Application of Human-Robot Interaction Features to Design and Purchase Processes of Home Robots

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Abstract. Production of home robots, such as robotic vacuum cleaners, currently focuses more on the technology and its engineering than the needs of people and their interaction with robots. An observation supporting this view is that the home robots are not customizable. In other words, buyers cannot select the features and built their home robots to order. Stemmed from this observation, the paper proposes an approach that starts with a classification of features of home robots. This classification concerns robot interaction with humans and the environment, a home in our case. Following the classification, the proposed approach utilizes a new hybrid model based on a built-to-order model and dynamic eco-strategy explorer model, enabling designers to develop a production line and buyers to customize their home robots with the classified features. Finally, we applied the proposed approach to robotic vacuum cleaners. We developed a feature model for robotic vacuum cleaners, from which we formed a common uses scenario model.

Keywords: Human-robot interaction process design · Build-to-order · Dynamic eco-strategy explorer model · Robot customization

1 Introduction

This paper presents the idea of combining two strategies, build-to-order and the dynamic eco-strategy explorer model (DEEM), into **the Hybrid Model**. The Hybrid Model is used to get maximum user satisfaction by giving the user to an opportunity customizing their domestic home robots. Robotic vacuum cleaners, in a word robovacs, are chosen to apply and evaluate this idea.

2 Feature Model of Vacuum Cleaner Robots

The technical features available in the market and the expectations of the product from the user can be evaluated by using a feature model. The existing and conceptual characteristics of robotic vacuum cleaners can be used to construct an essential feature model, which is rooted in the technical features desired to be added and creates the mechanical equipment and accessories to be used in the branches. R&D designers and engineers can

H. Li et al. (Eds.): ICSR 2021, LNAI 13086, pp. 808–813, 2021.
https://doi.org/10.1007/978-3-030-90525-5_76

benefit from the feature tree to create the essential structure of robovac to be advanced. The user group selection will be one of the most critical factors that will determine the quality, capabilities, and combinations of the technical part to be used in the device. Currently, due to standardized production methods, the customer cannot select the characteristics of the robotic vacuum cleaner. Instead, a customer chooses market products offered close to his/her needs. Figure 1 is a designed feature model consisted of essential features for the robotic vacuum cleaner.

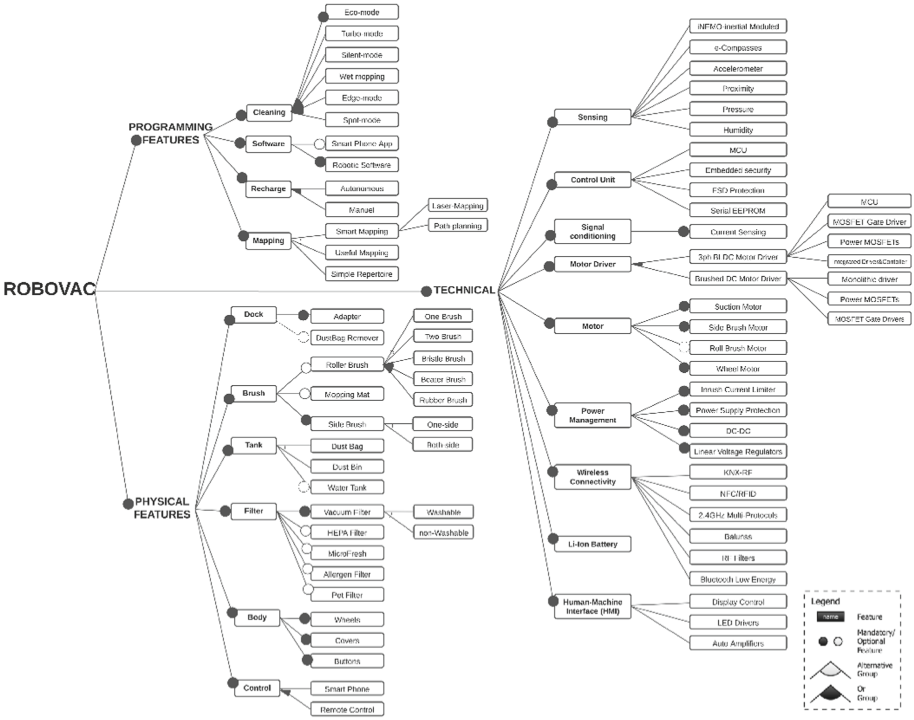

Fig. 1. Feature model for robovacs (the technical branch is modified from [1]).

