MInD Lab UG,T1 2020

Preliminary Report, Needs and functional requirements of a Smart Home for an Aged Population

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1. Introduction

Australia's at home aged care system comprises a broad spectrum of services that range from basic support networks to enable people to remain independent at home, [1] through to full time carers that come to their own house. As a result of this broad spectrum, a one size fits all approach would not be ideal to take as aged care is for everyone and does not discriminate against age, sex, race or nationality. Therefore, we need to ensure that within our IOT smart home using the graphene based sensor layer, we don't discriminate and ensure that our product is available and usable to everyone regardless of age, digital literacy and intellectual ability, to ensure it not only hits our target audience but also the broader community.

1.1. Who is in aged care currently?

Currently in Australia we have no minimum age to be eligible to receive government-subsidised aged care in Australia; rather, access is determined by assessed needs [1]. As a result of this subsidy, more than 1.2 million people received aged care services during 2017-2018, with most (77%) receiving support in their home or other community-based setting [1]. When put in context, all Australians aged 65 and over in 2017-2018 [1]:

- 7% accessed residential aged care [1]
- 22% accessed some form of support or care at home [1]
- 71% lived at home without accessing government-subsidised aged care services [1]

1.2. Who Qualifies for the care at home subsidy's?

From this information, we now know that 22% of individuals over the age of 65 required some form of support or care at home in-order to do their daily activities and they were able to do this through the "Home Care Package" [2]. The "Home Care Package" in Australia is given out to individuals who are deemed to have medium to high needs of care at home and this is determined by ACAT (Aged Care Assessment Team).

An individual is deemed to have a medium to high level of care required based on the following questions and their responses [1]:

- What support you already have, and if it will continue
- Your health, lifestyle and any health concerns
- How you're going with completing daily tasks and activities around the home
- If you have problems with your memory
- Any issues relating to their home and personal safety
- Family and community activities

From the questions asked above, we can safely assume that individuals who currently qualify for the home care package are at a medium to high risk of potentially injuring themselves at home and without a carer to check up on them daily could potentially die if they live alone and experience a critical injury.

1.3. What about the other 71% Living at home without subsidised aged care?

When designing and exploring the uses of the IOT related smart home devices and tracking/monitoring aged individuals we need to consider that just because an individual doesn't qualify for the Home Care Package that they are not at risk. As individuals age and become older they become more fragile and vulnerable than the rest of the community, one clear example of this is the prevalence of osteoporosis in those aged over 50 [3].

Based on a recent study measuring bone density in a population sample, the prevalence of osteoporosis among those aged 50 and over was estimated to be 23% of women and 6% of men [3]. The impact of having such a high prevalence of just osteoporosis resulted in 19,000 people aged over 50 being hospitalised due to a minimal trauma hip fracture [3] with the majority of these hip fractures coming from falls at home.

Now if an individual living home alone with no one checking up on them frequently has a fall and breaks a hip they might not be able to get up and access a phone or other form of communication device to call for help. For this exact reason, we have to ensure that our IOT related smart home utilising the graphene-based sensor layer is accessible to all individuals and not just those on the home care package as having this specific device could potentially save someone's life.

Therefore, we need to ensure that our product that we deliver is cost effective, reasonably priced and aesthetically pleasing to aged individuals to ensure that not only that it hits our target demographic but is effective and accepted by the target demographic as we initially expect a low acceptance rate of the new technology by users due to the nature of the graphene based sensor layer not being currently proven or tested in a research setting to effectively minimise the likelihood of a critical fall or the specific benefits it passes on onto carers/family members.

1.4. Usability Requirements

Currently, due to our target demographic being aged individuals, we will be assuming that they will have a low level of digital literacy and as a result we need to ensure that our IOT related smart home devices and the app meet the current usability guidelines as described by recent research [4]:

1.4.1. Installation Requirements

Due to the current need of the graphene based sensor layer needing to be physically installed into the clients/users home, we need to utilize this period to ensure that not only the system is set up but also other IOT devices in the users home are set up and connected to the system through the application.

The reasoning behind having all the IOT devices being connected up during the initial installation period rather having the user themselves connect the IOT devices up after the installation period is to ensure that the chance of user error is kept to a minimum to reduce the chance of the system producing an incorrect output such as sending a critical fall message which could have adverse flow on affects for all parties involved.

Furthermore, we need to note and ensure that this installation period is as smooth and stress free as possible for the user to ensure that the installation process does not negatively affect their opinion on the system or their use of the system. This is a crucial part towards the system and ensuring that we keep the acceptance rate of the system as high as possible as the installation process is a significant area that will vary from user to user.

