Digital twins as a resource for design research

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ABSTRACT

IoT products are embedded with sensors that transmit live data about their use and environment. A key challenge for designers is to gather useful insights from this data in order to accelerate product research, which can be time consuming and labour intensive. Through the Chatty Products dashboard we aim to explore how virtual representations of IoT products and their sensor data, also known as *digital twins*, can support insight gathering. This demo will present a series of Bluetooth IoT speakers, which are connected to the Chatty Products dashboard, a data exploration and visualisation research tool containing supervisory digital twins of the speakers. The project aims to visualise live data as it relates to the physical product in the wild, enabling contextual inquiry and supporting data exploration. The demo will promote a dialogue around how digital twins can be used to gather design insights based on live data.

CCS CONCEPTS

• **Computer systems organization** → **Embedded systems**; *Redundancy*; Robotics; • **Networks** → Network reliability.

KEYWORDS

digital twins, iot products, live data, design research, contextual inquiry

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1 INTRODUCTION AND BACKGROUND

While traditional data dashboards are rarely used within design cycles [7], it is the contention of this project that designers can gain valuable insight from live sensor data when it is visualised appropriately. One way to integrate live data is to utilise digital twins, virtual 3D models that are linked or 'twinned' with physical products in the wild via streams of real-time data from embedded sensors [7]. These types of visualisations can map out a variety of spatially bound information onto a virtual product, such as movement, where it is experiencing pressure, or what parts are overheating. These insights could then be used for the development of new design suggestions.

Figure 1: A researcher manipulates a physical product, which is then visualised through a supervisory digital twin into the Chatty Products dashboard.

Current state of the art Digital Twins revolve around making cost savings by monitoring equipment for failures and down time [4]. By collecting data over long periods of time they allow engineers and machine learning algorithms to track key performance indicators for high-value assets. This data can then be used to predict modes of failure and support maintenance [3]. While this data is readily available to engineers, there is as yet no solution that allows designers to interact with it in a simple format.

Sensor data can support designers in identifying issues and opportunities for product development. Perhaps even allowing them to understand how product use differs across cultures, locations, and user needs, which would support the design of customised objects for specific user groups, creating the formation of new species of products. The idea of speciation closely relates to Sterling's [6] vision of futuristic manufactured objects called Spimes that behave as: "material instantiations of an immaterial system". Thus digital twins will bring around a dialogue about the future use of live data as it relates to design.

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The surge of connected products has led us to investigate the potential for digital twins to visualise live data and support design research. A key challenge that we address within this demo is in understanding use in the wild beyond quantifiable product performance indicators (e.g. rotor speed) in order to shed light on human experiences [2].

2 FUNCTIONALITY OF CHATTY PRODUCTS DASHBOARD

Product View: Where live data from the devices can be seen individually and for all of the devices. The twins visualise the live orientation of the product alongside sensor and audio data.

Expanded Product View: The product can be expanded, revealing the internal components, their position and sensor states.

Aggregated Product View: An aggregated view of the commonalities and differences in sensor data of all or a subsection of speakers is available for further data exploration.

Communication: A chat system, which facilitates contextual inquiry with users.

2.1 Chatty Products Dashboard

The dashboard prototype allows designers to explore live data visualisations of real world, real time product use through Supervisory digital twins as defined in [1]. Every device and its virtual representation could be shown individually, collectively, or in an aggregated manner. Individual views show the real-world orientation of the object and additional live data streams including: acceleration, temperature, music playback state (playing/not playing), the volume, and track information. Aggregated data visualisations reflect commonalities in use across the entire set of connected objects. In addition to the use of digital twins, the Chatty Products research tool includes a preliminary method of interaction with the end user through a dedicated chat system, which supports real time contextual inquiry and sense making (Figure 1). By communicating with the end users one on one, designers can inquire about the contexts and motivations that frame the data they are seeing . Currently the chat system sends messages to a personal online chat account, future developments of the Chatty Products system will investigate less intrusive solutions, such as a screen on the IoT device.

The tool was created using a collection of IoT technologies, big data, non-relational databases, sensors, and game engines. Collectively allowing the realisation of a system that captures and visualises data which is typically lost in more traditional systems. It has the potential to support researchers and designers in understanding how products are being used, where issues occur and in the gathering of design insights that traditional research and focus groups can miss. For example, within the use of our speakers, post-hoc updating of data would indicate use outside of the home, coupled with an analysis of music choice and volume can indicate social outdoors listening. This can be verified through the messaging system. The designer may conclude that multi-directional speakers are more suitable for social listening for a future iteration of the design without conducting lengthy ethnographic studies. As part of a greater package this will enable designers to move seamlessly between the digital twin and the design where they can edit, then generate a new design for the digital twin and product.

2.2 Chatty Speakers

The Chatty Speakers are technology probes [5] designed to investigate the value of the Chatty Products research tool. They are Bluetooth speakers that can play any audio from a connected device. There are three different designs in order to observe differences and similarities in their use, which relate to their design (Figure 2).

They are composed of two speakers, a RaspberryPi ZeroW, and a 9-Degrees of Freedom, Inertial Measurement Unit (IMU) board, which measures the object's orientation, movement, and acceleration, updating every 100ms. They transmit the sensor data through a WiFi connection. The data is then displayed on the Chatty Products interface.

Figure 2: Three designs of speakers. Left: cube with button controls; centre: sphere; right: cube with gesture controls.

3 SUMMARY

Our demo contributes (1) a prototype of the Chatty Products research tool, which promotes data exploration through digital twin representations of IoT products; (2) a series of three IoT speakers sending live sensor data to the Chatty Products dashboard; and (3) through an interactive and playful demonstration we would promote a dialogue with the HCI community present at PerDIS around how live data can be used to gather design insights.

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