Automated Home Security System
By Harry Yelland

Abstract

My proposed product is a compact Automated Home Security System, making use of a STM32F7G-Discovery Micro-Controller board. The system in its full intentions will aim to focus on certain aspects of the user's home security/safety, whilst also providing ease of access lifestyle opportunities. Unlike other systems on the market, it is designed specifically with these in mind, whereas in other systems it is often found that there is a more generalised setup and thus specialised areas such as accessibility lose out (e.g: a home security system may only provide a simple locking system with alarm and number pad).
It is therefore my belief that this design that I am proposing will appeal to not only the general market due to it featuring these basic features but also would enhance the experience for users should they require the extra functionality by being a pre-packaged all-inclusive system. Due to the low cost of the individual elements, it is also my belief that within a marketplace environment, the system could be produced for a low price and thus caters to an even wider version of the all-inclusive market that was aforementioned. This could be compared to other systems that only boast a few features therefore not catering to a wider audience, or some that do have this added functionality but do not sell it as a single, affordable package, to which, for many they cannot afford to buy these overpriced specialised systems and thus a single cheaper option would adhere to their financial limitations in a better manner - a niche in the market my system is aspiring to fulfill.

Throughout this project I really wanted to encapsulate all key ideas for the system, making notes on areas of accessibility that would revamp pre-existing systems currently on the market, detailing my personal views and then gaining market research in a structured manner, first asking those around me (who should be considered potential end-users for all intents and purposes) and then furthering this knowledge by researching online to ensure all forefronts of my solution are not only adequate but also rather adept at fulfilling any needs in an effective manner.

Introduction

As described in the preceding Abstract, my product is a system of multiple philosophies – it is built to integrate security in a manner that is all-inclusive with regards to user's needs and in an affordable manner. These areas align with my own personal motivations, as someone that understands the importance of security but also due to my own personal circumstances - both of my parents have hearing impairments in differing fashions and due to this, understanding a customer's individual requirements is something I wanted to consider vastly with my system. Due to this, I planned and began development of the system with their personal requirements in mind in order to ensure that my ideas for inclusivity are achieved. By considering them, I evaluated the peripheral options to hand and considered how they could be constructed to form a system that matches the above criteria.

From my initial plans I knew that in order to enable security from a data security point of view, the system needed to be designed in a manner that didn't have to interact with an online database, allowing for the system to be expanded locally and reducing the risk of attacks or an online source compromising the user's home.
I then considered the average user's home and what functionalities are deemed mandatory - my initial thoughts going straight to smoke alarms, which obviously protect the user's home from fires. When inspecting the fire alarm, it can be noted that they are predominantly composed of a smoke detector and a buzzer/alarm component. In recognising this, I considered how the functionality could be improved - although the alarm could be loud, what if a user is hard of hearing? I knew upon evaluating this, I would have to implement some form of visual way of displaying the smoke alarms output.

Further looking into the average household, every household consists of at least one light (with a corresponding switch), allowing users to safely light up their house. With the recent popularity of smart homes such as Amazon's Alexa and Google's Home devices, there has been a shift in forefront to allowing for ease of access to control lighting and other components such as from phone's, as well as the typical switches. I wanted to consider this as a component to feature in my system - not only would it enable users to control lights from a favoured position but also by implementing this, it would allow users who cannot be as mobile to turn on their lights from a chosen place, whilst also allowing for a switch on the wall should they want to turn lights on whilst moving between rooms.

To keep with traditional systems it was also clear to me that a passcode system would make sense to allow for locking of the house and thus securing the household - therefore implementing a keypad could allow for this to work in an effective manner.