3 The Proposed Customization System Design: The Hybrid Model for Robotic Vacuum Cleaners

The traditional firms fulfill customer demand using their investigations and they choose a limited set of product configurations, thereby enabling consumers to find products that are close to their ideal choice [2]. However, considering the interaction process of a basic robovac, the various parameters, which need to be evaluated simultaneously such as the physical characteristics of the environment to be used, the smart ecosystem integrated with, and the householders, that will affect the use of the product emerge. When the combinations of these parameters are calculated, a great variety of standardized preferences should design and produce. However, the robovac market inherently has customers with heterogeneous preferences for product features, considering the network of interactions. To achieve maximum product satisfaction, we are proposing a designated product configuration process, which is the process of customizing a product to meet the needs of a customer, and an effective interaction process design for the marketing and selling phase.

In this section, two models utilized in various cases are examined robovac customization. **Dynamic Eco-strategy Explorer Model** is proposed with the aim of optimizing the energy and resources consumed through the use of a product by Serna-Mansoux et al. in 2014 [3]. The DEEM aims to choose the correct product among existing alternatives and does this by scoring the products and comparing the results with each. The DEEM model is composed of six stages in sequence, Choose, Understand, Explore, Decide, Test, and If [3]. In Fig. 2, the initial interaction process is assimilated from the implementation of Serna-Mansoux et al. [3]. **The Build-to-Order model** is the strategy, that enables mass customization with aim of customer satisfaction. It has some accomplished implementation instances by considerable companies including Dell Computer, Compaq, BMW, Mercedes. The BTO is a production method that switches the market power from seller-driven perception to buyer-driven one [4]. The proposed hybrid model utilizes DEEM and BTO in a novel combination. The DEEM is adapted to get high-efficient interaction. Moreover, the direct model is accepted as a business model that will build standards quickly and manufacture a highly configurable product.

The DEEM is redesigned to construct efficient interaction between customers, and product design that consists of standardized units from purchasing decisions. In our study, it mainly applies to the first interaction with potential users during the product choosing stage. *Choose* stage aims to get the purchaser to know the product, and determine customers' individual and environmental characteristics interacting with it.

At *Understand* stage, some usage scenarios are created by referring to the selected attributes at the previous stage. These scenarios are formed as the result of detailed customer segmentation based on needs and preferences by research and development, and design teams. The customer picks from the recommended usage scenarios. These scenarios are critical to generating some product alternatives based on needs and wishes. More questions are asked for customization.

In the stage of *Explore*, based on the responses to the detailed questions asked before, the interaction system presents a robotic vacuum cleaner as a composition of desired components. At this stage, the presented product can be considered as an optimized robotic product based on users' needs. However, even so, customers can control the component features and models by their wishes. In other words, the exploration of the robovac by the user is expected. Since the product is designed modular in the R&D and design phase of the BTO, the exchange and integration of the units will be possible at every stage. After the third and fourth stages, the concept of the process starts to evolve toward decision making. At stage four, the representative product is presented as videos. At stage five, in this way, users can have predictions about the usage of the product and can test the result digitally. The final stage is deciding whether to buy or not. Here, the product is either purchased and manufactured or returned to the third stage to be modified and rebuilt.

Moving on to the implementation phase of the BTO, here are the first two phases that are critical for us. Managing the product variety is essentially the first movement to customization design of the product to be manufactured. It starts with evaluating the existing usage environment and classifies them into groups. This classification generates some customer segments based on the requirements and preferences. Thus, interaction scenarios emerge for use in the next phase and the previous model (the DEEM) implementation. The next phase consists of the set of research & development and design processes. Concepts and scenarios created in the previous stage form the source for product and component design at this stage. The components used or supplied are presented in the interaction phase for use in the explore phase. Then, production starts with simultaneous production planning and supply chain integration. In addition to these explanations, this model is the first form of the study and is still being studied.

