

"I don't need technology to
nanny me!" - "growth" rather than
"declinist" framings for home IoT
systems



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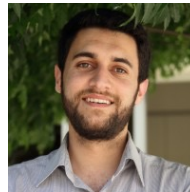
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The Internet of Things (IoT)

A network of interconnected everyday objects that can send/receive data via the internet

Examples include:

- “Smart” devices
 - Watches
 - Speakers
 - Lights
 - Thermostats
- Home Security
- Health
- Vehicles

IoT hold immense promise for enhancing the lives of millions.

The Internet of Things (IoT)

Current IoT systems risk excluding older adults due to poor design, ageist assumptions, and costs.

Most current home IoT systems marketed towards older adults are not growth-oriented but rather decline-focused, monitoring and signalling well-being issues.

In 2013, Rogers and Marsden¹ call to move beyond frailty and declinist drivers in developing such systems for older adults.

¹Yvonne Rogers and Gary Marsden. 2013. Does He Take Sugar? Moving beyond the Rhetoric of Compassion. Interactions 20, 4 (jul 2013), 48–57. <https://doi.org/10.1145/2486227.2486238>

The Older Generation Toolkit

Older Generation Toolkit

The Older Generation Toolkit is made up of three parts: (1) a collection of self-powered sensors, (2) self-powered displays, and (3) a central hub to collect sensor activation data and transmit activity data to the corresponding displays. Each self-powered sensor is designed to be as flexible as possible to allow the widest range of applications, where sensors can be used for many types of interactions e.g. one sensor type can detect both door and drawer use.

These three parts allow the tracking of activity data around the home. For example, you might like to track the amount of activity you do with your television, reading or shower. Performing this activity generates self-reflection such as "I read less than I thought I did". The three parts of the system work together to collect sensor activity data and display it back to the user in a meaningful way.

1 3 2

Cypress CYALKIT-E03

Solar-Powered BLE Sensor Beacons

Powered by ambient light falling on a 15 mm x 15 mm amorphous silicon solar module and charging 400 nF storage capacitor and 0.1 F supercapacitor via a DS4403A energy power management IC. The beacon is set to demo mode, meaning that the transmission interval varies with ambient light level (illumination). The beacon operates at a minimum illumination of 100 lux (e.g. 100-100 lux is the illumination in a typical domestic living room). The BLE transmit power is configured to 3 dBm (2 mW), with the time interval between BLE transmission being anywhere between 2 seconds (illumination of 1000 lux) to 60 seconds (illumination of 100 - 100 lux) depending on illumination.

Cypress BLE beacons are used in default configuration, except for the beacons, which require some modification as detailed below.

Beacon in PV Module using full air

Solar wires to PV module and add modulation logic

Solar wires to sensor PV module

Cypress BLE beacons need to make the beacons: the silicon PV module is severely overloaded from the beacon PCB using a hot air re-work soldering station. Two (back-to-back) silicon PV modules soldered in place with connecting wires, so that the beacons works either side up.

Triggred via Pico using the supplied BLE-008 BLE-008-008-008-008-008

EnOcean PM220

Energy Converter Module

EnOcean PM220 Energy Converter Module for Motion Energy Harvesting to Power PFM 5000 BLE. Each PM220 activation generates between 180 to 810 μC @ 3 V - which is sufficient to power the PFM5000 BLE transmitter module for a single wireless transmission.

PM220 configuration using a mobile app?

InPlay IN100 NanoBeacon™

Bluetooth® Low Energy Beacon

InPlay IN100 NanoBeacon™ Bluetooth® Low Energy Beacon allows the attachment of different forms of trigger modules. We used a Panasonic PIR sensor WRM51107118 to detect the presence of a person and trigger the NanoBeacon. The NanoBeacon is powered by Epilux Organic Photovoltaic module, as a trigger event requires constant monitoring.

The NanoBeacon consumes less than 500 nA in sleep mode while the WRM51107118 has a constant current consumption of only 1 nA. IN100 transmit power configured to 0dBm (1 mW). The IN100 is configured to transmit as an Beacon.

