domains for HRI. For each interaction domain humans and robot must have some issues that are important defined. These fundamental domains are design, control, sensors, biomimetic, software and planning. When its planning a HRI interaction, all aspects of design, control, sensors, biomimetic, and software must be considered. Also when the design domain occur, its necessary to considered the planning, the sensors that will be implemented, how the control will be proceed, the biomimetic and the software that will be used. Also when the domain control, software, sensors, and biomimetic will be implemented, its necessary to considered all the other domains. All these domains must be considered together in a HRI, because they are all related with each other. Finally, when its talked about sensors we talked about sensors, actuators, and mechanics, control, and software architectures.

In terms of issues, the fundamental issues are safety, dependability, reliability, failure recovery, and performance. In order to connected all this domains there is a need for pathways connecting crucial components and leading to technological solutions to applications, while fulfilling the viability requirements [10].

In case of robots its necessary considered the design of the mechanism, sensors, actuators, and control architecture in the special perspective for the interaction with humans. In case of humans being its necessary considered control of the mechanism, especially safety and performance, the ways that the interaction occurs in order to following the same metric, and planning. Moreover different roles of interaction with robot are possible, since different people interact in different ways with the same robot, and the robot in turns reacts differently base on its perception of the world.

The interface design is crucial to let the human be aware of the robot possibilities and to provide her/him with a natural way to keep the robot under control at every time.

8.2.1 Social Robots

Dantenhahn and Billard proposed the following definition about social robots: "Social robots are embodied agents that are part of a heterogeneous group: a society of robots or humans. They are able to recognize each other and engage in social interactions, they possess histories (perceive and interpret the world in term of their own experience), and they explicitly communicate with and learn from each other" [9].

In a social robot its important defines some concepts like autonomy, imitation, and privacy.

Autonomy can speed up applications for HRI by not requiring human input, and by providing rich and stimulating interactions. However, autonomy can also lead to undesirable behavior. When a robot has to perform a desired task in a given situation, it is favorable that the constructing system designed has a degree of autonomy. When we talked about sociable robots, its necessary that they have autonomous control in order to interact with humans depending of the situations. Usually, autonomous robots are designed to operate as autonomously and remotely as possible from humans, often performing tasks in dangerous and hostile environments. Other applications such as supplying hospital meals or vacuuming floors bring autonomous robots into environments shared with humans. Although, HRI in these tasks still minimal.

Imitation occurs when robot intended to imitate the human being. However, negative correlation between the robots physical realism and its effectiveness in HRI can happen when physical similarity that attempts in imitation of human-like appearance and behavior could cause discord.

Privacy is a question that is presented when the presence of a robot inherently affects a users sense of privacy [21]. Because of its synthetic nature, a robot is perceived as less of a privacy invasion than a person, especially in potentially embarrassing situations.

Social robot can be interpreted as the interface between man and technology. However its considered socially interaction robots that exhibit the following characteristics: express and/or perceive emotions; communicate with high-level dialogue; learn/recognize models of other agents; establish/maintain social relationships; use natural cues (gaze, gestures, etc.); exhibit distinctive personality and character; and may learn/develop social competencies. This type of robots can be used for variety purposes: as educational tools, as therapeutics aids, or as toys.

In social interaction robots can operate as an assistants, peers, or partner, which imply that they needs to have a certain degree of flexibility and adaptability, in order to interact with humans. Robots that are socially interactive can have different forms and functions, ranging from robots whose only purpose is to have a single task to robots that have a collection of tasks [6]. It is the use of social acceptable interaction between robots and humans that helps break down the barrier between the digital information space and the human being. These interactions may characterize the first stages where people stop perceiving machines as simply tools.

Social robots interactions are important in a wide range of domains. One example is the interaction where robots need to exhibit peer-to-peer interaction skills. In this case its necessary that robot solve specific tasks and interact socially with humans.