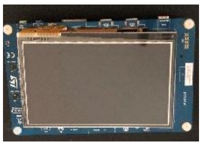
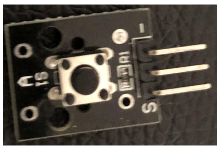
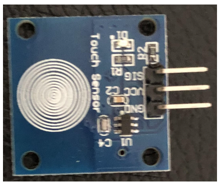
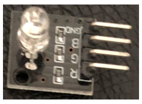
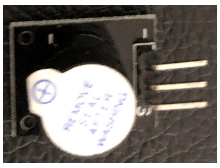
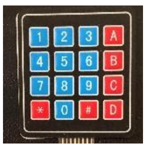
Market Analysis

My first demographic that I wanted to analyse was those with hearing impairments. According to 'Public Health England', 11 million people across the UK suffer from hearing loss, which is the inability to hear either partially or completely within at least 1 ear which is around 20% of the entirety of the UK population.

Having parents and grandparents that fit within this specific demographic, in varying manners, I decided to conduct an interview with them with regards to the development of my system. My mother, being born with only one formed/functional ear and my father who has been prescribed hearing aids since his early 30's lended quite the insight into the market from their own perspectives. In their experience, it can often be frightening that a smoke alarm may go off just outside the kitchen and yet they may not hear it until another, closer smoke alarm goes off. This admission prompted me to query it further, asking how they thought the system as a whole could be better implemented to inform them of a fire to which I was met by two main responses: either a wireless connection to interlink all smoke alarms so that all go off as soon as one does; or alternatively a visual representation of the alarm could be used to alert them - therefore circumventing the issues involved with hearing. This was an idea that really resonated with my intentions for the system, when picturing the wider scope of the demographic, someone that is completely deaf would be physically incapable of hearing a fire alarm and would require a visual representation as mandatory with any system. However I could also still see value in an alarm from the perspective of someone who doesn't have such impairments, indicating that a combined system would make the most sense. This factor was highlighted further to myself when researching people with sight loss within the UK, to which the NHS records 2 million people have sight impairments/vision loss.