NanoBeacon is configured using NanoBeacon Config Tool, via the plug in GPP programmer. The PIR sensor is connected to MGP204, which is configured as the trigger source for triggered advertising.

InPlay IN100 is configured using NanoBeacon Config Tool. Triggred advertising is set and MGP204 is used as the trigger source.

InPlay IN100 NanoBeacon™

Bluetooth® Low Energy Beacon

The InPlay IN100 BLE Beacon is powered by ambient light energy harvested by an organic PV module. Beacon transmissions are triggered by a PIR sensor (with the plastic Fresnel lens removed to reduce the PIR sensor's field of view) connected to MGP204.

WRM51107118 PIR module

Detection Range	8 m
Field of view	130 deg x 130 deg
Monthly current consumption	1 nA

Self-Powered Displays

Two user interface form factors were created, "pods" and "bridge magnets", which consist of a custom-made LED display board, driven by an ultra-low power microcontroller MSP430G2553 and a pair of W52008 each registers. Wireless communications between the pods and central hub is via 800 kHz ZigBee module. The pods are self-powered from ambient light energy harvested by Epilux Organic Photovoltaic (OPV) evaluation kits. Total current consumption of the pods/bridge magnets is sleep mode is approximately 1.8 μA at 3 V. The microcontroller is configured to program via J-Link.

The display of each interface consists of two circular rings of LED lights. The inner ring shows the amount of an activity estimated since activation, and the outer ring shows the amount of activity for the current day. Each interface has an activation button, which receives the activity information to display on the LEDs from the hub.

Each pod/bridge magnet activation consumes between 0.84 and 0.41 C, depending on the display size (i.e. number of LEDs illuminated). This means that a fully charged supercapacitor can power the pod/bridge magnet for typically no more than 4 to 8 activations.

The internal electronics are made to be identical, making production faster and easier. Thus, the three buttons of testing is created depending on where the interfaces could be placed. We have created "pods", a desktop interface, and "bridge-magnets", which are intended to attach to refrigerators. The image below shows the internal components.

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Schematic

Epilux ambient light energy harvester

Shift Register PCB

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Diagram

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Form-Factors

We created two form factors for the interfaces. The Pod and the Bridge-Magnet. The Pods were created using 3D printing and the Bridge-Magnets were made using a laser cutter. The Pod for the hub can be downloaded: [CLACK REACTED FOR BERRY](#).

The Pod is designed to be placed on counter tops or coffee tables, in a similar fashion that we have home assistant devices. The LED display is angled toward the user, while the Epilux module is angled towards the light. There is a large activation button on the top.

The Bridge-magnet is designed to be placed on flat surfaces, such as refrigerators or kitchen cupboards. Both the LED display and Epilux module are facing outwards.

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Diagram

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Data

All the sensor data is stored internally on the Raspberry Pi in CSV format. The data is stored by sensor type, activity and by day, to allow easier processing. Each data file is stored in the subfolder, and a new CSV is created each day. The file structure is as follows:

```
-root-
- activitytype
- activitytype
- activitytype
- location
- climate
- gate
- gate
- gate
- gate
- gate
```

Each sensor activation is sent into its corresponding CSV, where the data includes the sensor type, its ID and the timestamp of the activation. As seen below:

```
2,4,11-09-2023,04:10:21
1,10,11-09-2023,11:24:24
1,10,11-09-2023,11:24:29
1,20,11-09-2023,11:24:44
```

To make the data more readable, it will need to be processed using CLACK REACTED FOR BERRY, which adds meaning to the numbers. As seen below:

```
23-09-2023, 08:01:00: (Hassell) Drawer
23-09-2023, 08:25:07: Kitchen
23-09-2023, 08:25:15: Kitchen
23-09-2023, 08:24:24: Kitchen
```

This data is then able to be processed further to create heatmaps of activity, or even interpret by Large Language Models to create stories and diaries.