If we consider the situation where robot accompanies elderly care at home. In this case the robot may improve skills in order to maintain the elderly people interest. In these situations it may be desirable for a robot that he develops its interactions skills over the time.

The degree of social robot interaction is accomplished through a progressive and adaptive process. Its possible to considerer a minimum requirement for social robots interactions, which is the ability to adapt to social situations and understanding and communicate with.

8.2.2 Personal Assistance

In the last years, especially in domestic, entertainment, and health care a new range of application domains has emerged where robots can interact and cooperate with humans as a partner or as a peer.

Humans learn through a range of techniques including observation, imitation, instruction, and simulation [14].

An individual interacts with his social environment to acquire new competencies. With social robots its necessary that they learning with the environment that they interact. The problem of learning is that the robot needs to distinguish the correct actions and state in order to create new policy that enables a robot to select an action based upon its current world state. Additionally, because of differences in sensing and perception, robot may have very different views of the world. Thus, learning is often essential for improving communication, facilitating interaction, and sharing knowledge [23]. The way that the robot might learn can be very different. When its addressed to robot-robot work, their communication can be the "leader following" [8, 19], inter-personal communication [3, 5, 31], imitation [4, 15], and multi-robot formations [25].

In case of HRI there exits some approach to learning. One is to create sequences of known behaviors in order to match human models [24]. Another is to match observations to known behavioral such as motor primitives [11, 12]. Finally, the most common is imitation.

An intelligent personal assistant is an application or a robot that uses inputs such as users voice, vision (images), and contextual information to provide assistance by answering questions in natural language, making recommendations, and performing actions.

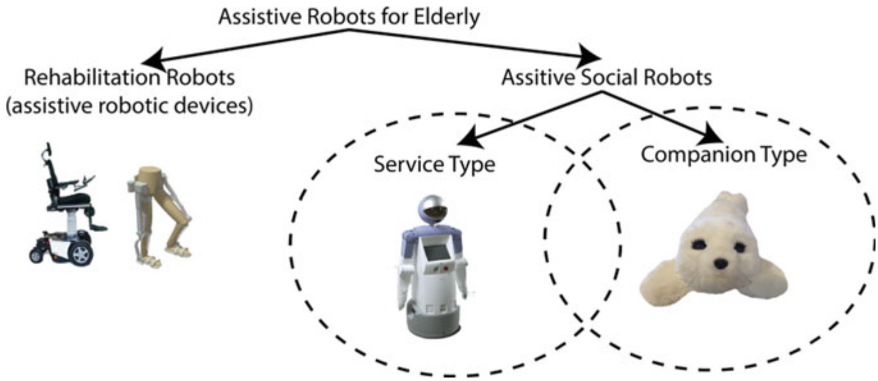

Fig. 8.1 Categorization of assistive robots for elderly

Nowadays, platforms with ambient intelligent and robotics are developing quickly and the results are products that have the potential to play an important role in assisting the elderly [28]. In health-care its required to have robust information with respect to their effects, which is necessary to used technology in an effective and efficient way.

In elderly care, personal assistant can have two types of robots: rehabilitation robots or social robots, which in Fig. 8.1 are presented these two types of robots.

The first type of robots its can use physical assistive technology that is not primarily communicative and isn't destined to seem as a social entity. Examples of this type of technology are exoskeleton [22], artificial limbs, and smart wheelchairs [16].

The second type of robots concerns systems that can be perceived as social entities that communicate with the user. Examples of this type of robots are service type and companion type.

The service type robots are robots that are used as assistive devices. The social functions of such service type robots exist mostly to facilitate interfacing with the robot. There functionalities are related to the maintenance of independent living by supporting basic activities and mobility. The basics functionalities are eating, bathing, toileting and get dressed. The functionalities related with mobility include navigation and provide household maintenance, monitoring of those who need continuous attention and preserving safety [2].

Companion type robot is study in the companionship that a robot might provide. The main functionalities of these robots are to enhance healthiness and psychological pleasure of elderly users by providing companionship. Social functions implemented in companion robots are principally aimed at growing well-being and psychological happiness.