As a result of the installation process having a potentially wide and volatile effect on the system and the acceptance rate of the client and its uses for the client, we need to ensure that each installation follows the following guidelines:

1. The installation is tailored specifically towards the client and not done using generic processes
2. The installation technician is proficient in not only the graphene-based sensor but also IOT devices and the processes used behind them (metrics they can gather such as gyroscope and accelerometer data)
3. The installation technician has strong levels of interpersonal skills to ensure they are compassionate towards the client and their needs

2. Needs of a smart home for an aged population

The population of Australia and many other developed nations have an ever growing ageing population that not only produces an extensive strain on the health care sector but also the emotional stress on family members. As a result of this strain that the ageing population produces, we need to shift to a more technological approach to look after this part of society and give them the best quality of life we can in their golden years.

As individuals age, their own individual risk of a variety of health concerns evidently increase with a positive linear relationship towards their age and associated health risks and these health risks not only have the possibility to impact their lives severely but, in some cases can potentially kill them.

This is exacerbated by the fact that many aged people live alone, with just under a quarter of people living alone in Australia being over the age of 75. Current predictions expect this number to jump as high as 48% by 2031 [5]

The need for rapid cost effective and meaningful dual purpose smart home technology is needed more now than ever as many of these elderly individuals have no way of contacting for help if they have a critical fall or any other serious medical event such as a stroke or heart attack that have the potential to occur based upon their current health condition.

2.1. Commonly used IOT products in an Aged Home

In the home of an aged person, very few IoT devices are used when compared to the rest of the population in Australia. However, the most common IoT device used is the smartphone with around 55% of Australians over the age of 55 owning a smartphone in 2018. This number over time will increase as around 90% of Australians own a smartphone currently as of 2018[6].

Within the use of the smartphones with aged individuals, we can safely assume that the majority of smart phones on the market have the following sensors and built-in features for us to access and use with the consent of the user:

1. Accelerometer
2. Gyroscope
3. GPS
4. Ambient Light Sensor
5. Microphone
6. Magnetometer
7. Internet Access/Bluetooth Capabilities

Other commonly used IOT products in an aged home are fitness trackers and smartwatches which are used every day by the aged population. Currently 24% of the elderly population in the US own some form of a fitness tracker whereas around 5% own a smartwatch[7]

While there is a variety of different types of smartwatch’s and fitness trackers on the market, we can safely assume that they will have at least one of the following built into them:

1. Accelerometer
2. GPS
3. Gyroscope
4. Internet Access
5. Magnetometer
6. Bluetooth Capabilities

The Use of IoT products in an aged home style setting is currently relatively low as many aged individuals don't use them in general in their own personal homes. Furthermore, it needs to be noted that during the marketing and installation of the product we will face individuals who won't have an active internet access outside of a mobile connection as they simply do not use any form or type of computer daily like the rest of population currently do.

Nevertheless, other possible IOT devices we are likely to see in aged individuals' home are the following:

1. Google Home/Alexa type smart home system
2. Autonomous lights activated by motion sensors
3. Autonomous vacuums such as Roombas
4. Wirelessly connected cameras
5. Smart IOT connected mirrors

Furthermore, an interesting trend to note is that the further out you go into rural Victoria/Australia the lower the level the acceptance rate of technology is whereas in the CBD it is relatively high when comparing the two [28]. The same trends also occur for internet access, internet technology as well as internet data allowance as well as the user's digital ability [28]. This data and visualizations can be seen in 2019 report "Measuring Australia's Digital Divide" [28].

A keynote to add is when targeting our demographic it is highly likely that will we run into individuals that don't have an active internet connection, especially the more rural the area is [28]. As a result, a possible solution to this issue is by providing a bundle with the graphene-based sensor for an extra cost which covers the areas that the client is missing in their home. It is crucial that they have a strong and active internet access in order for the system to function as intended as well as to report critical events with minimal levels of delay in relation when working with other IOT devices.

2.2. Current Technologies used in aged care homes

When reviewing the current level of technologies available for use within an aged care home, there is broad spectrum in the level of technology used in each aged care home. Furthermore, the level of technology used is generally in reference to the type of patients it takes care of, such as dementia patients. When reviewing aged care homes that specifically look after individuals with onset dementia, we can often see the following types of technology used to be better monitor and improve their conditions:

- **Smart clocks** - smart clocks are most commonly used to help carers set a routine for the patient as well as reminders to remember throughout the day. Furthermore, research has been done into the use of computer vision with smart clocks to better monitor and alert the user [29]
- **GPS devices** - GPS devices are most commonly used when the aged care home needs to keep track of a patient's location at all times [30].
- **Camera's** - this is the most common technology used in all types of aged care homes. However, the type of cameras used vary from centre to centre as some have a wired system whereas others have a wireless system and they are predominately used to monitor patients remotely [30].
- **Patient Database** - all aged care homes have some form of database whether it be digital or physical. This database holds confidential patient information to help with specialised care for each patient [31]