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Co-Designing the Toolkit

- Workshop I: Exploring views on home-based IoT systems
- Workshop II: Refining the Design Concept
- Implemented the concept design
- Deployments
- Improvements

Workshops I & II locations

Awen Institute Living Lab, Swansea



Workshop I:

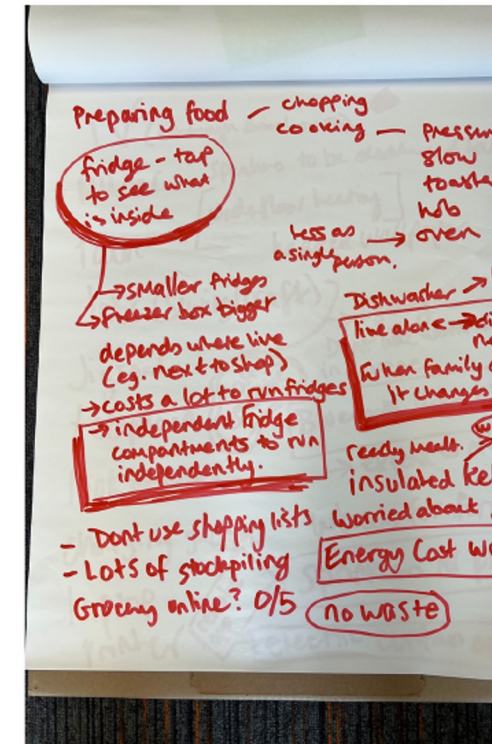
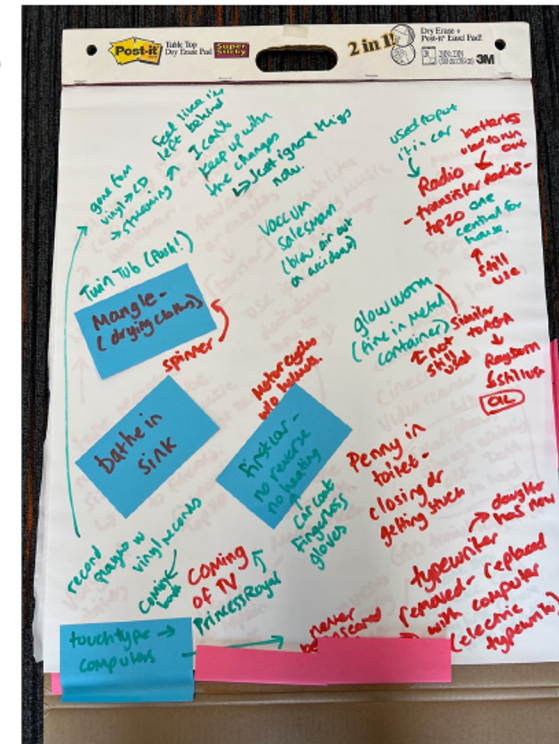
Exploring views on home-based IoT systems

- Recruit older adults who are describe themselves as “aging well”
 - 14 participants (9F, 5M; ages 52–76, mean 69.4, s = 6.6 and with mix of socio-economic backgrounds)
- Participants were split into three groups. During the day, groups took part in three session:
- Session one: Your life with Technology:
 - Discussions of their earliest memories of non-digital home technologies they had used
 - Discussions of their earliest memories of home digital technologies
 - A day-in-the-life activity where participants walked us through the physical and digital devices/objects they used morning, noon and night
 - Discussions of current standard IoT home devices (e.g., smart lightbulbs)
- Session two: Situated Experiences:
 - Using 3 simulated environments - kitchen, living area and garden - a bodystorming activity on what digital services might be useful in that context
- Session three: Current Technologies:
 - Discussions of current IoT targeted at older people.

Workshop I: Exploring views on home-based IoT systems

Findings

- i. Participants have diverse and full home-lives.
- ii. They demonstrated a “growth” mindset - which is contrary to the declinist narrative in many research papers.
- iii. Home monitoring was seen as an imposition on their home life.
- iv. Participants were very concerned energy usage and particularly the cost of living.



IoT Concept

Over a period of two months, we created a home IoT concept. The features of the proposed system were:

1. A multiplicity of simple sensors that could be attached to objects and locations throughout a home at low cost.
2. Objects and locations in the home would have significance [to the occupants] with regards to meaningful experiences and activities in the home (e.g., “fun”, “socialising,” “hobbies”).
3. Sensors would generate simple wireless “pings” when the objects or location in the home were active.



