HomeGrid - Experimental Displays for SmartHome Devices and Interfaces

HomeGrid

Moritz, MK, and Krause
Hof University, Institute for Information Systems
moritz.krause.2@iisys.de

Michael, MZ, Zöllner
Hof University, Institute for Information Systems
michael.zoellner@hof-university.de

ABSTRACT

In our society, displays are becoming increasingly prevalent. While it is nearly inconceivable to imagine a daily life without screens, scientific research indicates that our mental well-being is negatively affected by the increasing use and time spent on screens. The "HomeGrid" project has been developed as a smart home concept, aiming to explore how traditional screens in private environments can be reduced while still effectively conveying information in an intuitive manner. To achieve this, two main approaches were employed. Firstly, experimentation was conducted on the capture and communication of artificial light, and secondly, precise monitoring and visualization of indoor air quality were explored. These factors are fundamental indicators of both our mental and physical well-being, as high air quality, for example, enhances concentration, and light serves as a crucial regulator of our circadian rhythm.

CCS CONCEPTS

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

KEYWORDS

Air Quality Measurements, Ambient Light, IoT Devices

ACM Reference Format:
Moritz, MK, and Krause and Michael, MZ, Zöllner. 2023. HomeGrid - Experimental Displays for SmartHome Devices and Interfaces: HomeGrid. In *8th international Workshop on Sensor-Based Activity Recognition and Artificial Intelligence (iWOAR 2023), September 21, 22, 2023, Lübeck, Germany*. ACM, New York, NY, USA, 5 pages. https://doi.org/10.1145/3615834.3615850

1 INTRODUCTION

The world is becoming increasingly digital, affecting our daily private lives, communication methods, and how we spend time together. Digitalization in this context refers to making data accessible in new ways. Currently, there are two options to access this information: either using a device with a display and opening the corresponding app, or asking a voice assistant like Apple's Siri. However, both solutions have unnecessarily slow information flow. Voice assistants require formulating a question, hoping for accurate comprehension, and then receiving a response through voice or on a display. For instance, checking the time on a clock is much faster than formulating a question for Siri or unlocking a phone.

Home devices have seen increased sales with the inclusion of displays in recent years, such as in cars, smart home devices, and kitchen appliances. However, there is a trend in many areas to revert to traditional, tangible elements. This raises the question of whether new products and forms are necessary to display information that can be quickly grasped "at a glance." Will this improve the quality of data used in the smart home domain?

This project aims to explore and test new forms of information communication in the smart home field through designs, prototypes, and studies. Inclusivity will also play a role in these efforts. Additionally, considering the creation of a tool to customize and individualize the software of the products is conceivable, along with the development and implementation of the actual prototype.

2 RELATED WORK

In recent years, Virtual Personal Assistants (VPAs) [7] have dominated the smart home control market, becoming an integral part of modern smart homes. For instance, conversational interface commands like "Hey Siri, heat the office to 21°C and turn on the desk light" demonstrate their utility as they also serve as bridges for controlling the entire smart home network.

2.1 Personal Assistants

The three major providers of these systems are Google with Google Home/Nest [5], Apple with Siri/HomeKit [2], and Amazon with Alexa [1]. Each has its own advantages and disadvantages, and users must weigh them according to their individual needs. While Alexa currently boasts the most compatibility with accessories, it has the worst reputation regarding data privacy. HomeKit, on the other hand, has the best reputation for data privacy but is more limited in providing native support for third-party devices; for example, IKEA's Tradfri lamps were not natively integrated into HomeKit at the time of this work.

Since autumn 2022, version 1.0 of a new standard protocol for smart home systems, called "Matter" [8], has been established. Matter emerged through the collaboration of major players such as Apple HomeKit, Google Home, Amazon Alexa, IKEA, and others in the Connectivity Standards Alliance (CSA). It promises a unified standard for all smart home systems, finally enabling seamless interoperability among different devices.

2.2 Commercial Solutions

As mentioned earlier, the functionality of a smart home relies on the data collected and provided by various sensors. These sensors

iWOAR 2023, September 21, 22, 2023, Lübeck, Germany

ACM ISBN 979-8-4007-0816-9/23/09.
https://doi.org/10.1145/3615834.3615850

are offered by a diverse range of manufacturers and distributors, some of the well-known ones for private use being Bosch, Signify (also known as Philips Hue), IKEA (especially with their Tradfri collection), Tado, Eve, and many others. Each manufacturer has its own product lines and specialized areas of focus. For example, Signify specializes in lighting, lamps, and their controls. Tado, along with Bosch, is one of the most common systems used by private users for controlling, monitoring, and automating radiators. Additionally, there are manufacturers that offer completely independent systems, often designed for commercial building automation and office complexes, such as Loxone [9].

