Grasping Everyday Automation – A Design Space for Ubiquitous Automated Systems

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ABSTRACT

No longer only experts are confronted with (semi-)automated systems, yet automation has founds its way into our everyday lifes in various forms and applications. Based on a thorough literature review, we introduce a design space for "everyday automation" to uncover eight core dimensions of respective systems. These dimensions include the domain, the task type, the type of user interaction, and the automation level, among others. Visualized as a "morphological box", this design space is particularly supposed to support the ideation of novel automated systems for everyday life.

CCS CONCEPTS

• **Human-centered computing → Human computer interaction (HCI)**.

KEYWORDS

Automation, design space, user experience, automation experience

ACM Reference Format:
Jessica Bongard, Matthias Baldauf, and Peter Fröhlich. 2020. Grasping Everyday Automation – A Design Space for Ubiquitous Automated Systems. In *19th International Conference on Mobile and Ubiquitous Multimedia (MUM 2020), November 22–25, 2020, Essen, Germany*. ACM, New York, NY, USA, 3 pages. https://doi.org/10.1145/3428361.3432079

1 INTRODUCTION

Whether a fully automatic vacuum cleaner in the living room or a self-sufficient service for municipal information and applications: automation appears in numerous forms in our everyday life and is constantly evolving. "Everyday automation" (cf. [12–14]) is a very broad and complex research topic, which is particularly driven by recent advances in Artificial Intelligence (AI) and "smart" devices at affordable prices. Everyday automation can be understood as a union of the definitions of automation and everyday life. It is a process in which individual functions or entire activities are transferred from humans to machines, and which focuses on a person in their immediate, everyday environment. From a scientific perspective, a categorization of the numerous appearances of automation in our everyday life is relevant in order to provide a comprehensive overview and structure, to uncover possible gaps in research, and to identify promising future applications. By analyzing existing automation approaches for everyday tasks and by identifying potential variants, we strive to unfold the so-called "design space" of everyday automation. Design spaces for categorizing work in specific research areas have a long history in HCI research (cf. [3, 17, 21]). In the following, we present our design space for everyday automation. We report on the method, the core dimensions identified as well as a promising visualization approach.

2 METHOD

In order to derive the dimensions of this design space, we conducted a literature research on recent appearances of everyday automation in the *ACM Digital Library*, the *IEEE Xplore Digital Library*, and the *AIS eLibrary*. Additional alternative sources were covered by using *Google Scholar*. At the center of this review were keywords and keyword combinations which had been derived from contributions to two CHI workshops on "Everyday Automation Experience" [12, 14] and included "everyday automation", "smart technology", "smart devices", "everyday interaction", "digital assistants", and "home automation". These search terms were expanded during search with newly acquired knowledge. The main inclusion criterion for a paper was that the research contained recent approaches and examples for everyday automation. After the removal of duplicates, our literature collection contained 65 papers. To identify and structure common themes and derive universal dimensions of everyday automation from this collection, we followed a grounded theory approach [22] combined with a quantitative content analysis [20]. In an iterative process, we identified groupings of papers and derived the corresponding higher-level dimension. A dimension was included in the design space if it could be determined for each system described in the papers while its potential characteristics were defined by the variants found in the papers.

3 DIMENSIONS

From this literature analysis, we found eight core dimensions for a design space of everyday automation. Figure 1 visualizes the design space and its dimensions as rows in a so-called "morphological box". Therein, a specific system can be represented by a vertical path through the respective characteristics of each dimension:

D1: Presence of the System. Everyday automation applications can be differentiated according to the presence of a physical system. Based on the analysis of the examples, we propose a division of the applications into virtual (such as a digital agent [11]) and physical presence (such as a fully-automated coffee maker [16]).

