Prime: Towards the Design of a Small Interactive Office Robot

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Abstract. This paper presents the design and implementation of Prime, a small interactive office robot with features to support daily office activities by transporting small desktop supplies, carrying reminder notes and performing other gadget utilities. In order to create an effective inclusion of the robot in this particular workspace, the design of Prime is centered in three important aspects: functionality, aesthetics and interaction. This work is an exploratory research aimed to study the novel inclusion of small service robots in office environments and serve as a research platform to conduct human-robot interaction theories and experiments. The design and implementation of the presented robot results from an interdisciplinary work, including a survey to define Prime's functionality and behavior in response to specific office needs, as well as its design process that comprehends sketching, scale modeling and 3D prototyping.

1 Introduction

In the last years, the field of social and interactive robotics has presented a widespread development comparing to other robotic fields [1, 7, 11]. Within the insertion of robots in society, an emerging category of service robots are showing a more significant presence in daily-life activities performing as social agents [1, 8, 24]. For instance, these robots are able to assume roles, performing as receptionists, assistants, hosts, therapeutic and social companions [2, 7, 13, 17, 26, 27]. Recent design approaches for service robots does not consider functionality as the only priority, whereas interaction and aesthetics are playing a major role [14].

In this context, office oriented robots are considered as agents that exhibit some dynamic behavior and reside within a workplace [24], while performing tasks such as telepresence [18], cleaning [9], and supplies or snack delivering [10, 20]. Among these examples, telepresence robots are mostly commercially available [18], which demonstrates the acceptance of this type of robots. According to our research, there's no extensive published work concerning small office robots, especially those that can be portable and work in a desktop environment [6].

This paper considers the design and implementation of a small interactive office robot, in contrast to more robust and non-portable office robots found in literature.

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This robot is intended to be used as small assistant agent, supporting different desktop related tasks found in daily office activities. The presented work is an exploratory research which will serve as a framework for future research on human-robot interaction in an office context.

The remaining part of this paper is organized as follows. Section 2 covers the design components of the proposed robot, based on literature and supported by a survey. Section 3 presents the design and implementation of our robot. Finally, the last section presents conclusive remarks and directions of future work.

2 Design Components

This work is a first approach towards the design of a small interactive office robot. Therefore, it is necessary to define the robot's design components. Particularly, a theoretical approach by defining three design guidelines and experimental data collection conducted by a survey are presented.

2.1 Design Guidelines

There are three aspects considered in the theoretical design of the robot: functionality, aesthetics and interaction.

Functionality
Utility or performance along with functionality is one of the main pillars during the design process of everyday products [21]. Robots designed for office environments shouldn't distance from this focus. Previous research has evidenced that perceived usefulness of a robotic service is one of the main facilitators for the user's initial acceptation [2, 28].

Additionally, the daily exposure of an office robot requires mechanisms to ensure a long-term interaction [19], otherwise the user will cease using the robot after the novelty effects of its introduction vanishes [17]. We consider that by ensuring functionality as the main design consideration of an office robot, a long-standing bond with the user will be held.

Aesthetics
Aesthetics, from the product's design perspective is one of the major aspects that influences the response or reaction of people with an object, appliance or system [21], and it is important for determining if the product is rejected or evokes attraction to people [15]. Particularly, visual aesthetics has a symbolic function that influences how a product is comprehended and evaluated [3].

In the context of an office robot, aesthetics is intrinsically linked to the user, serving as a tool for holding the user's attraction to the robot while evoking strong emotions. It is suggested that if aesthetics is considered along with functionality in the entirely design process of the robot, then, it is perceived as being more usable by the target public [14]. For instance, by encouraging the user to ask for the robot's services

[2, 22]. In this way, aesthetics is a catalyzer for establishing user-robot interaction bonds, a desired feature for our continuously exposed robot [17]. This quality is comprised in the concept of aesthetic functionalism [12].

Interaction
Interaction is the design guideline that could differentiate the office robot from any other office machine or supply, because it can generate new user experiences that could attain preference for the robot and achieve a deeper bond with it [22]. For instance, interaction complements the robot's aesthetic functionalism by adding a sort of dynamism to the robot which boosts the user's perception of this object. From this approach, the robot works as an interactive gadget. Additionally, interaction is able to decrease the initial difficulty for the user to identify how to use the robot [23].

Furthermore, the level of interaction determines how a person perceives the robot as a sociable entity, influencing the user's acceptance of the robot [8]. By including a dynamic behavior, it is possible to transcend the robot from being regarded as a "mechanical utility" to a scope in which the user recognizes it as a helpful autonomous entity capable to relate with him [16]. For example, some robots include sophisticated social cues like an expressive head or anthropomorphic limbs to denote an elaborate corporal language [4, 5, 19]. However, a small office robot may exploit simpler social cues based on motion [8], for instance, by naturally wandering throughout its environment while offering its services.