2.3 Open Source & DIY Community

In addition to various manufacturers, systems, and devices, there are also open services and development environments that play a crucial role in smart homes.

One vital aspect of smart homes is automation, which involves data-driven responses. While Siri, Alexa, and HomeKit do offer automation capabilities, they may be limited in certain aspects. For instance, HomeKit, at the time of this work, does not provide native support for reacting to weather updates. To process such important information for many users, third-party services like "IFTTT" [6] (short for "if this then that") are needed. These services allow different systems and external sources, such as news or emails, to be linked and automated. Since smart home devices are inherently integrated into the local network, the web, Arduino [3], Raspberry Pi, and general developer communities have developed new libraries and solutions, such as "HomeSpan," to enhance smart home functionalities.

Like most of the commercial solution they build upon the open ZigBee [10] wireless standard for communication with the sensors. Today with the LoRaWAN [4] protocol for Internet of Things there are solutions to overcome the limited transmission range of ZigBee for smart sensors and devices.

Figure 1: Sensors *Sense A10* and *Sense L10*.

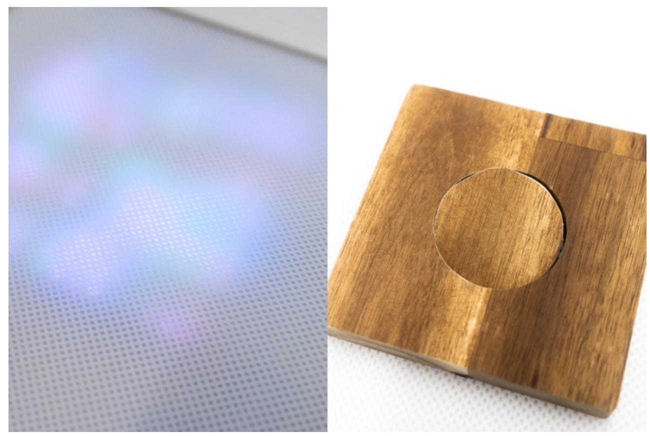

Figure 2: Displays *Make A10* and *Make L10*.

3 EXPERIMENT SETUP

3.1 Hardware Setup

Two different ESP32 configurations were used in this project: The "D1 Mini" from AZDelivery and the "Feather v2" from Adafruit.

There were two devices used to collect data: *Sense A10*, which measured air quality and consisted of a D1 Mini Esp32 and the Bosch BME680 sensor, and *Sense L10*, which determined ambient light conditions and featured an Sparkfun ADPS9960 Sensor instead of the BME.

Bridge X1 served as a central hub and was composed of a Feather v2, an 8×16 warm white LED Backpack, a CherryMX button, and an LiPo battery as backup power supply.

Make L10 (Figure 1) was the display used to communicate light conditions, comprising a D1 Mini and an SG90 motor. On the other hand, *Make A10* (Figure 2) displayed the measured air quality and was composed of a D1 Mini and the WS2812B LED Matrix.

Each device was programmed and controlled in Arduino C++. As communication protocol we choose mqtt [12] for remote access to data as Matter has not been accessible enough in the Arduino environment compared to the established "PubSubClient" Library. This enabled us to stay independent in the choice of SmartHome Environment as it can later be expanded.

3.2 Used materials

The materials used play an important role in communicating the data. For ambient light communication we choose spruce wood as it's very cooperative in manufacturing. Air Quality was displayed with the LED matrix sitting behind a thing sheet of paper and a translucent AirMesh, which is used to diffuse the light emited very much from the LEDs.

3.3 Software and Visualization

Each device must first connect to any WiFi-network with internet access – ideally the local home network of course. The procedure that's used to connect to the WiFi and the mqtt server is shared across all devices. The WiFi credentials are stored locally on each devices flash memory with the Arduino File System "LittleFS". If all attempts of connection to the saved WiFi fail, or if there are no credentials saved at all, the device starts an Access Point to which the user can connect to enter their credentials and assign a name

Figure 3: Access Point interface to setup the WiFi Credentials and device name.