- **Medication Management Systems** - a large majority of aged care homes have medication management systems in place to ensure that medication is taken at the correct time for each individual patient [31]
- **Specialized equipment** - currently a select few aged care homes have specialized equipment in place to detect specific events. One example is jewellery that can detect when a fall has occurred, however this is significantly rare due to the cost of this specialized equipment [30]

Furthermore, from the area's identified above we can assume that the technology present in aged care homes are usually more specialised than any home-based technologies for aged people as they are usually designed for the management of many aged people in a controlled and supervised environment.

Nevertheless, while specialized technology exists within specific aged care homes, when reviewing them as a whole, a majority still run on legacy on-premise solutions and clinical management tools, which are simply unable to manage the collaborative requirements of modern data and the applications through which it is used. Not only do the majority of aged care homes in Australia lack the performance capabilities, they can also be rigid, difficult and expensive to manage [20].

In a report released in 2017 from the Aged Care IT Council, it revealed that there is a need for greater interoperability and more technology readiness in today's still somewhat fragmented aged healthcare tech landscape. Furthermore, the report also called for a greater adoption of more sustainable, scalable and innovative solutions in Australian aged homes and that the industry needs to start taking digital transformation more seriously [20].

While many of these technologies may not be widely used by many aged care homes and the systems currently in place are outdated and fragmented, there are still some general technologies in place that can help in assisting with the care of aged people in these facilities and we can leverage them one way or another in conjunction with the graphene-based sensing layer. Furthermore, another point to add is, it is likely that the users in the aged care home will possess some type of general technology as seen within aged individual homes such as smart phones or tablets which hold various sensors, we are able to leverage.

2.3. How we can leverage these specific technologies

While the quality and quantity of IOT type devices in aged care homes as well as the system behind how they work might be outdated, we will still be able to use and gather their metrics as long as they are connected to a LAN, WAN, MAN or traditional router connected to the internet.

With commonly used IoT devices like smartphones, smartwatches and fitness trackers we can use their integrated sensors and features to help gather more information to help with aiding tracking their health and to enhance an aged person independence, wellbeing and quality of life. As well as using theses sensors to emulate the technologies used in aged homes for personalised home use while monitoring their health and providing insights towards the carer about the current status of the user/patient.

Whereas more unique systems as found within aged care homes such as Smart Clocks and GPS devices we will also be able to leverage, however specific functionalities will have to be made within the application in order to interact and view them in real time outside of the data each product outputs.

Some examples of how we might integrate common IOT devices found within aged care homes as well as an aged individuals' home are:

- Using a smartphones accelerometer to aid in the detection of a fall through the use of the inbuilt accelerometer and gyroscope
- Having a smartphone push notifications, to help with reminders like medication and appointments which are automatically generated from the application pairing to the user's current notifications or aged care homes medication management system
- Using a smart watch's heart rate sensor and pedometer for fitness tracking or the built in IMU data from smart phones if a smart watch is not present.
- Using existing data about a user to automatically tune the sensors for a user's specific needs to better detect if a critical event is happening such as an irregular heartbeat based on the user's average heart rate.
- Cameras could be used with computer recognition to detect a fall alongside the graphene-based sensor layer to verify if the fall was accidental or caused by another condition such as a loss of consciousness to better inform the carer
- Leveraging the GPS system currently in placed at aged care homes in conjunction with the graphene-based sensor layer to accurately track where a user is on the sensor layer as well know which user has specifically had a critical fall when there are multiple users on a single graphene-based sensor layer. A substitute when no GPS system is in place is utilizing the users phone GPS instead to accurately track them when multiple users are present.

Leveraging these specific technologies identified and describe above; we can create a smart home environment with a large and flexible feature set without having to install sensors or modify the users or company's environment. In addition it will provide further data metrics which can be compared towards the graphene-based sensor layer in order to not only improve its accuracy but also the possible critical events it can detect and alert carers or family members.

2.3.1 How we can leverage these technologies to increase the systems accuracy

As mentioned above, we are able to leverage the most common IOT products in an aged individuals' home as well as aged care homes to not only increase the accuracy of the graphene-based sensor layer but also extend it to possibly predict other critical events such as heart attacks.