2.2 Survey Analysis

A survey was performed in order to collect information to support the design guidelines and implementation process of the proposed robot from the user's perspective. The examination was taken to 32 office workers, 11 male and 21 female, in order to explore their expectations regarding the inclusion of a robot in their workplace. The participants may be biased towards female workers due to the female gender predominance in this particular surveyed work context.

The survey was structured in two parts. The first part consisted of exploratory questions about the personal opinion of the participants according to visual appearance, functions and behavior of what they considered an office robot. The second part presented the concept of a small interactive desktop robot, and questions about its features were requested.

Results of the exploratory question about the robot's visual appearance showed that 62.5 % of participants preferred an anthropomorphic office robot, 25.0% a zoomorphic appearance and the last 12.5%, a machine-like appearance. Regarding the desired robot's behavior, participants were asked to pick one of the following conducts:

- **Option A:** The robot is placed in a corner or specific spot, waiting for the user to send a command to come and carry out the service it offers. After offering its service, the robot will go back again to its spot and wait for anybody to use it.

- **Option B:** The robot is wandering around the office workplace in a natural way, so the user can approach to it in order to require the service it offers. Eventually, the robot may approach and look for interaction.

The 37.5% of participants chose option A, while a significant 62.5% preferred option B, the more dynamic behavior. Additionally, participants were asked to justify their selection. In the case of participants that selected the second option, they chose a more dynamic behavior, therefore the robot could look for attention, encourage the surroundings people to use it, and show that it is not a mere decoration. Furthermore, explanations related to an interactive behavior of the robot were registered. Participants stated they didn't want a slave or a lazy robot employee, they expected something more natural and easier to relate with, something that could distinguish itself from other electronic devices. On the other hand, participants who chose option A mainly explained that a dynamic behavior in an office robot may represent a physical obstacle for the labor of workers.

In the second part of the survey, the concept of a small office robot for operating in a desktop was introduced. Among the functions defined by the participants, a 34.5% preferred the robot to keep papers and envelops, a 17.2% to carry supplies, and a 51.7% specified gadgets functionalities such as USB storage, music playing, alarm notification and date displaying. Additionally, participants specified the means of interaction with the desktop robot: a 70.6% preferred talking to the robot and a 30.0% interacting by touching it. Participants who chose the first option explained that oral communication was more intuitive. In contrast, the group that selected touching the robot discarded oral interaction as the robot could obey surrounding voices and mentioned that touching was a way of how a person relates with a pet. Finally, participants were asked to list which office supplies they considered important for the desktop office robot to carry. A total of 13 different types of objects could be identified, among them, carrying pencils and highlighter 33.3%, envelops or papers 19.7%, clips 9.1% and reminder notes 7.6%.

The examination results supported two important statements from our design guidelines. First, functionality is the most important consideration for the perception of an office robot, and that this will have a strong impact on accomplishing a long-standing interaction with the robot. Second, the survey showed that participants appreciated a continuous dynamic behavior of the robot, because it corresponds to the busy working context of an office. In this way, motion could be an important social cue. Finally, the survey demonstrates that a desktop robot might not be the type of robot an office worker expects, thus, it is an attractive field for further research.

3 The Desktop Office Robot Implementation

After analyzing the survey results and contrasting them with the design guidelines, an adequate focus for the development of a small office robot can be established. In this context, our proposed robot, Prime, was conceived as a desktop office robot and as a platform to explore and research in human-robot interaction.

Prime's functionalities are basically those related to be used as an additional office utility. Therefore, its main application is to be functional without disturbing the user or being a physical obstacle in its working environment. Additionally, Prime distinguishes from other office tools by creating an appropriate mimicry with the worker's environment such that it will not be regarded as a mere "service supplier", but a more dynamic interactive gadget. For instance, Prime will display a self-explanatory functionality while being an aesthetically pleasant robot. Furthermore, Prime's mimicry with the office environment will be achieved through displayed motion, which, as noted in the survey, will encourage the user to interact with it and obtain its services.

3.1 Design Process

A first consideration for Prime's design process was the definition of its particular physical features. Even though an anthropomorphic appearance was preferred for the robot in the survey, it is impractical for desktop environments due to its limited space, compromising the robot's movement and dimensions. Therefore, we chose the second best option: a zoomorphic appearance. Particularly, Prime resembles an ape. Additionally, previous works suggest that zoomorphic features in robots generate adequate human responses during interaction [13, 25].

