Towards Ethical Agency in the Smart Home “Living Place”

On the Conception and Development of Ethical Smart Home Systems by Elective Projects within Computer Science Education

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Abstract: Smart Home applications exert immediate influence on inhabitants. While the widespread availability of supporting frameworks and technologies facilitates ad hoc application development, assessing and designing the impact on inhabitants have to be considered as well. In this paper, we outline a concept for an elective bachelor's project for computer science students planned for the upcoming winter term. This course builds on our experience with two elective courses on the topic of "machine ethics”. In this project, we understand the smart home "LIVING PLACE" at HAW Hamburg and its interior as ethical actors and outline how to advance this viewpoint to a testbed for experimenting with principles of (machine) ethics and embedding ethical values during system development. (125 words)

Keywords: machine ethics, computer science, social sciences, autonomous agents, adaptive systems

1 Introduction

Intelligent living environments have been in development for several decades and are now finding practical applications. These environments are suitable for both younger and older target groups. They can also be integrated with mobile health and self-tracking applications. Studies on the ethical dimensions of smart-home technology often raise concerns about topics like privacy, consent, data ownership, social isolation and equity of access [Bi17, Fe24]. It is not surprising that after approximately fifteen years of technology-driven research, the dimensions of the impact of technology and the social and ethical consequences are increasingly coming to the fore. The proliferation of smart home devices has led to the collection of vast amounts of data pertaining to users' activities and behaviours. To ensure the protection of this data from cyber threats and to address concerns related to data collection and usage, it is of the utmost importance to implement robust security measures. There are, of course, many other areas of research relating to the smart

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home, such as interoperability, energy efficiency, user experience & interface design, legal compliance, etc., which we cannot pursue further here. In the following, we will focus on working with students to investigate in detail how a smart home environment supports and influences residents in their everyday lives and what values these technologies should be committed in order to avoid or at least minimize undesirable side effects and consequences. What are the implications for residents when their home environment is influenced not only by themselves but also by smart, augmented objects, such as mirrors, plants, or cups? How does it affect them when their home actively monitors their behavior and interactions, relays it back to them, and even provides suggestions for future actions? What are the potential outcomes when the living environment autonomously communicates with smart devices, such as wearables, including watches or clothing?

Our paper outlines a concept for a bachelor's project for computer science students in the upcoming winter term. The course builds on our experience with two elective courses on the topic of *machine ethics* [DS23]. We aim to complement our previous theoretical work with practical considerations to build ethically informed prototypes as actors in the smart environment.

This paper is structured as follows. In the next section, we give a brief outline of ethical challenges in Smart Home applications. The following Section 3, we introduce the HAW Living Place, relate this environment to ethical development practices and outline a prospective testbed environment, based on the Living Place. A corresponding project for computer science students is presented in Section 4, before we conclude and give prospects for future work.

2 Ethical Challenges in Smart Homes

In this project concept, we understand the smart home laboratory "LIVING PLACE" [HA24] and its smart interior as ethical actors and therefore, we would like to realize a testbed for experimenting with (machine) ethics and embedding ethical values during system development. The smart home environment "LIVING PLACE" at HAW Hamburg is a realistic experimental environment and enables user experiments. We are focusing mainly on four aspects. (1) A conceptualization for activating devices and artifacts in the smart home by an IoT-based overlay and software agents to control devices and interact with the human inhabitants. Basically, this supplies an environment for ethical actors. (2) We define scenarios in which the smart home influences the inhabitants and decide to what extent ethical aspects like transparency, privacy, fairness or trustworthiness can be included in the decision-making process. (3) Exploring how value-based engineering processes (e.g.) can be applied within the Smart Home domain. (4) One way to gain insight into one's own practices in the living environment is through an “autoethnographic” exercise (f. e. in the form of a diary study). "Autoethnography is an approach to research and writing that seeks to describe and systematically analyze (*graphy*) personal experience (*auto*) in order to understand cultural experience (*ethno*)" [El11]. At the beginning of the course, students are asked to record their daily routines in the context of technology use for a period of three weeks. “Diaries are a method to collect data at the daily level or even several times a day. During the past decade, diary methods have been increasingly used in work and organizational research [...], particularly in the areas of health and stress [...], emotions at work [...], work-home interface [...], and social interactions” [Oh10]. As Jarrahi et al. put it: “Diary studies offer three commonly acknowledged affordances: ‘in situity’, context specificity and longitudinality” [Ja21].

First, it is important to identify the potential target groups for whom the artefacts in the smart home will be developed. Different approaches are possible, including a) older adults (65+), b) children and adolescents, and c) people with disabilities (e.g. visually impaired). Secondly, in addition to literature research, experts should be interviewed to address the development needs of specific target groups. For instance, for the older population, discussions can be held with counsellors from the 'Barriere Frei leben' association in Hamburg, who provide advice to caregivers on the use of digital aids.