Workshop II: Surfacing Home Activities

- Recruit older adults who describe themselves as “aging well”
 - 16 participants (12F, 4M; age 59–84, mean 71.2, $s = 6.3$) and with mix of socio-economic backgrounds
 - 6 returning participants
- Split into 3 groups and rotated through 3 sessions:
- Session one: The life of the home.
 - Participants were asked about the positive and important activities they regularly took part in at home.
 - For each activity they were asked to describe the sorts of objects and places that were involved.
- Session two: Self-powered sensors and objects/places.
 - Participants were then provided with the set of harvesters-cum-sensors and asked to associate them with any of the objects/places mentioned in session one.
- Session three: The quantified home.
 - We explained how the pairing of objects/places [session one] and sensors [session two] could be used to surface the “quantity” of meaningful activities participants had identified.

Workshop II: Surfacing Home Activities

Findings

- i. A collection of everyday activities and their associated objects
 - “I keep my good plates in the dining room dresser and keep them for best”
- ii. A list of objects associated to the harvester-sensors types
 - Kinetic-energy switch to binary states (opened/closed)
 - PV linked with storage areas
- iii. A collection of activities our participants were particularly interested in reflecting upon
 - Such as hobbies, cooking and socialising.



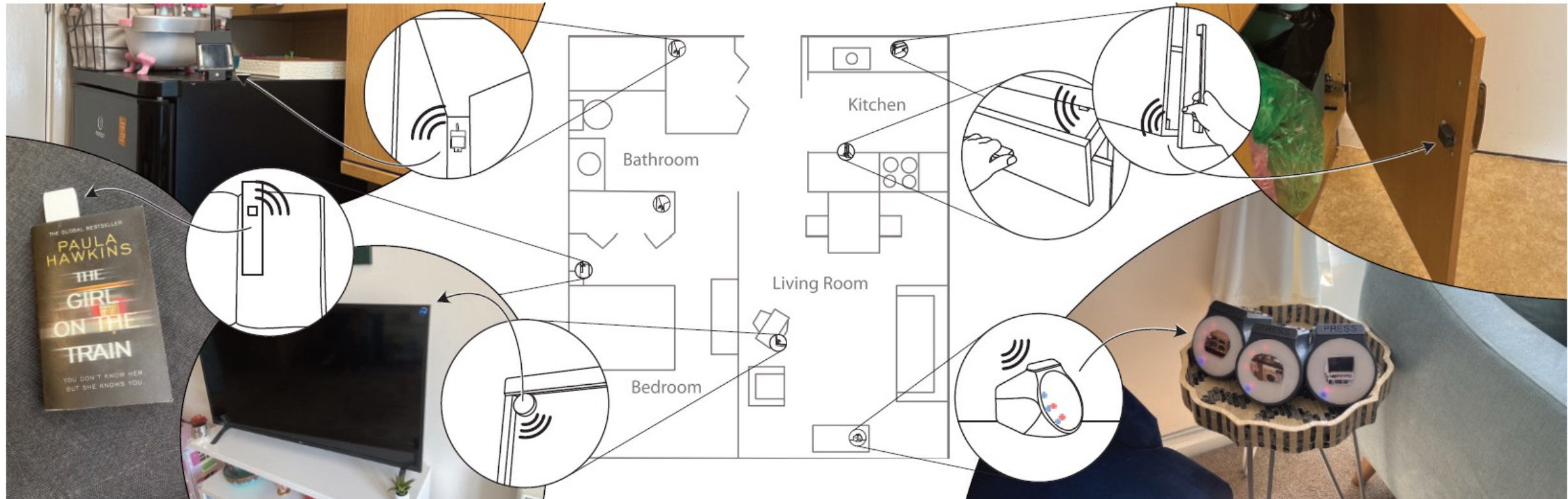
Refine and Implement the Concept

- Design a toolkit that is predominantly self-powered.
- Only platforms reflections, conversations and insights (non-intrusive) by the occupants and visitors in regard to diverse, user-defined, meaningful home activities, *e.g.* hobbies, socialising, fun, relaxation *etc.*