Nevertheless, there are robots that have the two functions: they can be companion robots as well service robot.

8.2.2.1 Personalization

There is not a single accepted definition about the meaning of personalization. So we can define personalization in very different ways:

- As a system with methods that incorporate technology in order to differ from resources and processes, based on each learners skills, interests, and needs and learning profile in order to accelerate and deepen learning [17, 32].
- Personalized service mentions to any behavior happening in a service interaction intended to individuate customer and service experience [33].
- Personalization is the ability to supply services and actions that can responds to the users requirements and goals based on deep knowledge about personal preferences and behavioral obtained through client monitoring [29].
- Personalization is the result of intimate relationship and knowledge about a user. When a relationship with a user increases the level of personalization can also increase. Personalization is intended to facilitate a process of interactions between the robots and the users.

A robot that remembers and recognizes its past interactions with users might give them the feeling of getting special attention and personal recognition when they meet the robot again. The feeling of being treated as special is one of the reasons why users build relationships [18].

Recommendation systems are a main point of research in relation to personalization, and different variables are used to control the recommendations: learning styles, performance, learners activities, browsing behaviors, learners interests or social connections among others. This type of systems can better predict and anticipate the needs of users, and act more efficiently in response to their behavior [35].

8.3 The Proposed Design

In our western population there is a growing necessity for new technologies that can assist and care the elderly in their daily lives routines. There are two reasons for this. First, people prefer more and more to live in their own homes as long as possible instead of being institutionalized in sheltered homes, or nursery homes when problems related to ageing appear. Second, it is expected that western countries will face a tremendous shortage on staff and qualified healthcare personnel in the near future [26].

The quality of life for people remaining in their own homes is generally better than for those who are institutionalized. Furthermore, the cost for institutional care can be much higher than the cost of care for a patient at home. To balance this situation, efforts must be made to move the services and care available in institutions to the home environment.

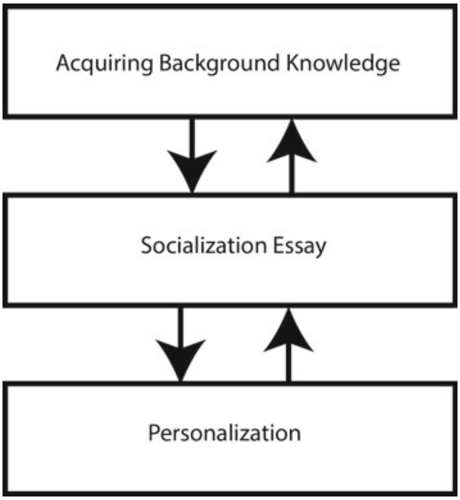

Fig. 8.2 General model for a personal assistant to elderly or persons with mobility impairments

However, human nature created persons that are individual and personal characteristics. Elderly people and people with mobility impairments have individual needs and specific characteristics that a companion would have to adapt to.

For this reason its proposed to develop a personalized robot that can serve as companion and that can adapt to the needs and interaction styles of elderly or those with mobility impairments that they are interact with. Such robot will be personalized, which individually reflects the needs and requirement of the social environment where the robot is operating in.

In Fig. 8.2 and Table 8.2 its presented a general preview model for a personal assistant to elderly or person with mobility impairments.

In the first phase its necessary to have extensive user studies need, as well as appearances influence peoples attitudes, opinions and preferences towards robots. Its also required knowing the tasks that the robot is supposed to perform, the physical environment that the robot is operating in, as well as the social environment.

In the second phase its the socialization essay. Based on the generic knowledge acquire in phase one, a first prototype of the robot can be tested and redefined in controlled environmental conditions, in order to determine the default settings. In this phase, basic behavioral patterns for the robot are defined and personality will be formed. The information about personality profiles as well as requirements and constraints derived from the tasks or environment that the robot is supposed to perform are also defined.