Classical ethical concerns for designing Smart Home applications are the Security and Privacy concerns (e.g. see [Ch21]). The automation of tasks requires contextual information that, when related to inhabitants and users, reveals personal information. Breaching the automation systems enabled misuse of functions and information. However, these are collateral implications of the involved infrastructure. We are more concerned with the immediate implications for inhabitants. E.g. in [EK21], issues concerning the constraining of inhabitants have been identified. Ethical issues concerning levels of observation are supplemented with issues that (1) *constrain* behaviors of inhabitants, (2) *regulate* the availability of *commodities* and (3) *predefining practices*, i.e. the use of space and appliances. We are particularly interested in designing the immediate *impact* on inhabitants. When the inhabitant directly interacts with the Smart Home positive and negative impacts can be induced. E.g. energy saving programs in homes, which turn appliances off or regulate access, can be perceived as a positive enhancement for supporting personal responsibility as well as paternalism. Thus, engineering practices must consider which core values are to be supported (cf. Section 3.2).

To guide and structure the elicitation of ethical values in student projects (see Section 3), we propose to structure ethical values in a multidimensional space of contracting system properties (cf. Fig. 1). These are:

- self-determination - heteronomy,
- traceability - non-traceability,
- delegation - self-activity,
- contextual control - lack of control,
- individual - collective / communal.

Ordering these dimensions in opposing properties emphasizes that good systems designs must balance values and support beneficial ones, i.e. the absence of self-determination is not the same as enabling heteronomy and if a system is not supporting contextual control is not as severe as leading to a loss of control for the individual. E.g. when Smart Homes automate energy-savings, the contextual control exerted may be almost unnoticeable or restrictive for the individual. The system design and user interfaces influence the transparency of the system for inhabitants. These criteria are geared towards a human-centered view on the system in question. They describe how the system is to be perceived by inhabitants. Technical aspects influence these perceptions.

Fig. 1: The multi-dimensional space of ethical implications in Smart Homes

The dimensions for the controller model have been derived from ethical evaluation approaches such as the MEESTAR or MAST model [We19] – which focus on the evaluation of assistive technology for elderly people. However, in contrast to the significant absolute dimensions, we are exploring a regulator model in which we aim to work with two poles in each case. We also assume that there are interdependencies between the individual dimensions, which can vary depending on the application. The exploratory dimensional visualization is based on the 'didactic slider' by Axel Krommer [Kr20], and is intended to facilitate, analogous to [Ca20], the analysis of ethical conflicts. Our proposal is not meant to be conclusive; the list can and should be expanded, based on practical experience and feedback.

3 Project Outline

3.1 The HAW Living Place

The LIVING PLACE lab, founded in 2009, is a 140 qm loft-style apartment that includes sections for cooking, dining, sleeping, and working, as well as a separate bathroom ([HA24]; cf. Figure 1). The LIVING PLACE lab provides a realistic context for investigating ubiquitous computing systems. These systems focus on human-computer interaction and explore how individuals respond to novel interfaces. They also discuss contemporary concerns, such as quantified self, environmental monitoring, and value-sensitive technologies. The LIVING PLACE lab examines the evolving sense of self-perception that arises from the ongoing negotiation and tension between residents, their personal belongings, and their living environment. The lab is situated at the intersection of computer science, sociology, media art, and interaction design. The lab is a fully functional apartment designed for conducting experiments under real-life conditions. The research design and teaching methods employ both qualitative and quantitative approaches, with an emphasis on ethnography, participatory observation and action research. User studies can last from several hours to several days and are documented and supervised from an adjoining control room [HA24].

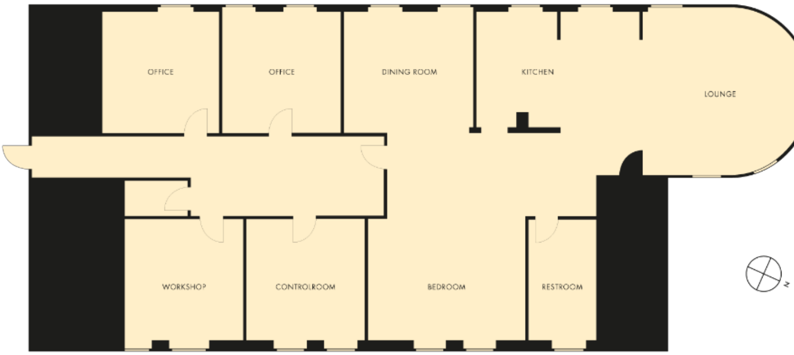

Fig. 2: Ground plan of the HAW Living Place, from [HAW24]