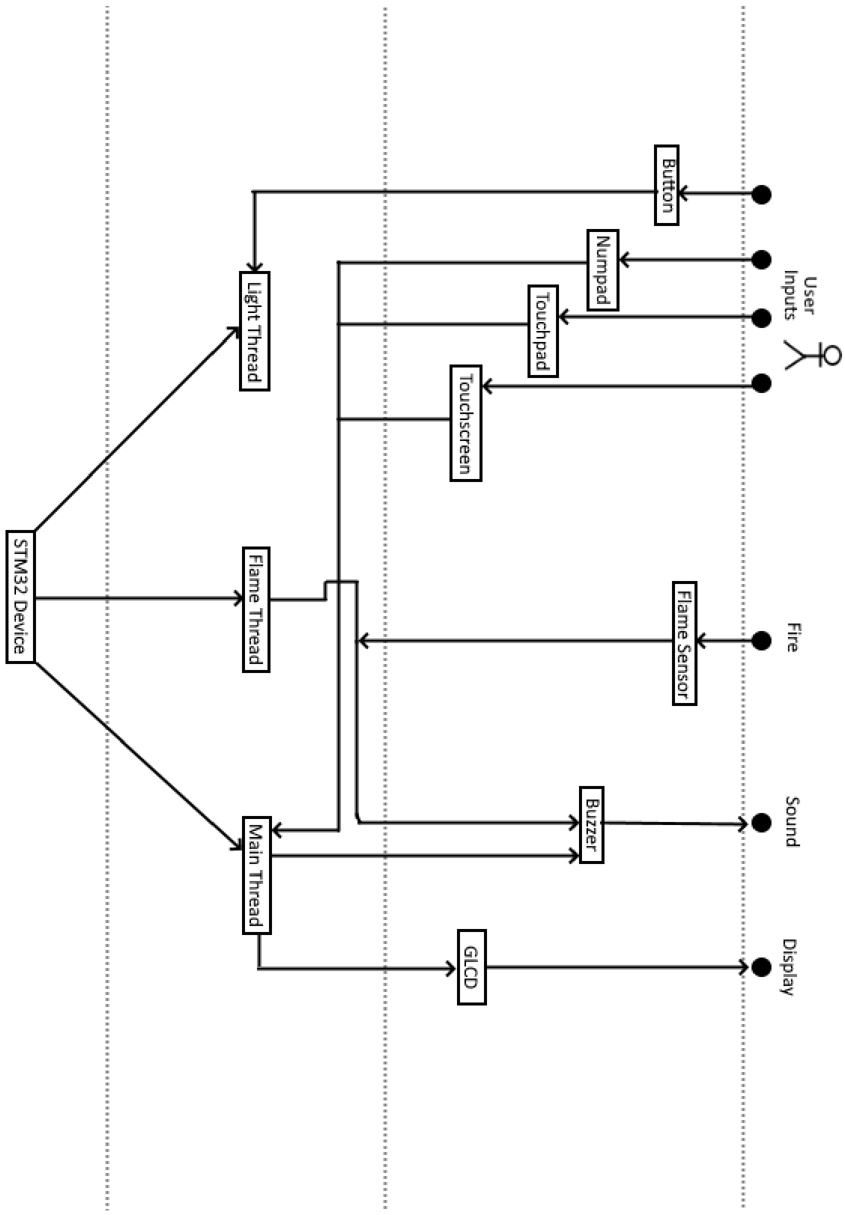
I was also interested in establishing an understanding of another demographic, those in the UK with mobility issues. This was harder to find exact statistics on as mobility issues are much harder to classify as a group, however following general trends, as a person tends towards the much more elderly stages of their life, they are often less mobile. While mobility issues are not solely limited to the elderly, due to the lack of data explicitly referencing mobility issues to hand, I decided to model my research with regards to my grandparents, who are now having to make use of a walking stick and a trolley (that often helps stabilise them during walking). Having discussed with them the other aspects such as locking/securing the home and asking them about the lighting situation in their house, mobility was brought up for one main occasion. They often found that due to their reduced mobility, moving about in order to turn lights on/off can be a struggle - often procrastinating the task due to their circumstances. It was clear from our discussion that a way of controlling it from a touchscreen device that could be situated in a more comfortable location would more than benefit them and when I suggested coupling that with a visual representation of the smoke alarm (given they also have hearing loss issues), they were rather intrigued and thought the system would benefit them massively.
From this market research, I felt I understood my target demographic well and could thus commence work towards a solution.

Product Expenses

Peripheral/Item	Link	Price* (£)
STM32F7G Discovery Board 	https://estore.st.com/en/products/evaluation-tools/product-evaluation-tools/mcu-mpu-eval-tools/stm32-mcu-mpu-eval-tools/stm32-discovery-kits/32f746gdiscovery.html	38.96
Push Button 	https://www.az-delivery.uk/products/button-modul	5.00
Touch-Pad 	https://www.dx.com/p/produino-jog-type-touch-sensor-capacitive-touch-switch-module-for-arduino-blue-2038545.html#.YKl47KhKhhE	1.49
RGB LED 	https://alltopnotch.co.uk/product/ky-016-5mm-rgb-led-breakout-board/	2.69
Flame Sensor 	http://www.kumantech.com/kuman-flame-sensor-module-for-arduino-ky16_p0128.html	7.08
Active Buzzer 	https://www.cricklewoodelectronics.com/Active-buzzer-Module-for-Arduino-KY-012.html	2.50
4x4 Matrix Numpad 	https://www.switchelectronics.co.uk/4x4-matrix-membrane-keypad?gclid=Cj0KCQjw16KFBhCgARIsALB0g8IeERoRsZ28t9xCrkeJbqwUTnR08kluGEL6GdsRQvZPRw7slIom4m0aAlr6EALw_wcB	1.99
Breadboard Wires	https://www.amazon.co.uk/gp/product/B01EV70C78/ref=ppx_yo_dt_b_asin_title_o00_s00?ie=UTF8&psc=1	6.99
Total		**66.70**

