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Design in robotics based in the voice of the customer of household robots

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HIGHLIGHTS

- The state of the art in welfare-oriented and housekeeping robots are analyzed.
- Customer requirements for welfare-oriented and housekeeping robots are analyzed.
- Customer needs are transferred to a design features for reaching large masses.
- Definition of priorities and design inputs for housekeeping robots.
- List of design features for welfare-oriented robots for care of elderly with dementia.

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ABSTRACT

The aim of this study is the analysis of the state of the art in consumer robotics dedicated to personal care and housekeeping, for further critical analysis of it. After interviewing different users we will follow a methodology to find the voice of the customer. From these interviews we get the customer's needs which will be structured and ordered in a hierarchy that will help us to set the priorities, concluding with the design requirements and the basic features that the robot must have.

1. Introduction

In the last 50 years the development of robots in industry has been significant and has great expectations of exponential growth in the coming years [1].

The wide variety of existing robots of complex design and manufacturing, are usually for the development of heavy, complicated, repetitive or at high-speed tasks; exempting humans from them, increasing industrial productivity, economic benefit, job security and improving the quality of life of society in general.

Another variety of high-tech robots are robots for naval, space or research purposes. These robots require complex analysis of the functional requirements and goals of the design, being essentially the robot itself a research and development project in most cases.

Open source platforms like Willow Garage [2] and similar invite the community of engineering and programming to evaluate and improve the mechanical, electronic and programming development of open robotic platforms, where most of the knowledge and progress made in the robot is shared.

But the presence of large robot consumption in present human life is focusing on the domestic sphere (personal and service) with expectations of exponential growth [1]. Financial turnover in robotics in 2013 was $13,000 million of which $8500 million were from sales of industrial robots and $4500 million were invoiced from sales of household robots [3].

We are currently observing that the robot's interaction with humans is limited to the performance objective of the robot, while the human being, despite the functional limitations of the robot, develops an emotional and personal interrelation with the robot.

The aim of this study is to analyze the state of art in designing a robot for the household sector. Later, this information will be complemented with the analysis of design requirements by studying the customer's voice, to be able to transfer these features to a lean design and thus achieve a robust, functional, economic and safe design of robot that can reach large masses.

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The essential functions of a basic robot would be the cleaning and hygiene of the house floor in an autonomous way, free of the intervention of the user. Other useful functions would be the telecare for the elderly, providing company and control of their vital signs, and house's monitoring. These are the requirements of the present society for the new generation of robots.

A robot that meets all these features in order to fulfill these functions at an affordable cost does not currently exist. In either case there are robots with similar characteristics and functions separately, but with all that do not completely fulfill each and every one of the requirements found in this article.

2. Analysis of the state of the art

Bram Hendriks et al. [4] reported, in a study on personality and behavior of the vacuum cleaning robots, the kind of personality that the customer would like the robot to have. The same study found that as people recognize the behavior of his vacuum robot and recommends the use of a personality model as a tool for developing robot behavior.

Fig. 1 expresses the flow analysis of personality imprinted in robot design, morphology and behavior and how the behavior of the robot is perceived as a personality by the user in response to the experience enjoyed therewith.

It is suggested in this study that the development of the robot has to serve anthropomorphic aspects, i.e. the attribution of human characteristics to non-human qualities, describing personality five-factor model, such as neuroticism, extraversion, openness to experience, kindness and conscientiousness.

The studies conducted showed that people prefer more friendly and extroverted personalities rather than introverted and formal [5].

The preliminary design analysis and the search for the future questions by analyzing the voice of the customer, are set to perform two steps in the study. The first is the investigation of what kind of personality we want the robot to have according to Norman DA [6] and the second part of the study is to investigate how people experience the personality of the robot and how it by man is perceived as models identified by JE Young and others [7].

Therefore, if we consider a priori the development of a robot not only we will have to take into account the mechanical and electrical design of it, but also the anthropomorphic design and equip it with items that will bring it personality to ensure that we will understand well the robot and we will trust it, considering the personality characteristics that people use every day to describe people and also products [8].

Antonuccio, RS et al. [9] propose to explore and analyze the role of industrial design in consumer robotics since it is an area where design and specifically industrial design can be used to create innovative and unique robots that would be functional, aesthetically pleasing, with a strong element of human interface, that would be also easy to use [10] and that have a good correlation between functions and cost of the robot to be widely accepted by the consumer. Within the industrial design of the robot, colors, materials and physical attributes of a product affect the way the consumer perceives it [11]. Both the colors and materials will help us emphasize the physical attributes of the robot, depending on the personality traits that we want to attribute it.

Another factor that should define the mechanical design of the robot would be to take into account a vision-based and self location systems that would meet the different requirements for recognition. Basically the three qualities of the artificial visioning system are recognition, classification and object detection [12]. Depending on the purpose of the robot we have to choose the type of recognition algorithm and the appropriate hardware. These two points will affect the mechanical design of the robot. The algorithms used are commonly evaluated by Arnau Ramisa et al. [9] detecting various problems such as:

- Detection: Having the ability to detect in which part of the image the object is located. In most situations, large parts of the image are occupied by objects that introduce unwanted background information that can confuse the object recognition method.
- Rating: A convenient capacity for object detection method is to be able to generalize and recognize previously unseen instances.
- Occlusions: Usually the object to be recognized is not available for the robot. An object recognition method must be able to handle partial object information.
- Texture: The rich texture objects are often easier to recognize that them that only are defined by its shape and color. The behavior of each method with both types of objects will be considered.
- Repetitive patterns: In some objects, like a chessboard, repetitive patterns cause problems in recognition methods that have a data association phase.
- Resolution set: Large images generate more features at different scales (especially for the little ones), they are certainly useful for object recognition. However, if the training images have a much higher resolution than in the test image descriptors may be very different.

Ja-Young Sung et al. in their study "My Roomba is Rambo" [13] suggest four design implications in domestic robots (form related to function and intimacy through ambiguity, accountability and support) that could increase people's enthusiasm towards domestic robots and smart homes, since observed the behavior of the users vacuum cleaning robot from iRobot company seeing increased the pleasure of cleaning and even domestic users came to adapt their homes to use the robot. Although a robot with human facets awakens greater attachment, it has been shown that different designs from living things is also achieved a high degree of attachment and people may even be more comfortable at home, so suggest that humanoid or animal forms are not necessary to awaken a strong attachment to the device and this opens up many design possibilities.

Scholtz's work [14] on the conceptual design of intelligent systems adds that "The design should be aesthetic and minimalist". This must be the principle design of robots for use in homes, such as the Roomba, i.e., having a simple user interface to maintain a low cost robot while we get a simple use. Scholtz also suggests that developers should make the architecture scalable and support the development of platforms to prevent the robot will become obsolete in a short period of time.

In addition to the design suggestions of different authors analyzed, the international standard ISO 13482:2014 specifies requirements and guidelines for safe design, providing protection measures and information for the use of robots for personal or custodial care, and in particular the three types of robots:

- Mobile service robot.
- Physical assistance robot.
- Robot transport people.

The standard describes the risks associated with the use of these robots and provides requirements to eliminate or reduce these risks to an acceptable level. This standard also covers the applications of physical contact with the robots.

- Presents likewise significant hazards and risks describing how to treat them for each type of assistive robot.
- Covers robotic devices for use in personal care applications which are treated as personal care robots.
- Is limited to non-flying robots.
- It is not applicable to robots traveling at speeds above 20 km/h or toy robots.