# From a Robotic Vacuum Cleaner to a Robot Companion: Acceptance and Engagement in Domestic Environments


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## ABSTRACT
This paper shows preliminary results of the project DR4GHE (Domestic Robot 4 Gaming Health and Eco-sustainability). The main purpose is to develop a Robot Companion for domestic applications able to advise and suggest good practices to users. Interaction and engagement with the user are introduced providing to the Robot Vacuum Cleaner RVC an additional intelligence and leveraging the existing level of acceptance. Morphological aspects, in addition to behavioral traits, assume a key role in the perceptual transition of the RVC from object to subject. Human-robot interaction takes place on two levels: direct interaction, in particular with visual and sound signals; and mediated interaction, through a GUI for smartphone and tablets.



## Categories and Subject Descriptors
H.5.2 [Information Interfaces and Presentation]: User Interfaces---Prototyping, User-Centered Design, Graphical User Interface (GUI);

## General Terms
Measurement, Design, Experimentation, Security, Human Factors.

## Keywords
Edutainment; Mobile robots; Human Robot Interaction; Robot companion; Sustainability; Situational Awareness.


## 1. INTRODUCTION
Today we are witnessing the diffusion of a large number of small robots that started to populate service environments like workplaces, public spaces and, especially, homes. Mobile robotics in domestic environment is quite diffused and consists primarily of cleaning robots, such as robotic vacuum cleaner, mopping robots or floor scrubbing robots. These types of robots are, then, crucial to understand how people perceive robots [4] and accept them in daily life. Recent studies [4] highlight common habits in Robotic Vacuum Cleaners owners, e.g. *helping children to crawl*, *conversing*, *entertaining pets*, *watching for fun* and, above all, *naming the robot* [4]. Indeed naming, in other words the act of giving a name declares the fact that the robot is perceived as a subject instead of an object. This high level of acceptance arises from the fact that users have low expectations towards RVC, due to the fact that is not perceived as a robot but rather as an household appliance [6]. High level of acceptance of these robots collides with the small cognitive capabilities. As a matter of fact, they are usually, able to move autonomously and avoid obstacles but do not have interaction and companioning capabilities. The presence of RVC in domestic environments is, anyway, extremely important because it, also, paves the way to the acceptance of other robots, as it is explained in [4], a survey conducted on 379 Roomba owners, the presence of RVC in domestic environments is the first step towards a wider acceptation of robots in daily life.



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## 2. THE IDEA

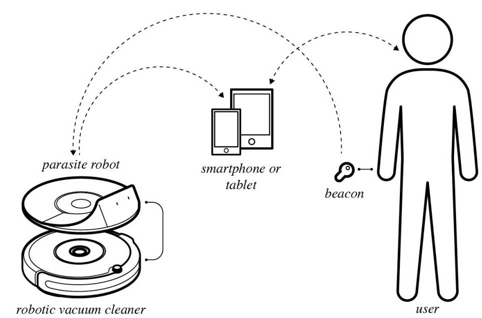


*Fig. 1: Synthetic scheme of the HRI implementation*

The intent is to develop a robot companion, able to inform users and suggest them good practices for daily life improvement. This robot is able to detect environmental information like: humidity, temperature, electromagnetic pollution, smoke, CO2, benzene, various air pollutants and gas. Due to the potential offered by the current and perspective presence of RVC into home environment, this robot is developed as a *parasite* [2] in shape and behavior: it is physically attached to (clung) the RVC of which exploit the ability of movement. It also take advantages of the high level of acceptance that robotic vacuum cleaner already has, enhancing it as a robot companion. The human-robot interaction takes place on two levels: direct interaction, consisting of visual and sound signals; and mediated interaction, through a GUI for smartphone or tablet, and a wearable key (beacon) that allows the robot to recognize the presence of the user in the house. The robot, therefore, assumes the role of a *mentor* [1]: instead of taking actions in the environment, it advises the user, feature that makes it highly acceptable by the user [5].

## 3. METHOD

In order to enable transaction from object to subject, namely from RVC to robot companion, the research activity focuses on product design and GUI development. The **product design** defines both the practical aspect of carrying a parasite robot on a RVC and morphological aspects that, in addition to behaviors [3], improve acceptance. The **graphical user interface** (GUI) is a mediator of the human-robot interaction (HRI) and consists, mainly, of notifications and visualizations of all the data collected by the robot. At the GUI prototyping phase, follows **usability tests**, the GUI is submitted to a group of users in order to identify the level of acceptance, appeal, effectiveness and decay of interest over time. The feedbacks obtained with the tests are the base for the subsequent developments of the GUI. The project includes also a preliminary phase that consists of a **survey** on technology and domestic environment, and a subsequent phase of **hardware and software prototyping**.