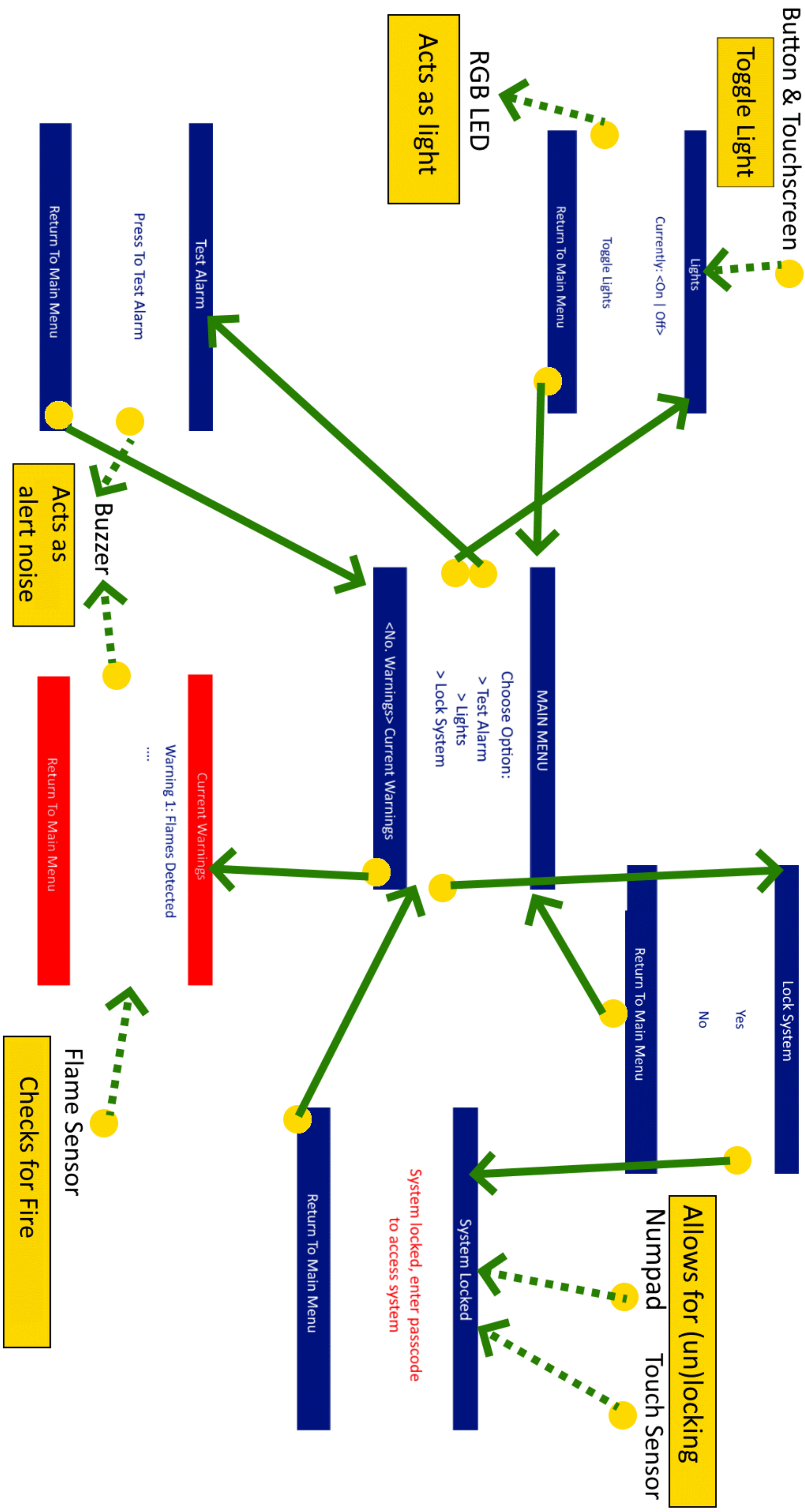
** Prices are reflective of conversions rates (USD $ → GBP £) at time of creation.*

