Care-O-bot® 3 – Vision of a robot butler

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ABSTRACT

In this paper Care-O-bot® 3 is introduced, which is designed as a prototype for a household robot. In contrast to merely technology driven service robot developments, many considerations on embodiment were conducted. In particular, Care-O-bot® 3 excels in its user-interaction oriented design. Nevertheless, it is equipped with leading edge technology, which is highly integrated into a very compact form. This convergence of design and technology accounts for the idea of Care-O-bot® 3 being a product vision for a robot butler.

Keywords

Domestic robot design, convergence of design and technology, robot butler.

1. INTRODUCTION

In the last decades a lot of robotic platforms have evolved, most of which have one thing in common: they are purely technology driven development platforms with little emphasis on end user related issues like design or usability. The target of the service robot introduced in this paper, Care-O-bot® 3, is to develop an overall concept suitable as a product vision, combining technological aspects with a compact and user friendly design.

Therefore, this article introduces user studies about an appropriate appearance for a robot helper in people's homes. Furthermore, the two paradigms of anthropomorphism and technomorphism are presented and the advantages and disadvantages discussed with respect to their suitability for a domestic robot design. Finally, the design of Care-O-bot® 3 is presented and how it was influenced and inspired by these considerations. Finally a user interaction scenario was implemented to show the user interaction concept.

2. HOW SHOULD A ROBOT BUTLER LOOK LIKE?

The classical field of human-computer interaction (HCI) is well established since many decades, while human-robot interaction (HRI) is a fairly new branch of HCI and has gained a lot of attention recently. Concerning a mobile service robot, additional aspects with respect to user acceptance and their expectations have to be considered. So, what are people's views on the role of an intelligent service robot in their home?

Different studies have been conducted to investigate people's attitudes towards domestic robots.

Syrdal [1] carried out a survey in order to examine adults' attitudes towards an intelligent service robot. Participants were 21-60 years old, while most of them were in the age of 21-30.

Results show that most of the participants were positive towards the idea of an intelligent service robot and view it as a domestic machine or a smart intelligent equipment that can be 'controlled', but is intelligent enough to perform typical household tasks. On the other hand, Scopelliti [2] investigated people's representation of domestic robots across three different generations and found that while young people tend to have positive feelings towards domestic robots, elderly people were more frightened of the prospect of a robot in the home.

Studies within the European project COGNIRON assessed people's attitudes towards robots via questionnaires following live human-robot interaction trials [3]. Responses from 28 adults (the majority in the age range 26-45) indicated that a large proportion of participants were in favour of a robot companion, but would prefer it to have a role of an assistant (79%), machine/appliance (71%) or servant (46%). Few wanted a robot companion to be a 'friend'. The majority of the participants wanted the robot to be able to do household tasks. Also, participants preferred a robot that is predictable, controllable, considerate and polite. Human-like communication was desired for a robot companion, however, human-like behaviour and appearance were less important.

These three studies, conducted in different European countries, agreed with respect to the desired role of a service robot in the home: an assistant able to carry out useful tasks, and not necessarily a 'friend' with human-like appearance.

These considerations led to the definition of a robot companion which must a) be able to perform a range of useful tasks or functions, and b) carry out these tasks or functions in a manner that is socially acceptable and comfortable for people it shares the environment with and/or it interacts with [1].

This creates the following challenge for the development of such a robot: we have to bridge the gap between functionality, which goes along with hard technological properties of e.g. an industrial robot, and social acceptance, which goes along with the comfortable design of e.g. an electronic pet.

3. ANTHROMORPHISM VERSUS TECHNOMORPHISM

Anthropomorphism is a constant pattern in human cognition [4, 5, 6, 7], and the interaction of a human with a robot (or any kind of machine) can not completely elude it.

According to Mori [8], the so-called uncanny valley would suggest to either stay in the domain of very non-human, toy-like robots, or to create a robot that appears to be almost perfectly human-like, because a robot in between may elicit rather fearful responses. Unfortunately, at present the uncanny valley is not a good starting point for robot engineering and lacks a solid empirical foundation [9].

Furthermore, there is disagreement. The matching hypothesis [10] predicts the most successful human-robot interaction if the robot's appearance matches its role in the interaction. In highly interactive social or playful tasks participants in a study [10] preferred the human-like robot. In serious, less emotional tasks, however, they did prefer the machine-like robot. We must be aware of the fact that the appearance of the robot communicates its strengths and competences to the user.

Human-like appearance is likely to trigger expectations that go beyond the capabilities of a machine. But being humanoid in appearance does hardly suffice to meet the expectancy of human-like reactions. To achieve this, the robot needs to interpret situations correctly to adapt its behaviour. This requires elaborate models of cognition and emotion. Even though research makes progress in these matters, e.g. within the COGNIRON Project [11], this is not suitable for every-day technology yet. Instead findings suggest that if a machine triggers high expectations concerning its capabilities, the user adapts accordingly and tends to overchallenge the machine [12] while getting frustrated himself.

Furthermore, the relation between human and robot gets even more complicated if we expand the focus from the capabilities of the robot to the characteristics of the interaction. Patterns of social behaviour become more important in this context. Thus, the robot designer also needs to be familiar with issues regarding social interaction aspects. At present, however, findings are still too preliminary to serve as design guidelines for a socially acceptable humanoid service robot.

4. KEY FEATURES OF CARE-O-BOT® 3 DESIGN

Based on these arguments, we decided against a human-like robot design and even investigated in measures to avoid anthropomorphic attributions, and instead support technomorphic perceptions.

The most important of these measures include the avoidance of any parts that resemble a face or produce gender specific expressions. Furthermore, the robot behaviour was modelled under considerations described above; the robot should never refer to itself by “I”, or express its needs in a human way like “I am hungry” if the battery is low, for example.