Regarding the utility of Prime as an office tool, it was designed to carry small office supplies, such as pens, pencils, highlighters, post-its and clips. Prime's main purpose of carrying the previously mentioned small office supplies spans almost 50% of the expected objects from the survey.

Freehand Sketches

Hand-made sketching was an important stage for defining the morphological considerations of the robot. Prime, addresses the goal of integrating functional and interactive qualities in an object [22], by having a self-explanatory anatomy, which is partly achieved by Prime's ape-like appearance with two relative big limbs, as seen in Fig. 1.a. Additionally, Prime holds a backpack in order to carry the defined small office supplies, a self-explanatory feature which visually communicates the user that "things must be placed here". Notice in Fig. 1.a. that the inclusion of this backpack does not affect Prime's zoomorphic appearance, so the robot's functional and aesthetics design guidelines do not conflict with each other.

Scale Model

The dimensions' definition of the desktop robot is a critical factor to be considered due to its constraint workspace. This urged the need of experimenting with a tangible object before going to a further prototype complementing the 3D modelling software process. As a result, a scale model was constructed using a wire structure covered with modelling clay, as seen in Fig. 1.b. This physical representation contributed not only to define Prime's true dimensions, but to generate additional utilities for Prime, for instance, the fact that post-its could be stick on Prime, serving as a living reminder utility.

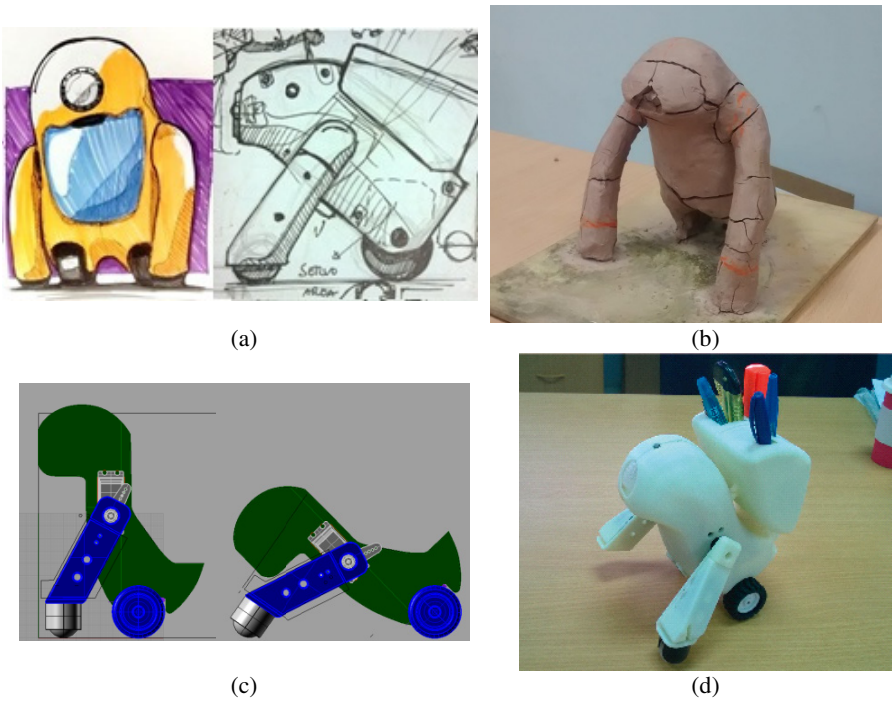


Fig. 1. Prime's design process a) Freehand sketches b) Clay scale model c) Prime's stretching and spreading movements d) 3D prototype

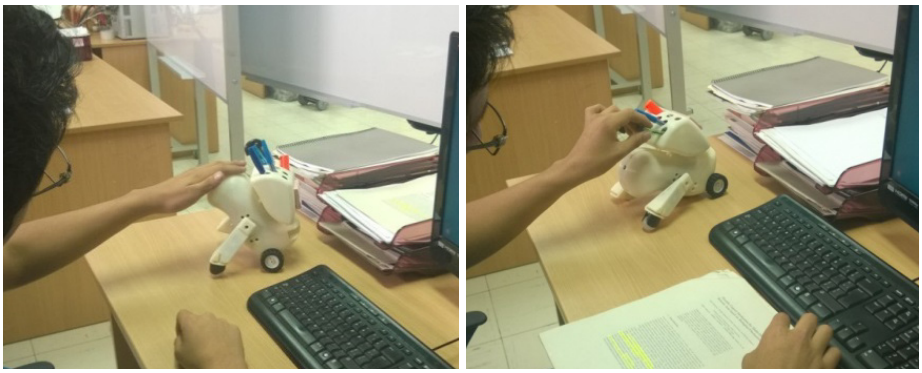
3.2 Interactive Behavior

Prime can perform animal inspired movements that have demonstrated effective responsiveness in previous research [1, 16, 22], and which have been previously stated as adequate social cues in office workplaces according to the survey results.