System Architecture



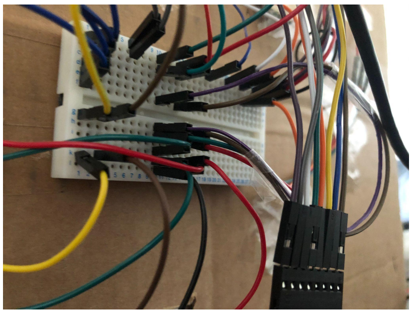
System makes use of three threads which I have categorised the system architecture within, these being the: light thread, flame thread and main thread. The reason for this is realtime priority is assigned to both light and flame, high priority for the main thread and this causes each peripheral to interact with the system as a whole slightly differently.
I have shown the user's inputs on the left: Button, which goes to the button thread, numpad, touchpad and touchscreen, that all go to the main worker thread. The flame sensor goes to the flame thread, which in turn goes to the buzzer for its output. Everything else is handled by the main thread, which reads the aforementioned user inputs (except the button) and outputs sound via the buzzer peripheral or to the glcd display.

UI Design & Flowchart

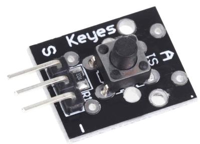


<u>Peripheral Integration</u>

From a practical business point of view, I wanted to model the system in an easy to follow and expandable design. Due to this it was my intention to keep ports ordered and the wiring in between to make use of dedicated colours per each signal line for each peripheral, where green represented ground, red represented Vcc, and then a varying colour chosen based on the peripheral. Throughout all of this we use pulldown, which forces the pin to low, therefore keeping them consistent for reading.



Known Peripherals:



KY004 Push Button – Clock G, Pin 7, Input, Pulldown, D4

The KY004 (Switch) Push Button was connected into the breadboard for each pin, the signal going to its own dedicated row (through a yellow signal wire), whilst the ground (green cables) and Vcc (red cables) were connected to a block (as shown above). This yellow cable was then connected up to the GPIO port D4 of the CN4 digital connectors. With reference to the STM32F7 datasheet, D4 can be referenced via the STM32 pin: PG7 – to which in the code Clock G needs to be enabled and initialised with GPIO pin 7, setup with the mode pulldown input.

KY016 RGB LED – Clock C, Pin 7, Output, Pulldown, D0

The KY016 RGB LED was connected into the breadboard for each pin, the signal going to its own dedicated row (through blue signal wires), whilst the ground (green cables) were connected to a block (as shown above). This blue cable was then connected up to the GPIO port D0 of the CN4 digital connectors. With reference to the STM32F7 datasheet, D0 can be referenced via the STM32 pin: PC7 – to which in the code Clock C needs to be enabled and initialised with GPIO pin 7, setup with the mode pulldown output. It should be noted that the blue cables (for each pin: red, blue, green) connected to the same breadboard row but could have been separated to add more functionalities for different light colours being used.

4x4 Matrix Membrane Keypad:

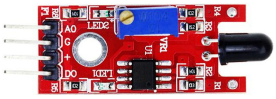
The keypad was not connected to the breadboard and was instead connected directly to the CN7 connectors of the STM32 device, making use of ports D8-15. This translates to pins 8 & 15 for clock A, pins 8, 9, 14, 15 for clock B and pins 1 & 2 for clock I. All make use of both Input/Output modes as Pulldown.

