

Introduction

The aims of this project were to research, design, and produce a working modular home security system. The research section, an investigation into the current market and the techniques that could be used within the final product. The Design and Implementation section shows how the product was designed, assembled and tested.

Research

Current market: The investigation shows a growing market with a large range of products existing across it. The large range of products shows many different techniques used, some wireless products, a large example of this being the “Ring” product range [1], with other major brands doing this as well. There is also a wired product market, but this is not as large currently. This will be investigated further as even though the wireless is more common it is less safe due to security as seen in Stories from BBC Rip Off Briton [2] and Panorama [3]. The best approach for determining this will be through the customer survey. The most common products in this market are camera systems and motion sensors, less common sensors are things such as leak and smoke detectors.

Customer research: A customer survey was used to collate information from a group of people that were interested in a home security system. This was then used to gather opinions on how the system should operate and the key goals. The Key takeaways included modules that should be prioritized, the communication method, the way the cameras operate and more.

Possible Techniques: For this there are 3 main core techniques that need to be decided, these are:

- Communication. Wireless Vs Wired [4]

After the customer survey Wired was determined and upon investigation of wired techniques POE (Power Over Ethernet) was determined as most applicable due to its ability to transmit both data and power efficiently.

- Storage. Local Vs Cloud [5]

Local means less storage but removes the requirement of interest access and increases the security.

- Video compression H.265/4 Vs MJPEG Vs MPEG[6]

This is a trade-off between quality Vs cost and processing required. In this case MJPEG was selected due to not requiring licensing.

Methodologies Used

Research Methodologies

Investigation: Allowing the collection of large amounts of information relevant to the task. In this case, this was first used to examine the product market, identifying available products and their costs.

Customer Survey: A vital method allowing for the collection of information from potential customers.

Development Methodologies

Simulation: Used to simulate the circuit design without generating waste or incurring unnecessary costs from component damage or purchases.

Prototyping: Builds on research findings to create a product, which is then iteratively refined until the final version is completed.

Design & Implementation

Window/door & Motion Sensor Simulation

A design was created using a simple PIC12(L)F1840. This design was created in Proteus, allowing for a circuit to be created seen in figure 1. The same thing occurred for the motion sensor; a simulation was produced and used to create a circuit diagram.

Central Hub & Camera Module Plan

For this simulation was not possible, instead research was required to determine the requirements. In the case of the central hub, a Raspberry Pi 4B was used, the camera module, an ESP32-S3-ETH from WaveShare. Then using a POE switch to connect this all together, this was used over a non-POE switch and injector due to cost and simplicity.

Window/door & Motion Sensor Prototype

For the prototype, using the knowledge from the design the appropriate components were selected. Once components were selected, a circuit was built and tested on a breadboard. An example of this can be seen in Figures 2 & 3 where the creation of the motion sensor prototype can be seen.

Central Hub and Camera Module Prototype

The first prototype for this can be seen in Figure 4, this shows the system connected and a successful ping between the Raspberry Pi and ESP32. A later version added the ability to pass video, then a saving function, as shown in Figure 5.

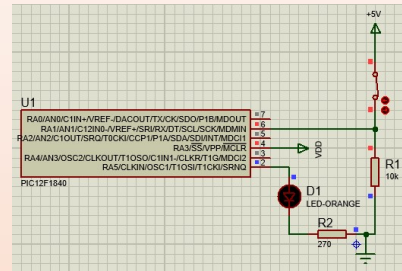


Figure 1 : Window/door monitor simulation

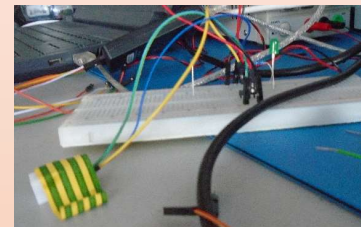


Figure 2 : Motion sensor Prototype, Low

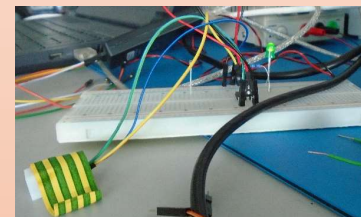


Figure 3 : Motion sensor Prototype, High

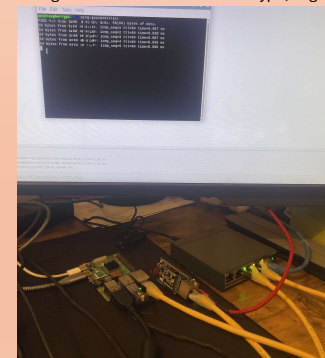


Figure 4 : Ethernet Setup and Successful Ping

Conclusion

The key takeaways for this task are:

- **Design:** The design was completed successfully and from the testing so far it appears adequate to complete the project.
- **Communication Method & Networking:** POE has been a successful method of passing the data and power and has performed reliably.
- **Code:** Using Python to program the Raspberry Pi and C++ for the remaining code has allowed skill development in both languages.
- **Project Management:** Over the course of this task mistakes were made in underestimating task complexity and not allocating buffer time for delays or unexpected issues.

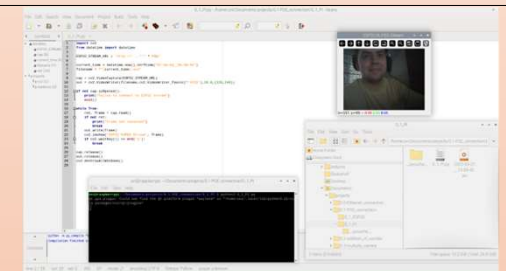


Figure 5 : Final Camera Viewing and Saving Code

Future work

- Create the connection between the ESP32 and modules, creating the code which can pass the variable to the Raspberry Pi module via the server
- Implement the variable into the code on the Pi so the system only records when sensors are high.
- Alter the Pi code to be able to view additional ESP32's in the system.
- Creating the emergency power supply which will be able to power the system through a power outage.
- Ensure the product applies to applicable standards: for the code this is C++23 and PEP8. For the electronics, some examples are BS EN 62368-1 and BS 7671.

References

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- [4] Safe Secure Homes, Wireless VS Wired Home Security Systems: Pros & Cons, <https://www.safesecurehomes.co.uk/wireless-vs-wired-home-security-systems-pros-cons/> , August 2023
- [5] Wollerton, Megan, CNET, Home security 101: Local vs. cloud camera storage, <https://www.cnet.com/home/smart-home/home-security-101-local-vs-cloud-camera-storage/> March 2016
- [6] Philsecurity, Video Compression: MJPEG vs MPEG4 vs H264, <https://philsecurity.com/guides/dvr/compression/>