First, the robot can autonomously display erratic and random displacements throughout its environment while avoiding obstacles and without disturbing the user or falling from the desk. This allows Prime to be seen as an autonomous attentive agent [16], actively looking for establishing interaction with the user and being busy during its stay in the office. Complementarily, as shown in Fig. 1.c. Prime is able to perform stationary animal-like movement such as stretching and spreading its limbs like an ape. Lastly, another possible benefit is that Prime might add some playfulness to the work environment without being distractive.

Prototype

Prime's 3D printed prototype, as shown in Fig. 1.d., served to explore the user interaction with the robot. The user will need to touch the robot's head as he would be



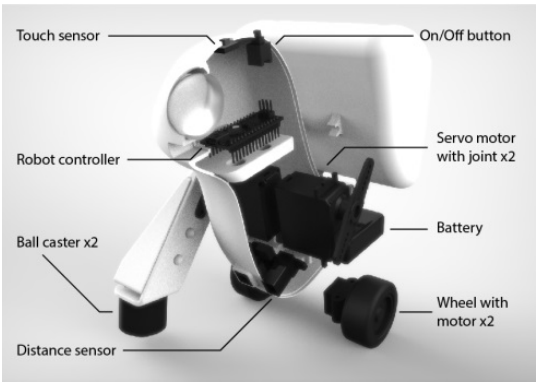
(a) (b)

Fig. 2. Prime's dynamic behavior a) Prime being petted by the user b)Prime stretches its body and the user acquires its services

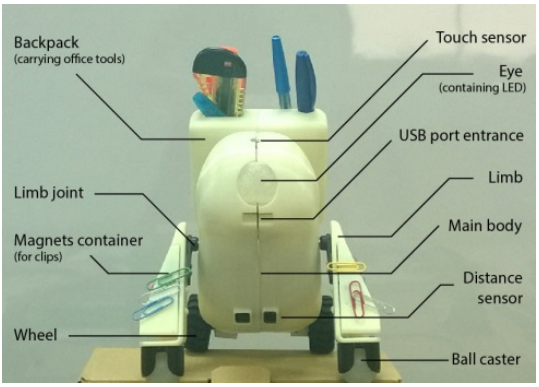
Fig. 3. Prime carrying small office supplies

petting a pet in order to request the robot's service. This action is enough for Prime to interpret that the user's needs its service, and then it will pause and spread its body, so the user can take or place the office supply he wants, as depicted in Fig. 2. According to the design guidelines, this intuitive communication enhances the functionality of the robot. Fig. 3 shows how Prime carries three types of office supplies. The prototype demonstrated that Prime has the potential of including other gadget functionalities demanded by people in the survey, such as USB storage, a display for timing, a cell phone holder, etc.

Prime was implemented with the necessary electronics and mechanical components in order to accomplish all the requirements defined in the design process. The electronics are detailed in Fig. 4.a., and a more extensive appearance description along with functionality details are shown in Fig.4.b.



(a)



(b)

Fig. 4. Prime's electronics and appearance details a) Inner view b) Frontal view

Fig. 5. A group of Prime robots on a meeting room table

There are two possible main scenarios where Prime is intended to be used. First, Prime may serve as a personal assistant by giving support to a single user in its daily office routines, as shown in Fig. 2. Second, Prime may serve a group of people, wandering around in meeting room tables where many people are present, so each person is always sufficient supplied. This is shown in Fig. 5.

4 Conclusion and Future Work

This work has presented an exploratory research towards the design and inclusion of competent office robot. Throughout our study, important features have been recognized to be considered in the design of a small office robot. Additionally, they might be extrapolated to other office robots. As a result of our research, we believe that the presented robot's intuitive communication, boosted by its dynamic animal-like behavior, aesthetic functionality and self-explanatory anatomy will encourage people to use it in their daily office working routine.

Future research will consist on introducing Prime in real office workplaces and testing the user's response and experience in a long-standing experiment, in order to measure its degree of acceptance and be a proof of concept for the different design considerations expressed throughout this work. For instance, defining the amount of dynamism Prime must display for not being regarded as a distractive element. Finally, we know that Prime is a personal and portable robot, so we believe its usage can transcend the office environment and start being used in home desktops: another impact study for further research.

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