Finally, in phase three the robot will be personalized. In this phase personality profile and other information that can be acquire about people and environment that the robot interact will be adjust on robot behavior repertoire. Once the robot is place in home he will interact with person that it is supposed to live with. The robot needs to adjust their default settings and learn from their experience.

Table 8.2 Model for tasks to be carried out in each phase of HRI

Phase	Task to be carried out
Acquiring background knowledge	Defining tasks to robot perform
	Knowing physical environment
	Knowing social environment
	Defining user profiles
Socialization essay	Defining a prototype of the robot
	Defining basic behaviors patterns
	Defining reactiveness /autonomous robot
Personalization	Adjustment robot behavior
	Interactions histories
	Learning from experience
	Adaption on social learning

Related to the social behavior that influences the HRI various parameters need to be identified in HRI studies. Examples of these parameters are interaction distance, seeking attention, reactiveness/autonomy, and expression of intentionality. All of these parameters might be different and depends on the environment and the profile of the user that the robot will interact.

As a result of this process even two robots with the same structured and initial defining settings, will over the time develop individualized settings creating a unique personality. Such robot will have to be able to manage with changes in relationship with elderly people and persons with mobility impairments.

Figure 8.3 depicts the process through which the system operates; it is possible to observe the different classifications of information in order to allow, in the end, the management of HRI.

8.3.1 Dynamic HRI Monitoring Architecture

The robot must have a platform that allows moving in every direction. Consequently the robot should be omnidirectional, with three wheels. The wheels are placed at 120 between them. The robot should be used a Arduino microcontroller and be constructed with a several separate modules in order to be easily changed, which makes it possible to changed robot functions quickly and safely. The height of the robot will be around 60 cm, which is the ideal height for the robot to interact with people sitting on a chair or lying on a bed. When the battery drops below 10%, the robot will autonomously move to the doc-station, where it will charge.

A survey will collect information about the most common needs of the person. This module, upon converting the sensory information into useful data, allows for a contextualized analysis of the operational data of the persons actions and this frame-

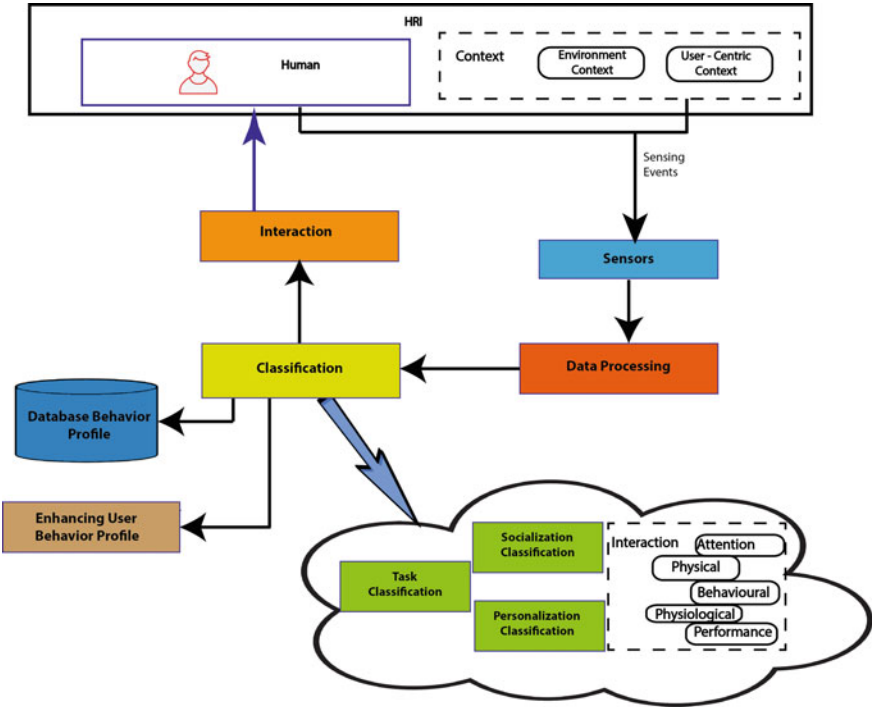

Fig. 8.3 Dynamic interface architecture for HRI

work performs this contextualized analysis. Then, the persons profile is updated with new data, and the robot acts in order to the feedback from this module. The system is developed to acquire data from normal working compiles information from persons activities.