## 4. PRELIMINARY RESULTS

### 4.1 Survey

The survey is composed by 25 questions and aims to collect data on three main issues: knowledge and appeal of robotic vacuum cleaner, interest in the quality of home environment and appeal and effectiveness of two representative GUI. The preliminary results from a sample of 56 people, show that just 3,5% of the people owns a RVC but almost 60% (mainly aged between 20 and 40) would like to have one. Taking into account the data from a survey conducted in USA in 2008 [4], where most of Roomba's owner were aged between 18 and 29, is possible to predict that there will be a large diffusion of these products among young people who now are interested in having one. Concerning the interest in the quality of home environment, the survey provides data on how much people are worried about domestic data such as humidity, temperature, electromagnetic pollution, air pollutants or gas. The survey reveals that 91% of the people are quite or highly worried about the quality of home environment and the 82% would be willing to install an app (on smartphone or tablet) to improve the quality of home environment. In addition, only the 5,3% is not interested in buying an item for the same purpose, but the 53% would buy it depending on the cost. Interestingly, the findings of the preliminary survey show that, although, the majority of the people expressed a medium-high level of concern about the quality of the home environment, the level of awareness about the presence of air pollutants in houses is quite low. In fact the 42% of people stated that they have no idea about the presence or absence of these pollutants in their home and the 23% declared that in their house none of these pollutants is present. About the two examples of GUI shown in the survey, around the 80% of people agree that the first example (from CubeSensors project) is more appealing, easier to read and more effective than the second.

### 4.2 Hardware and software prototypingv

The architecture of hardware prototype (fig 2) is composed by: a Raspberry PI board, an Asus XTion camera, an air quality sensor, a temperature and humidity sensor, an electromagnetic filed detector and a Wi-Fi adapter. In our application, in order to provide meaningful information about the monitored parameters, it is necessary to create a map of the environment and to estimate the position of the robot in the map during operation. Most cleaning robots are usually not able to localize themselves. Some newer models, like Dyson 360 Eye, also perform localization using different sensors. Anyway, these robots do not provide external access to that information. Therefore, Localization and Mapping (SLAM) framework has been implemented. Only distance sensor is used, since access to these sensors is not available for most platforms. In order to perform SLAM, the gmapping package, available in the Robot Operating System (ROS), has been used. An Asus XTion Pro RGB-D camera has been used to simulate a laser range finder. The robot trajectory is estimated using a scan matching algorithm. In this way it is possible to obtain a map of the environment and the position of the robot in the map while it is moving in the environment. The robot continuously creates and updates a planar map of the home while it is moving. As soon as the uncertainty about its own pose in the map falls below a certain threshold (that is, the robot is sure enough about the map and its own position in it), sensor measurements are attached to the relative position of the robot.

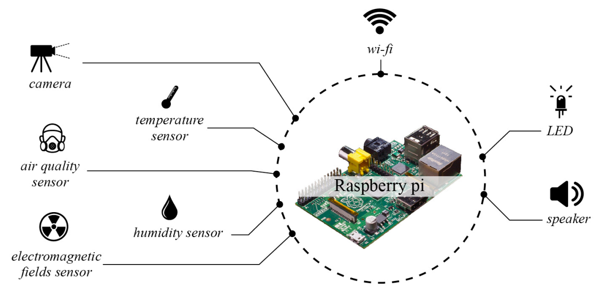


*Fig. 2: Architecture of hardware prototype*

## 5. REFERENCES


[1] M. A. Goodrich and A. C. Schultz. 2007. Human-robot interaction: a survey. *Found. Trends Human-Computer Interaction* 1, 3 (January 2007), 203-275. DOI:http://dx.doi.org/10.1561/1100000005

[2] S. Marini, 2007. *Parasite architecture. Recycling strategies for the contemporary city.* PhD Thesis, SCHOOL OF ADVANCED STUDIES Doctorate course in Conoscenza e progetto delle forme dell'insediamento cycle XIX.

[3] M. L . Walters, D. S. Syrdal, K. Dauthenhahn, R. Boekhorst, K. L. Koay, 2008. Avoiding the uncanny valley: robot appearance, personality and consistency of behavior in an attention-seeking home scenario for a robot companion. *Autonomous Robots*, February 2008, Volume 24, Issue 2, pp 159-178. DOI: http://dx.doi.org/10.1007/s10514-007-9058-3

[4] A. Y. Sung, R. E. Grinter, H. I. Christensen, L. Guo, 2008. Housewives or technophiles?: understanding domestic robot owners. In *Proceedings of the 3rd ACM/IEEE international conference on Human robot interaction* (HRI '08). ACM, New York, NY, USA, 129-136. DOI:http://doi.acm.org/10.1145/1349822.1349840

[5] J. Y. Sung, H. I. Christensen, R. E. Grinter, 2009. Sketching the Future: Assessing user needs for domestic robots. In Proceedings of the 18th IEEE International Symposium on Robot

[6] F. Vaussard, J. Fink, V. Bauwens, P. Rétornaz, D. Hamel, P. Dillenbourg, and F. Mondada. 2014. Lessons learned from robotic vacuum cleaners entering the home ecosystem. *Robot. Auton. Syst.* 62, 3 (March 2014), 376-391. DOI:http://dx.doi.org/10.1016/j.robot.2013.09.014