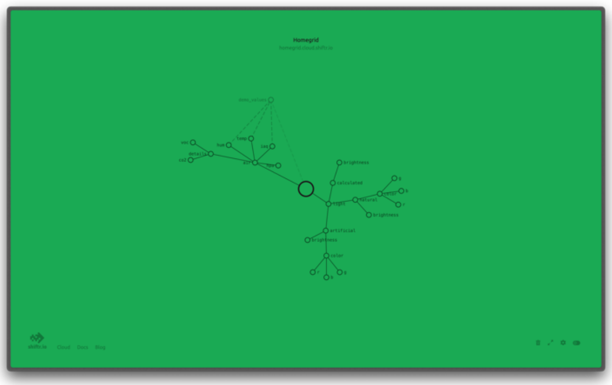

Figure 4: MQTT Server Structure (shiftr.io).

to the device (Figure 3). For *Sense L10* it's also required to define whether the device is measuring artificial or natural light.

After successfully connecting the sensoric devices send the data they collected to the mqtt server for the Bridge to structure and compare these values to one another. Therefore, an average can be computed which is then used to A) update the displays and B) adjust e.g. the homes lightbulbs to match the natural brightness.

We are using the provider *shiftr.io* [11] as mqtt service host, as it's a cloud based approach due to its online functionality (Figure 4).

4 RESULTS AND DISCUSSION

The "HomeGrid" devices demonstrate innovative information communication for the private environment. The research findings clearly indicate that relying solely on traditional screens for smart home scenes is not optimal. Instead, a mixed-use approach between screens and displays, as demonstrated in this study, is most effective. Considering that smartphones, tablets, laptops, and other devices have become constant companions in our lives, this combination is likely to persist in the future. However, there is a need for more screenless devices in the future, not just prototypes like those used in this study, but fully developed market-ready products.

Moreover, the research revealed a scarcity of studies and research focused on privately used smart homes. Existing studies often narrowly target specific areas, such as the effects of screen time on children. While the relevance of such research is not to be questioned, attention needs to be drawn to other application scenarios and impacts of screens. Additionally, it was found that very few personal data from smart homes are shared for (socio-)scientific research purposes, likely due to concerns related to surveillance or similar issues. This limited data availability poses a significant problem for scientific research, as valuable insights into societal functioning could be gained from such data.

5 CONCLUSIONS AND FUTURE WORK

To further expand this project, a corresponding website could be developed to raise awareness among end-users about the issue of excessive screen usage. This addition may be included shortly after the project's initial publication.

During the development and use of individual products, certain aspects emerged that couldn't be included due to time constraints. For example, the "Sense" devices still require some additional craftsmanship to complete the surface, and the use of AirMesh would be an optimal solution planned for this purpose. While "Make A10" proved to be highly effective in practice, adding a dimming function to the display might be beneficial, possibly adjusted based on data collected by "Sense L10."

REFERENCES

[1] Amazon Alexa Voice AI | Alexa Developer Official Site: https://developer.amazon.com/en-US/alexa.html. Accessed: 2023-07-19.

[2] Apple Home: https://developer.apple.com/apple-home/. Accessed: 2023-07-19.

[3] Banzi, M. and Shiloh, M. 2022. *Getting started with Arduino*. Maker Media, Inc.

[4] de Carvalho Silva, J., Rodrigues, J.J., Alberti, A.M., Solic, P. and Aquino, A.L. 2017. LoRaWAN—A low power WAN protocol for Internet of Things: A review and opportunities. *2017 2nd International multidisciplinary conference on computer and energy science (SpliTech)* (2017), 1–6.

[5] Google Home: https://home.google.com/welcome/. Accessed: 2023-07-19.

[6] IFTTT - Connect Your Apps: https://ifttt.com/. Accessed: 2023-07-19.

[7] Këpuska, V. and Bohouta, G. 2018. Next-generation of virtual personal assistants (Microsoft Cortana, Apple Siri, Amazon Alexa and Google Home). *2018 IEEE 8th Annual Computing and Communication Workshop and Conference (CCWC)* (Jan. 2018), 99–103.

[8] Lagervall, M. 2023. *Smart Home Protocols: User perception and experiences.*

[9] Loxone - Building Automation: https://www.loxone.com/int/. Accessed: 2023-07-24.

[10] Safaric, S. and Malaric, K. 2006. ZigBee wireless standard. *Proceedings ELMAR 2006* (2006), 259–262.

[11] shiftr.io: https://www.shiftr.io/. Accessed: 2023-07-19.

[12] Soni, D. and Makwana, A. 2017. A survey on mqtt: a protocol of internet of things (iot). *International conference on telecommunication, power analysis and computing techniques (ICTPACT-2017)* (2017), 173–177.

APPENDIX