MUM 2020, November 22–25, 2020, Essen, Germany

ACM ISBN 978-1-4503-8870-2/20/11.
https://doi.org/10.1145/3428361.3432079

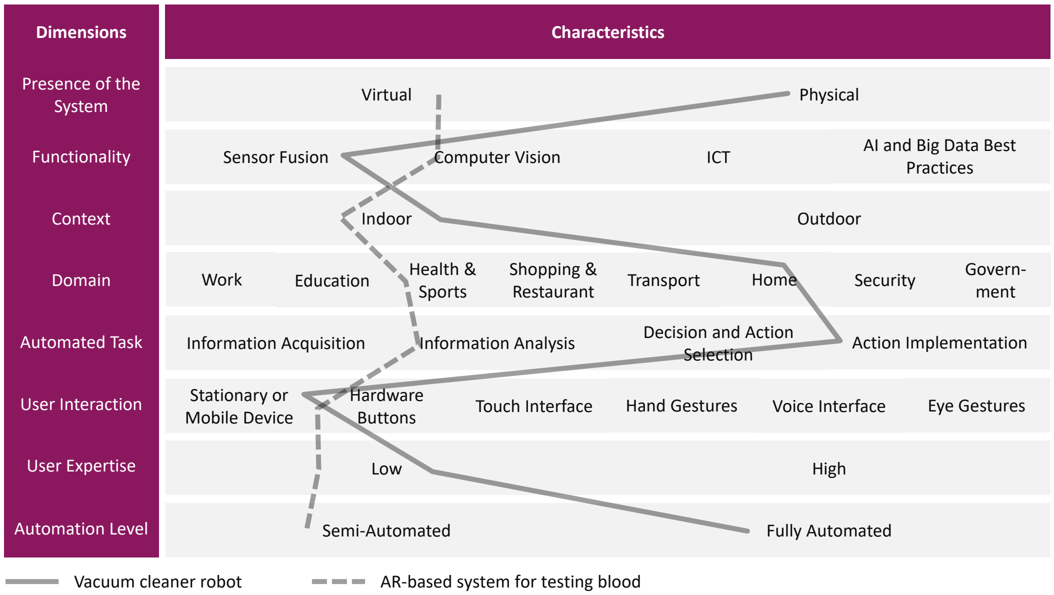

Figure 1: The design space of "everyday automation" with its eight core dimensions visualized in form of a morphological box. Two automation examples from literature [7, 19] are represented by vertical paths through the dimensions.

D2: Functionality. The dimension functionality describes the technological foundation of the automated system. The following four enablers were identified: computer vision (for eye tracking, face recognition, augmented and virtual reality, e.g. [8]), sensor fusion (for voice recognition, motion detection, etc., e.g. [30]), information and communications technology (Wifi, Bluetooth, etc.) and AI and big data techniques (machine learning, text analysis, etc., e.g. [27]).
D3: Context. The context of an everyday automation application can be either indoor or outdoor. For example, guided cooking with an automatic food processor (e.g. [18]) takes place primarily indoors. On the contrary, an automatic garden irrigation system (e.g. [28]) is only used outdoors. In some cases, however, an application can be used indoor and outdoor, such as autonomous drones (e.g. [4]).
D4: Domain. The following application domains of everyday automation were identified from the literature examples: work (e.g. [11]), education (e.g. [24], health and sports (e.g. [2]), shopping and restaurant (e.g. [6]), transportation (e.g. [15], home (e.g. [28], security (e.g. [10], and government (e.g. [1]. Frequently, several different areas of application are mentioned for the same example. For instance, food recognition of smart refrigerators (for automating ordering processes, e.g.) can be used at home, but also in restaurants.
D5: Automated Task. Our task types of everyday automation are based on related previous research on categorizing automation by Parasuraman et al. [23]: information acquisition, information analysis, decision and action selection and action implementation. While information acquisition describes purely sensory functions for capturing data from the environment, information analysis deals with processing the captured data. The decision or action selection deals with the derivation of further action steps and the action implementation represents the actual action execution.
D6: User Interaction. Six different user interactions for everyday automation applications were identified from examples in literature: stationary or mobile external device (e.g. [28], hardware buttons (e.g. [18], touch interface (e.g. [16], hand gestures (e.g. [26]), voice interface (e.g. [1]), and eye gestures (e.g. [29]).
D7: User Expertise. While fine-grained user expertise models have been presented in literature (cf. [9]), we propose a simpler model for categorizing everyday automation applications. "Low" expertise for applications that can be used without significant previous experience (e.g. automatically unlocking a cell phone display [5]) and a "high" level of expertise for everyday automation applications that require a certain level of competence and extra information (e.g. defining rules for smart home lighting [26]).
D8: Automation Level. Based on a categorization by Parasuraman et al. [23], we classify the degree of automation in semi-automated (a task is carried out by combining the advantages of human skills with the advantages of the machine, e.g. [26]) and fully automated tasks (a task is solved completely and exclusively by the machine, e.g. [25]).

4 CONCLUSION

We presented a design space for everyday automation consisting of eight core dimensions derived from a literature review. The proposed visualization provides a compact overview of manifestations of everyday automation and particularly supports the ideation of novel automated systems for everyday life. For example, future variants of the vacuum cleaner robot in Figure 1 could be explored by reflecting on different characteristics for specific dimensions (e.g., changing the type of user interaction from "hardware buttons" to a "voice interface" or switching the domain from "Home" to "Shopping & Restaurant"). Since the eight dimensions are not supposed to be exhaustive, future research might build on this work and explore additional dimensions to capture the multi-faceted nature of everyday automation.

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