3.2 Development

Prior working with students in the Living Place lay the technical foundation for embedding ethical behaviours [Er24, Kr21, Sc21]. Thus, the basic connectivity of devices and appliances is given, and development of the overlay can commence in an agile setting. This is particularly relevant for student projects, facilitating quick iterations and experimentation. Thus, the project work is based on and rehearses programming and software engineering practices from earlier stages of the student bachelor studies. A particular challenge is addressing ethical issues in human-system interactions. Integrating ethical issues in computers since education is a pressing matter [DS23] and it is particularly important to address these issues in development practices. While development can be guided by ethical principles, adopted by numerous organizations [EK21], the resolution of conflicting principles, e.g. *privacy* vs. *efficiency*, is challenging. Thus, we aim at applying value-based Engineering [Sp21, Sp23, IE21]. Here, a structured process is posed to elicitate and ponder values a software system can bring by. Using this process, students are guided to empathize with potential users and, thinking from their perspective, reason about the rational and emotional responses that Smart Home provokes. Value-based Engineering consists of three distinct phases, namely (1) the *Concept and Context Exploration*, (2) the *Value Exploration* and (3) the *Ethically Aligned Design* [Sp23]. During the first phase the System to be developed is studied. Based on this, the second phase aims at identifying and priorizing the core values that a system can foster or bring about. Finally, the support for values is expressed as so-called Ethical Value Requirements (EVR) which are integrated into the system development, i.e. the set of requirements. To integrate value-based engineering, this design approach is introduced early on, and the value exploration is to be discussed in parallel to the system design steps (cf. Section 3.1)

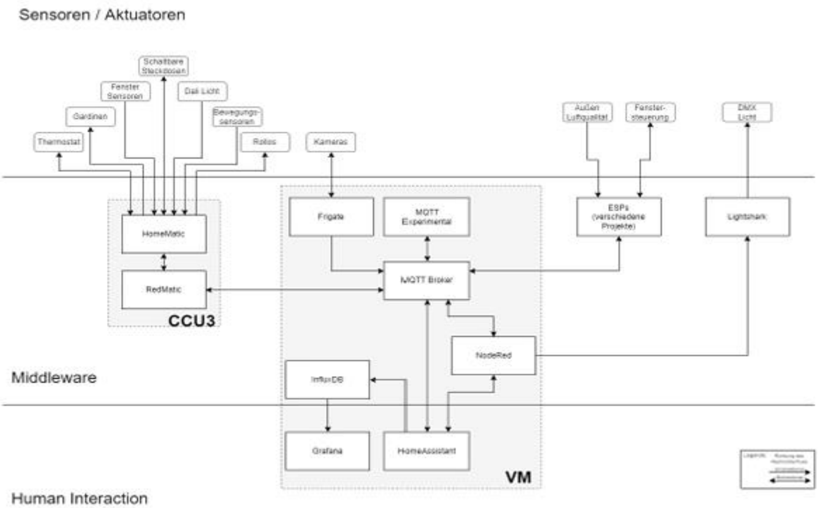

Fig. 3: Architecture Living Place Lab HAW [Er24]

3.3 Developing a Testbed Environment

Experimenting with ethical implications requires a dedicated environment which allows real-life interactions and modifiability of inter-device policies. Thus, we aim at an Environment which connects appliances with a flexible overlay of controlling entities (cf. Figure 1). This effort builds on and extends *Internet of Things* (IoT) based controls of the

Living Place. A *publish-subscribe*-based communication infrastructure enables monitoring and control applications. Users physically move within the Smart Home and interact with different appliances. Each appliance is to be controlled by a software artifact (1:1 relation). Potentially, the user perceives each appliance as an ethical actor [ref], based on their individual interactions. This perception is based on the experience and the intentional stance of the user and does not imply a specific implementation approach. Thus, we want to be able to experiment with differing sophistications of decision making and reasoning ranging from simple IoT-based monitoring applications to agent-based controls and coordination. Appliances function not as merely reactive entities, but the software artifacts can supplement monitoring and reactive functionalities as well as proactive and event-based behaviors. It is to be noted that ethical actors are to coordinate with each other [Wo09] thus, the whole Smart Home can be perceived as an aggregate Actor. Initially, software components will contain hard coded modes of operation, but perspectively, experiments would benefit from externalizing device configurations and modes of coordination, possibly leading to organizational models [SK22]. Foreseeable technical challenges are the integration of the available hardware sensors and actuators and the context-based, behavioral design of the overlay. Thus, proficient software engineering practices are demanded and practiced.