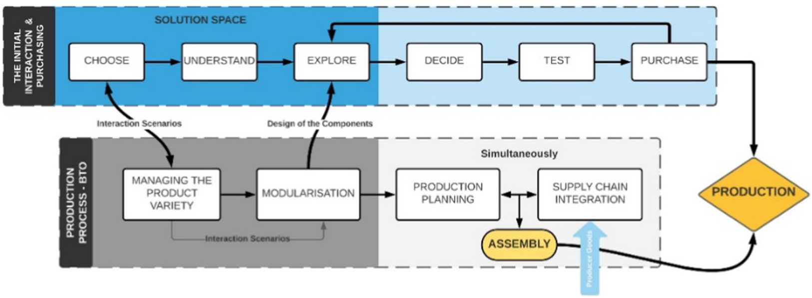

Fig. 2. The proposed hybrid model

4 Evaluation: RoboCuD Home

This study considers personalization according to usage conditions as a critical principle in the robotic vacuum cleaner development process. However, the number of product variations to be created with required and optional feature combinations reach too high for users to decide and for manufacturers to produce. To demonstrate, Fig. 1 can be utilized. Firstly, the number of features that can be added to the robot is calculated with combination calculations for each branch. Afterward, the number of robot versions is computed by using the cartesian product. The number of combinations for each branch is shown in Table 1. If all decisions are left to the user, the number of products that can be created is calculated as 84,934,656, although only the engine option is included among the technical features, and this number can be increased. This number is calculated by the multiplication of the feature tree combination possibilities.

A simple multipartite graph will be used to explain the simple implementation of this model and for the RoboCuD Home we are developing. In the first stage, we create a set, which we call *prerequisites*, which is used to define the ecosystem in which the robot will be used before recommending a robot to the user and to create product recommendations based on this. Figure 3 shows a cross-section of the items that will help determine the

Table 1. Feature model-based product options

	Cleaning Modes	Software	Recharge	Mapping	Dock	Brush	Tank	Filter	Body	Control	Motor
Number of options	32	2	3	3	2	96	4	32	1	3	2

characteristics of the home environment and the user in which RoboCuD will be used. The item combinations selected from the set for the user are designed to present the most suitable RoboCuD models for a specific home environment and user group. In the second part, user segments are created from the selected combinations. Figure 3 shows two of these segments in the *cases* section.

Finally, RoboCuD models are presented to the user in accordance with the environment, and user segments are determined for RoboCuDs appearance. The resulting models form the basis that the buyer will use before customizing the product according to his wishes. Then, the user can start customizing the robot at the website. For ongoing and detailed website design, [5] can be visited.

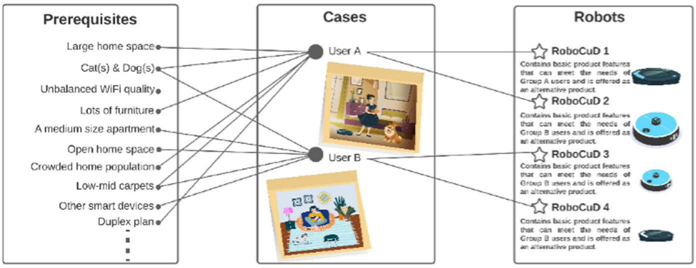

Fig. 3. Multipartite graph - a basic explanation of how the proposed system works.

5 Conclusion

This paper presents the idea of domestic social robots' customization with the proposed Hybrid Model, based on user needs by considering customer satisfaction. Robotic vacuum cleaners are selected to implement the study. Technological advancements in robotic technologies, especially in robovacs are deeply studied, and the chosen DEEM and the BTO model are combined to create a multiple-stage customization system. Then, the initial form of the Hybrid Model is explained in detail.

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