The proposed framework includes not only the complete acquisition and classification of the data, but also an interaction level that will support the human-based or autonomous decision-making mechanisms that are now being implemented.

The Sensing Events are charged for capturing information describing the behavioral patterns of the persons, and receiving data from context environment. This layer encodes each event with the corresponding necessary information. These data are further processed, stored and then used to calculate the values of the behavioral person.

The Data Processing layer is responsible to process the data received from the Sensor layer in order to be evaluate those data according to the metrics presented. Its important that in this process some values should be filtered to eliminate possible negative effects on the analysis. The system receives this information in real-time and calculates, at regular intervals, their position and the interaction that must occurred.

The Classification layer is where the indicators are interpreted for example: interpreting data from the interaction indicators and to build the meta data that will support decision-making. When the system has an enough large dataset that allows making classifications with precision, it will classify the inputs received into different interaction levels in real-time. This layer has access to the current and historical state of the group from a global perspective, but can also refer to each person.

For that, this layer uses the machine learning mechanisms. After the classification, the Enhancing User Behavior Profile layer is responsible for providing access to the lower layer. The Database Behavior Profile is also a very important aspect to have control off. This possibility allows to analyses within longer time frames. This layer, whose function detect persons mood preserving those information (actual and past) in the mood database. This information will be used by another sub-module, the affective adaptive agent, to provide relevant information to the platform and to the mentioned personalization module.

Finally at the top, the Interaction layer includes the mechanisms to build intuitive actions, language and visual representations that make the robot interact with a person. At this point, the system can start to be used by the people involved, especially a supervisor who can better adapt and personalize his strategies. The actual persons mood information is used in the Interaction layer, and can be used to personalize actions according to the specific person.

8.4 Discussions and Conclusions

In this chapter its presented a framework for a social robot in order to act as a person, and more especially for personal assistance for elderly people and people with mobility impairments. This robot will possess individual and social learning skills, which make it unique.

Predicting preferences of elderly and persons with mobility impairments and providing the personalized robots based on persons preferences are important issues. However, the research for offering robot personalized considering the persons preference on context-aware computing is a relatively insufficient research field.

Nevertheless the robots are developed and deployed for the purpose of solving social problems, however its impact on the lives of the elderly and people with mobility impairments, there are social and ethical implications associated with the deployment of the robots. The advantages associated with the use of social robots in healthcare settings are largely dependent on the process of personalization, in order to facilitate the human-robot relationships [7].

Although, the ability for robots to interact with people and to control from these interactions to perform tasks better, to promote their self-maintenance, and to learn in an environment as complex as that of humans is of tremendous pragmatic and functional importance for the robot.

Suitable personalization is necessary to meet peoples needs and to ensure that robots could function independently to respond to people and unfamiliar situations. But it also raises ethical and social concerns, such as the tension between personalization, safety, and privacy [34].

When designing process of personalization, collection of personal data is necessary for the social robot to be personalized to meet the purpose for which it was designed.

For the point of view of robots, they not only have to carry out their tasks, but also have to survive in the human environment. From the robots perspective, the real world is complex, unpredictable, partially knowable, and continually changing. The capability of robots to adapt and learn in such an environment is essential.

This research suggests the basic direction for provision of the personalized services of robot and utilization of context history. Additionally, this research can be the basic direction of design and the guidelines of development for personalized robots. However, the prototype was not implemented according to the proposed framework. Also, the protection of personal information or privacy needs to be considered.

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