Co-designing Home Health IoT Systems

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ABSTRACT

There is an increasing need to support individuals who self-manage health conditions outside of the clinical settings. Doing so aids the promotion of independence and relieves pressure on health care systems. In order to assist these self-managing activities, we argue there is potential to use the Internet of Things (IoT) and Artificial Intelligence (AI). It is our belief that through the usage of sensor-based IoT systems, support can be given, not just for a chronic condition, but rather an individual person with individual needs.

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With this in mind, we use the methodology of co-design to ask those individuals who self-manage health conditions what type of IoT sensory system they would need. Additionally, we hope to understand how IoT health systems can be customised in order to be incorporated within people’s homes and everyday lives.

**INTRODUCTION**

The HCI community has a growing interest in how technology can aid people who self-manage their chronic health conditions outside of the clinical settings [8,9]. With a commitment to design bespoke systems within HCI [13] and real world health communities [5]. We believe there is an opportunity to investigate how technological advancements can be leveraged within the context of smart homes for health. Providing bespoke self-management solutions or supporting individual customisation. Building upon the growing acceptance of commercial smart home IoT solutions such as Amazon Alexa and Google Home.

What, though, is the next technological innovation for smart home IoT with a focus on the health community? We believe due to today’s increasing healthcare costs that the next technological innovation will be that of a home based IoT sensor-based system, supporting individuals who self-manage chronic illnesses [2]. Ballegaard et al argues that healthcare is not just about keeping individuals healthy but allowing them to continue to live sustainable and independent lives [1]. With this in mind, we look to IoT systems such as SPHERE (sensor platform for healthcare in a residential environment) which uses AI to algorithmically interpret data based on the individuals patterns of living at home [16]. Smart home technological sensors, however, come with issues of privacy, some users only accepting them when the alternative is to move out of their home, despite other health benefits [17].

With these smart home IoT healthcare systems, there is opportunity to investigate how they might better engage with the idiosyncratic nature of chronic conditions and the bespoke needs of individuals [8]. We look first to co-design and then to customisation as a way forward.

**TOWARDS THE CO-DESIGN OF HOME HEALTH IOT SYSTEMS**

To enable individual users to understand the complexity of IoT sensory systems that are used for self-management such as SPHERE, there is a necessity for a multi-disciplinary approach in order to help these users to influence the design. Co-design is a research methodology that empowers the user, this approach has already been implemented widely in health care. With UK hospitals using co-design as a way to innovate and improve their services and with smart home systems where...
researchers investigated the language used when explaining the individual components of the SPHERE system [3,7]. Other researchers have used co-design to investigate particular chronic illnesses first, Crohn’s disease and participants daily living activities in order to developing AI algorithms and ways to visually display data based in these activities, second, Rheumatoid Arthritis and the creation of a self-management smartphone application [6,10]. Due to the complexity of IoT sensory systems, there is a challenge of translating systems such as SPHERE into something understandable for the participants of co-design workshops.

To start this research we must initially complete three steps in order to translate the SPHERE system into a toolkit that enables the user to engage with co-design and customisation. First, we educate ourselves in how SPHERE works, second, the knowledge gained of the system is documented in a simplified way to that of the design team, third, a toolkit is created so that those with limited technological understanding can gain an overview of the system, its limitations and its capabilities. Once these initial three steps have been completed the research can move to the fourth step, that of the co-design sessions.

Step 1: Understanding the SPHERE system

In order to understand the SPHERE system we looked at the publications and documentation produced by the researchers. This enabled us to, gain an overview of the network infrastructure, the construction of the hardware sensors that make up the SPHERE system and the methods used to produce data via AI [4,14,15]. We additionally learned that when setting up the SPHERE system a number of the sensors have predefined requirements, e.g. the ‘environmental’ sensor could not be pointed towards the rooms window [12] (Fig. 2). There was little published on the SPHERE user interface used in the home, the SPHERE Genie (tablet), so we organized a workshop and further in-depth interviews to gain an understanding. Participants were involved in its design, built the Genie tablet application, were AI experts or had experience with the SPHERE system in homes. This gave insight into the user interactions with the SPHERE system and what potential visualizations of the AI outputs could be supported. We discovered that even though the Genie, ran on an Android tablet, that it was in fact a web based platform and part of a closed system disallowing direct internet access.

Step 2: Educating the design team

Documenting the system in a visual way enabled us to present that findings in a booklet that was

**Figure 2: Two hardware sensors and there visually presented data.**
created by a UX designer, enabling those with some technological knowledge to understand the overall SPHERE system. The document was broken down into a five distinctive sections (Sensors, Hardware, System, Interaction and Data). As an example for each section, the ‘sensors’ were categorized into 4 groups, that of ‘Utilities’, ‘Rooms’, ‘Appliances’ and ‘Person’ (Fig, 1). Each ‘hardware’ device was described, with illustrations, situational photos, text description and visually presented data (Fig, 2).

**Step 3: Create the SPHERE system education toolkit**

Our next steps are to work with a team of creatives (writers, artists and designers etc.) to design an interactive way of translating the sensor system and the capabilities (and limitations) of the AI behind the system. This will aim to enable those with low technical knowledge to gain a full understanding of SPHERE, the data captured, and how the AI might be explained. We intend to use this translated toolkit to support co-design workshops with participants to design the home based sensor toolkit and related AI visualizations to support their chronic health conditions. Through these workshops, we hope to develop a design framework that will advance smart home healthcare through explainable AI systems.

Following this we will work with a number of volunteers who have chronic illnesses and take them on a journey that will include in-depth interviews in their home, using the toolkit to understand SPHERE sensors, and ultimately designing a system that supports the idiosyncratic needs of the chronic condition. However, there will still be individual aspects of that person’s life, their preferences, and their specific home that might influence the systems adoption when in-situ. Therefore, we look at how this co-designed system might be then further customised.

**TOWARDS THE CUSTOMISATION OF HOME HEALTH IOT SYSTEMS**

Through the later co-design workshops, the participants will have the opportunity to define the sensors aesthetics, highlighting how they shall be displayed within their homes. We have already identified the needs of some forms of customisation based on previous experiences with the SPHERE system. For instance, early participants complained about the form factor of the watch (Fig, 3) and depth camera (Fig, 4). Considering the watch to be bulky and the depth camera to not fit into their décor, for example having a black casing and being placed on a white ceiling. We believe that this aesthetic customisation might influence the acceptability of the home IoT sensor system.
CONCLUSION

We have presented our intention to run a number of co-design workshops, in which participants select sensors from the IoT sensory system SPHERE. The sensors being selected with the purpose of aiding the participants in self-managing their chronic illness at home. During these co-design workshops the participants will have the opportunity to customise the selected sensors. Once the co-design has been completed, the IoT sensor system will be deployed in the participants home and final feedback will be sort.

REFERENCES

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