Deployments

- Toolkit sensors and displays deployed
- 3 homes (2 flats; 1 house)
- 2-3 weeks

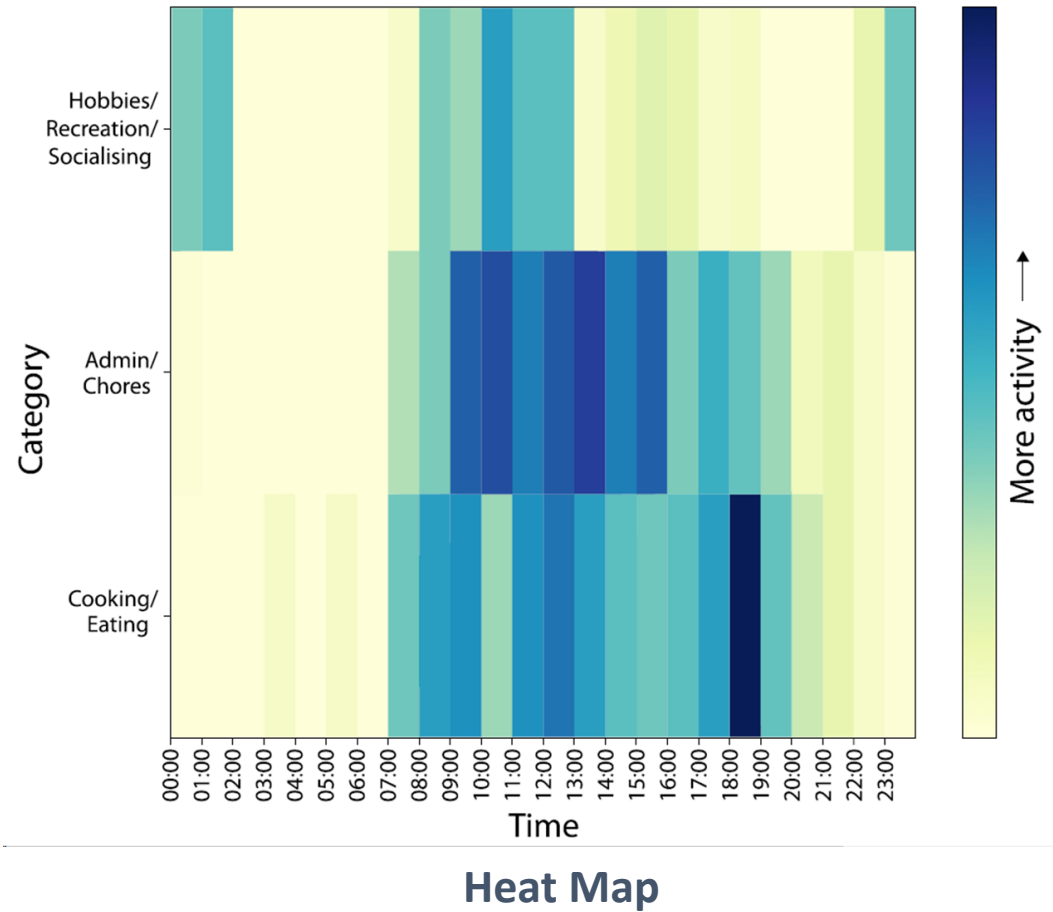


Deployments

- Retrieve the data following deployment
- Formatted in various forms

23-08-2023,	08:21:59,	Utensil Drawer
23-08-2023,	08:25:07,	Kitchen
23-08-2023,	08:26:16,	Toybox
23-08-2023,	08:26:24,	Kitchen
23-08-2023,	08:26:51,	Utensil Drawer
23-08-2023,	08:27:03,	Bin Cupboard
23-08-2023,	08:29:19,	Kitchen
23-08-2023,	08:55:33,	Utensil Drawer
23-08-2023,	09:04:11,	Kitchen
23-08-2023,	09:49:50,	Toybox
23-08-2023,	10:53:05,	Bin Cupboard
23-08-2023,	10:53:09,	Kitchen
23-08-2023,	10:58:51,	Toybox

Raw Data



Deployments

Story

“In the cosy one-bedroom flat nestled on the fourth floor of a charming block of flats, lived X, a woman in her early 60s

.....