Unknown Peripherals:

Produino Capacitive Touch Sensor – Clock B, Pin 4, Input, Pulldown, D3

Datasheet - https://www.drouiz.com/blog/2016/03/14/sensor-touch-arduino-2/

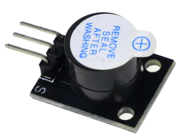
The Produino Capacitive Touch Sensor was connected into the breadboard for each pin, the signal going to its own dedicated row (through a brown signal wire), whilst the ground (green cables) and Vcc (red cables) were connected to a block (as shown above). This brown cable was then connected up to the GPIO port D3 of the CN4 digital connectors. With reference to the STM32F7 datasheet, D3 can be referenced via the STM32 pin: PB4 – to which in the code Clock B needs to be enabled and initialised with GPIO pin 4, setup with the mode pulldown input.



KY026 Flame Sensor – Clock G, Pin 6, Input, Pulldown, D2

Datasheet - https://arduinomodules.info/download/ky-026-flame-sensor-module-zip-file/

The KY026 Flame Sensor was connected into the breadboard for each pin, the signal going to its own dedicated row (through an orange signal wire), whilst the ground (green cables) and Vcc (red cables) were connected to a block (as shown above). This orange cable was then connected up to the GPIO port D2 of the CN4 digital connectors. With reference to the STM32F7 datasheet, D2 can be referenced via the STM32 pin: PG6 – to which in the code Clock G needs to be enabled and initialised with GPIO pin 6, setup with the mode pulldown input.



KY012 Active Buzzer – Clock C, Pin 6, Output, Pulldown, D1

Datasheet - https://arduinomodules.info/download/ky-012-active-buzzer-module-zip-file/

The KY012 Active Buzzer was connected into the breadboard for each pin, the signal going to its own dedicated row (through purple signal wires), whilst the ground (green cables) were connected to a block (as shown above). This purple cable was then connected up to the GPIO port D1 of the CN4 digital connectors. With reference to the STM32F7 datasheet, D1 can be referenced via the STM32 pin: PC6 – to which in the code Clock C needs to be enabled and initialised with GPIO pin 6, setup with the mode pulldown output.

Connecting the Peripherals to the STM32F7 Discovery Board:

All peripherals stated are connected between the CN4 and CN7 connectors (see STM32F datasheet page 23 for these - https://www.st.com/resource/en/user_manual/dm00190424-discovery-kit-for-stm32f7-series-with-stm32f746ng-mcu-stmicroelectronics.pdf). The push button is checked to see if its been pressed/toggled. If it has then this will cause the pin for the led to be written. The membrane keypad and touch sensor are checked to see if the passcode has been entered and touch sensor pressed when the system is put into unlock mode (via GLCD touchscreen). The flame sensor provides an input to the system, which is read, which when it goes high (flames detected), the system turns the buzzer on (again pulls it high due to it being setup in pulldown mode). The GLCD Touchscreen can be used to turn the lights and buzzer peripherals on/off as well, whilst also being integral to the locking/unlocking of the system which then requires the keypad and touch sensor. On top of this, when the flame sensor is read, it updates the warnings counter/list on the GLCD so the output of this is also displayed in a manner that does not use the buzzer.

Project Management

References

Public Health Matters hearing loss study - https://publichealthmatters.blog.gov.uk/2019/06/05/health-matters-hearing-loss-across-the-life-course/#:~:text=There%20are%20around%2011%20million,of%20whom%2050%2C000%20are%20children

NHS report on vision loss - https://www.nhs.uk/conditions/vision-loss/#:~:text=In%20the%20UK%2C%20there%20are,as%20blind%20or%20partially%20sighted

Touch Sensor datasheet - https://www.drouiz.com/blog/2016/03/14/sensor-touch-arduino-2/

Flame Sensor datasheet - https://arduinomodules.info/download/ky-026-flame-sensor-module-zip-file/

Active Buzzer datasheet - https://arduinomodules.info/download/ky-012-active-buzzer-module-zip-file/

STM32F7 discovery board datasheet - https://www.st.com/resource/en/user_manual/dm00190424-discovery-kit-for-stm32f7-series-with-stm32f746ng-mcu-stmicroelectronics.pdf