The basic concept developed was to define *two sides* of the robot. One side is called the ‘working side’ and is located at the back of the robot away from the user. This is where all technical devices like manipulators and sensors which can not be hidden and need direct access to the environment are mounted. The other side is called the ‘serving side’ and is intended to reduce possible users’ fears of mechanical parts by having smooth surfaces and a likable appearance. This is the side where all physical human-robot interaction will take place. One of the first design sketches can be seen in Figure 1.

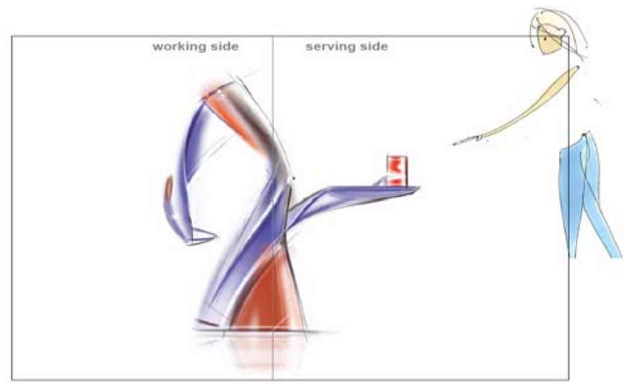

Figure 1: First design sketch

After several steps of design-technology convergence a simplified rendering can be seen in Figure 2 on the left. Based on these images the underlying technology was integrated into this shape. The final design is shown in Figure 2 on the right.

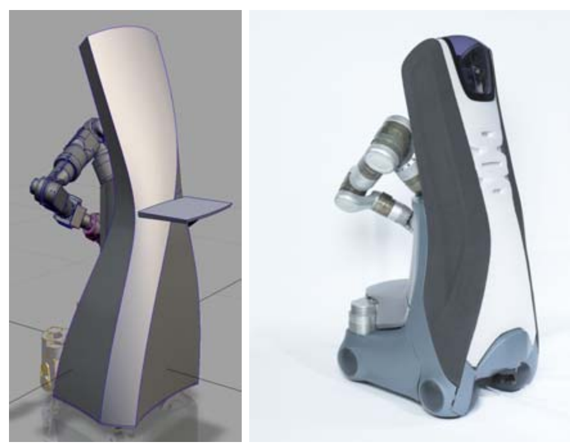

Figure 2: Left: first technical rendering. Right: final design

5. IMPLEMENTATION OF A SIMPLE USER INTERACTION SCENARIO

In order to demonstrate the *two sided* design concept, a fetch and carry application was implemented on Care-O-bot® 3. A domestic environment was created (see Figure 5) to make the scenario as realistic as possible. As basis of the communication with the user, a graphical user interface was developed in cooperation with the company User Interface Design and integrated into the tray.

The user interface has basically three different modes: in visualisation mode, the current state of the robot is displayed (manipulating, navigating, detecting objects, etc.) In user interaction mode, the user can choose a drink (e.g.cola, lemonade, apple juice), which he wants to be delivered by the robot. In order to be able to put an object on the tray without triggering commands, the object delivery mode deactivate most parts of the touch screen's sensivity. The different modes of the user interface are depicted in Figures 3 and 4.

The complete sample scenario consists of the following steps:

- Care-O-bot® 3 approaches a person and the tray is raised (state visualisation mode, navigation symbol displayed)
- The user is invited to choose a drink via the touch-screen (user interaction mode)
- Care-O-bot® 3 confirms the request and drives into the kitchen (navigation symbol displayed)
- The robot tries to detect the requested drink on the kitchen counter (object recognition symbol displayed)
- If successful, the robot grasps the requested drink and puts it on the tray (object delivery mode). After that the arm is retracted behind the back according to the *two sided* concept.
- The user is approached again to deliver the drink.
- As soon as the user has taken the drink, the robot retreats into the kitchen.

Figure 3: Left: Start-Screen, Middle and Right: user-interaction mode ("choose a drink" and "order accepted" respectively).

Currently, the robot has speech output capabilities and is able to express simple gestures, e.g. bowing when the drink was delivered to the user correctly. The user's demands can be reliably and fast communicated to the robot via the user interface in the tray, such that speech input is not necessary in this scenario.

The robot performs the whole scenario autonomously, i.e. navigation, object detection and manipulation are executed without pre-programmed positions. Figure 5 shows the robot performing the scenario.

Figure 4: Left: State Visualisation mode (Navigation screen), Right: Object Delivery mode

Figure5: Care-O-bot 3® performing as a butler. Top: The user chooses a drink via the touch screen. Middle: The robot grasps the desired bottle autonomously. Bottom: The user is able to safely grasp his drink.

6. CONCLUSION

Most service robotic projects currently focus on technological aspects and robot capabilities. But creating an appealing product is not solely a question of bringing individual functions to perfection and to assemble them afterwards.

When constructing a holistic product for a service robot application an engineering team faces different challenges. Not only hardware engineers, information technologists, mathematicians, etc. are required in the development team, but also designers, psychologists, and sociologists.

Also, the design team needs to have a clear idea on who the potential users might be, people who might be interested to change their lives by acquiring a robot. Knowing the target user group also requires to study and understand the desires, motives and attitudes of the user group.

This paper highlighted a few challenging issues in the design of a service robot product, i.e. a robot meant to fulfil a role as a useful and socially acceptable companion in people's homes. A user interaction scenario was implemented in a domestic environment set-up consisting of a kitchen and a living room. The first tests with the staff and also visitors were encouraging enough to state a proof of the user interaction concept. Placing the robot in real world environments and testing it with a larger number of users with different backgrounds will be one of the future challenges.

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