Utilizing Service Design Approach to Apply Digital Twins in Home Automation

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Abstract

Digital twins can be a key technology when it comes to automation. However, very few research has been focused on the design aspects of digital twins for home automation, the majority of research focuses on the technology itself. As smart home research is shifting from a technology-driven to a consumer-centric and design-driven approach, service design, as a customer-centric design approach, can be beneficial to the development of the automation domain. This research will apply digital twins in home automation based on service design methods.

Keywords

Digital Twin, Home Automation, Smart Home, Service Design

1. Introduction

Automation is not just simply replacing human labor toward machines. It aims to increase the efficiency of activities and provide seamless services to users. For example, a smart thermostat system can adjust the temperature based on various factors such as occupancy, time of day, and weather conditions. It increases the efficiency of heating and cooling activities in the home and provides a more efficient and convenient experience for users, further reducing energy consumption and costs. In this situation, how humans interact with automated systems and how automated decisions impact humans are both critical issues to consider. Conventional home appliance has now become connected and integrated via the Internet of Things (IoT) or other technologies, typically known as smart homes. The introduction of new technologies in smart home will change how people interact with their surrounding environments, which will impact the services provided within homes. As a result, new service functions and features will shape the new user interface and the process of delivering services, which will in turn impact the service logic and service flows. For smart homes, it is necessary to consider new service logic and flows to support emerging scenarios, such as sustainable living.

In terms of studying and designing home automation systems, Gopinath et al. [3] pointed out that the digital twin is a revolutionary development in IoT, which could solve problems encountered during smart home automation, such as monitoring and operating the home by tracking the physical smart home through a replicated virtual model. Digital twins are a key technology to the development of automation, providing features such as energy monitoring and fault monitoring and prediction and optimization of systems [4, 6]. These characteristics could help individuals manage their homes in a more sustainable way. Therefore, to provide users with additional capabilities of smart homes, my research aims to leverage digital twin technology in home automation.

Deploying digital twin technology could help smart homes become more sustainable, especially in terms of energy reduction. As part of the Sustainable Development Goals (SDGs) of the United Nations, the seventh goal aims to ensure

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access to affordable, reliable, sustainable, and modern energy for all [8]. Therefore, it is important to develop new types of predictions in smart homes that can help people save energy and live a healthier lifestyle, which is also in line with one of the SDGs - "Ensure healthy lives and promote well-being for all at all ages." Home automation can contribute to indoor energy management and supervision. The agility and resilience of digital twins have been identified as key attributes for increasing automation [1]. Thus, digital twins could aid in achieving the SDGs for smart homes.

Marikyan et al. [5] discovered research on the smart home is shifting from a technology-driven to a consumer-centric approach. They suggested that future smart home research could focus on the functions and services from the user's perspective. Overall, technology, services, and meeting users' needs are the three common characteristics [5]. Therefore, my research will study home automation systems with digital twins from the perspectives of service design and user-centered design.

As new technologies emerge, new design challenges are also brought up in society. To the authors' best knowledge, none of the current literature on design addresses the framework of home automation systems using digital twins. My research aims to fill this gap.

2. Research Methodology and Aim

Forlizzi [2018] suggested considering service design to respond to the emerging challenges in the HCI community, which designs for multiple stakeholders and a systemic, value-exchanged, and socio-economic system. Service design thinking has brought benefits for designing for rising trends of technologies, such as Software as a Service (SaaS), social computing, and crowdsourcing platforms [10]. More than that, service design has even been applied to the digital twin domain. Aheleroff et al. [2021] proposed Digital Twin as a Service proposed Digital Twin as a Service (DTaaS) under Industry 4.0. DTaaS is a service that enables access to Digital Twin capabilities, providing access using augmented interfaces across physical, digital, and cyberspace. Its value is to provide a simple, scalable paradigm to realize the importance of mass individualization. Therefore, this service design approach could be also beneficial to home automation research.

Automation is not replacing humans; it is helping humans and our planet become more efficient and sustainable. Home automation is aiming to provide seamless services to humans, which helps improve people's well-being and reduce energy consumption. As smart home research is shifting from a technology-driven to a consumer-centric approach, service design, as a customer-centric design approach, could have significant impacts on developing new concepts for the automation domain. Based on the service design approach, I expect to develop a new design framework for home automation systems with digital twins, which could lead to more sustainable behaviors in the future.

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