Monday morning arrived, bathing X's living room in a soft golden glow as the sun's rays filtered through the sheer curtains. Her worn yet welcoming furniture seemed to come alive in the morning light, and the faint hum of the kettle indicated the start of another day

.....”

Deployments



Structured Diary

Patterns & Observations:

1. Leisure and Reading: Your dedication to reading was evident, with regular reading sessions both early in the morning and in the evenings. These moments allowed you to unwind and enjoy personal time.

.....

Recommendations:

1. Efficient Kitchen Organisation: To streamline your kitchen activities, consider reorganising cupboards and drawers for easy access to utensils, pans, and cleaning supplies.

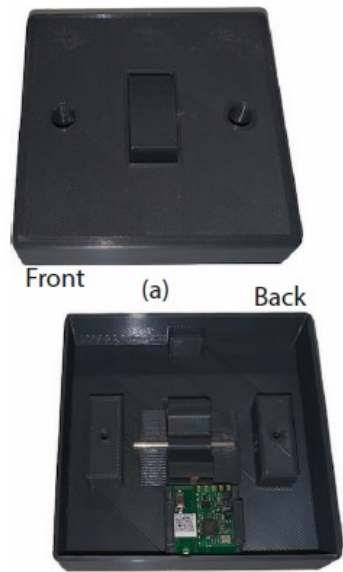
.....

4. Hydration and Breaks: With your busy routines, remember to stay hydrated and take short breaks to maintain your energy levels throughout the day.

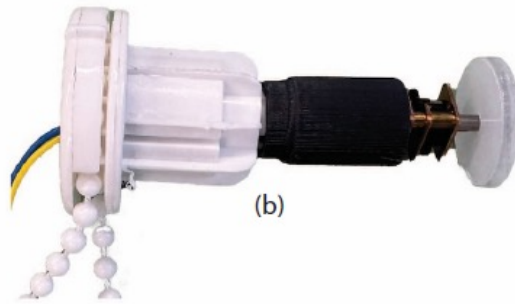
Deployments

- Participants reflected on their home use
 - Often made suggestions for more sensor placements
 - *“Just having it here is making me think more of what I do around the flat”*
- Often found the Stories to be amusing
 - *“What an exciting life we lead!”*
 - *“My partner doesn't dance until they have had five pints”*
- Were able to identify events from Heatmaps and RawData
 - *“That was me in the kitchen making tea past midnight on Tuesday”*
 - *“We are obviously unloading the dishwasher then”*

Improved Sensor Actuators



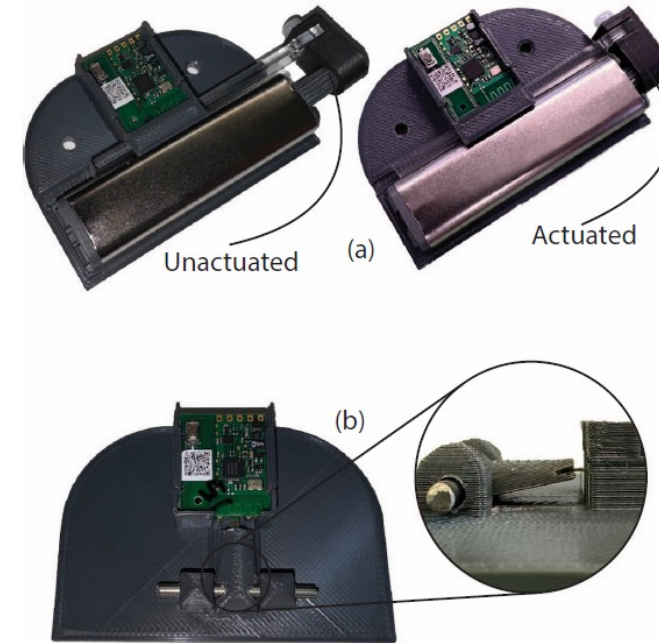
Light Switch Sensor
(single, double, triple)



Roller Blind Sensor



Thermal Sensor



Drawer & Door Sensors



AI Generated Images



Thanks for listening!