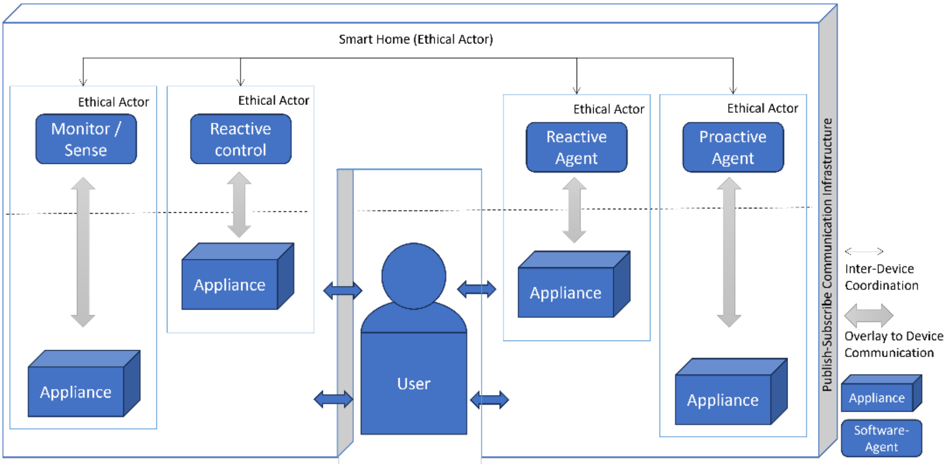

Fig. 4: Agent-based overlay for devices provides a testbed for ethical interactions with users

4 Procedure

The following section outlines the proposed project course, tailored for advanced 5th semester students. The course aims to introduce students to the topic of (machine) ethics through an introductory reading phase. Two selected texts will be read and discussed in the project group. Following this, there will be an introduction and discussion on the topic of Agent Modelling. In the second phase of the project, the students will develop and implement ethically informed prototypes. To achieve this goal, students take turns working on their prototypes in self-organized groups and presenting their results to their lecturers, peers, and other critical friends.

The project is structured in two phases (cf. Figure 5). The first phase (Theory) lays the conceptual foundation. In 4 Sessions, the students are introduced to the challenge of developing ethical agents. The project is initiated (*Kick-off*) by presentation of the project idea, agreement on project goals, the formation of student working groups and the coordination of readings. In the subsequent sessions the references [Sp21] and [Mi22]. Technical foundations for agents and agent-based modelling and development complements a technical perspective. In parallel, students are carrying out a diary study, analysing requirements and expectations on Smart Home environments by projecting their own living contexts.

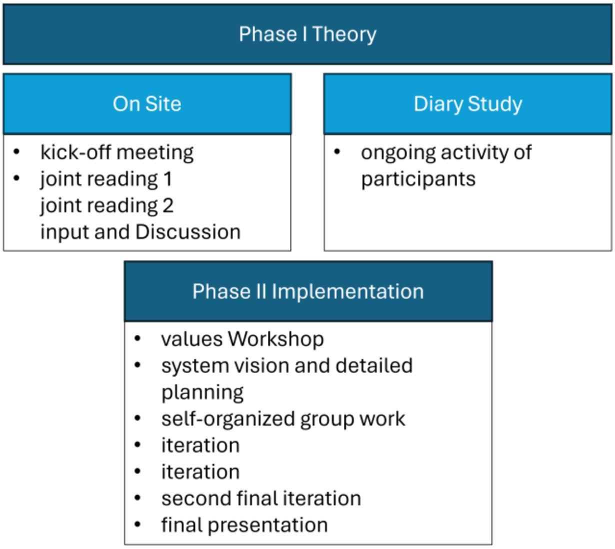

Fig. 5: Project Procedure: Lectures and diary studies prepare for the system analysis and development.

In the second phase (Implementation), these studies and taken up by an initial Values Workshop (Session 5) and a subsequent elaboration of the system vison and detailed planning. System Development is carried out with in 2 Sprints of 3 weeks respectively, followed by a final work phase and final presentation. The rationale behind this twofold structure is to combine theoretical illustrations with firsthand experiences by students in the first phase. We take inspiration of value-based engineering to guide the elicitation of values [SP21, SP23]. However, this procedure is not fully applied, due to time constraints as we fit the project into in one semester. The initial criteria for success of the students' projects are as follows:

- Proven engagement with their own smart everyday practices as part of the "diary study".
- Documented reflection on values such as fairness, transparency or traceability.
- Transfer of values, which are considered important, into a functional prototype in the smart home environment.

The development phase applies agile development practices. As we can expect students to be aware of these.

5 Conclusions

In this paper, we propose to use an on-campus Smart Home environment as a laboratory testbed for ethical agents. The rationale is that devices which directly interact with humans can be perceived as (ethical) actors, thus the Smart Home itself can be regarded as an actor, even as a malicious [EK21]. Thus, we introduce a concept with a set of dimensions of ethical implications, outline a testbed environment, and design a corresponding elective student project. Future work is mainly concerned with conducting this project with different student groups, iterating and advancing the testbed environment. The proposed set of ethical dimensions requires field trial and is likely to be revised.

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