Examples of technology identified above that we can leverage to make the system more accurate and extend its capabilities are:

- **Accelerometers** from smartphones and smartwatch devices can be used in our application to measure the acceleration of the body and help with detecting if the body is accelerating at the rate it would in a fall. Furthermore, recent machine learning techniques have shown promise in detecting a fall based on accelerometer data alone.
- **Cameras** already installed in the home/facility can be used to visually detect if a person has fallen over, using computer recognition software/algorithms. Furthermore, we are able to leverage it as a recording and provide a live feed to the carer/family member of their current state after the critical fall, another possible area we can review is the use of computer vision to visually detect the health of an individual such as the level of their skin pigmentation for medical reasons such as dehydration
- **Gyroscopes** used in smartphones and smartwatches could also be leveraged to detect the angle a person is falling at and possibly be used to detect whether or not the fall is critical or minor and feed that information into the graphene based sensor layer and then use that information to predict a falls severity from saved data for that specific user where gyroscope data is not available

- **GPS systems** already in place in aged care homes can be leveraged to directly detect which individual had a fall on the graphene-based sensor layer when multiple individuals are present at once or through the use of the user's smart phone when a dedicated GPS system is not present.

2.4. What an Aged Population Needs from a Smart Home and the Product

When reviewing the non-functional functions of our application and the general use of a smart home measured against the needs of an aged population who both have carers and don't have carers, we can safely assume they will need to be centred around the following areas:

- General Health inquires such as calories burnt, steps taken etc.
- Wellbeing, both physical and mental
- Daily reminders, set by both the carer and user
- Peace of mind, in relation to their own personal safety when home alone

When it comes to a smart home focused around the health and wellbeing of the individual, it should be able to detect falls, monitor heart rate and blood pressure to make sure the person is in good health and that no abnormalities occur in their health throughout the duration of the day without affecting the users normal daily activities. We are able to do this within our current product if the reasonable IOT devices are connected such as a smart watch and heart rate sensor.

This is particularly important as if the system can detect the deterioration of an aged persons health or a rapid negative spike in their health, it can automatically contact the required parties such as an ambulance in the event of a heart attack/stroke or schedule a GP visit if less severe.

Another major area that an aged population needs from a smart home is related to primarily fitness and wellbeing. This is particularly important as a number of aged individuals tend to become sedentary the older they become and being able to actively monitor and track their fitness levels and spikes throughout the day will provide the carer with crucial information in regards to their health and potential health risks such as blood clots from sustained periods of sitting down. One simple way that our product can provide this information is by providing daily messages and reminders towards the user as well as providing analytical data such as daily steps taken and calories burned from IOT data collected from the user's phone, smart watch etc.

Carrying on, the wellbeing and mental state is another crucial area that we should and will be targeting. As the mental state of any individual is at the forefront of health technologies due to 7% [22] of all individuals over the age 60 suffering from depression, this number is only increasing in today's rapid society and increases if the individual also lives alone. Therefore, as a result it is important that within our smart home, we provide not only activities within the application to keep the users mind sharp but also to ensure they are interacting with others. Currently senior isolation is one of the biggest threats towards the health of Australian citizens as the effects of social isolation has been linked to increased blood pressure, heart disease, obesity, a weakened immune system, anxiety, depressing, cognitive decline, Alzheimer's disease and in some cases death [23].

As a result, one possible solution we can include into our application to combat senior isolation is the inclusion of a games room and a video chat room. With the inclusion of an online games room, it will not only help aged individuals keep their mind active but also interact with others in a hope to combat the disconnect from other individuals. Nevertheless, the inclusion of a virtual video chat room is to provide someone to talk to, whether it be another individual using the application or a health professional.

The final major area that we will target and focus with the graphene-based sensor layer in a smart home type scenario when paired with IOT devices is safety while the individual is home alone. When an individual is aged 65+, they are at a significantly higher risk of having a fall at home that results in the admission to hospital. Currently the leading reason for admission to hospital for those aged over 65 is a fall related injury resulting 38% of all admissions [21]. When spread out across the population of individuals aged over 65, 1 in 3 people over the age of 65 will experience a fall resulting in the need of them to be admitted to hospital this year alone [21].

As a result of 1 in 3 people over the age of 65 going to be admitted to hospital just for a fall related injury this year alone [21], it is crucial that their safety in all regards and not just fall related injuries are considered. This can be done by providing the user the peace of mind knowing that if a critical event does happen, the correct carers and health professionals will be contacted, and this will be achieved through the automatic message sent when a critical fall is detected from the graphene based sensor layer or other IOT devices connected.

2.5. Other areas we can branch out with a hive mind intelligent system

Within a hive mind intelligent system, we have access to every piece of data that has been collected from all connected devices. A sample hive mind system when paired with IOT devices in the current setting set above not only increases the potential accuracy of the graphene-based sensor layer but also the possible critical events it can detect.

As a result of using a hive mind intelligent system rather than multiple standalone systems, it will allow not only greater clarity in the data collected and real time analysis but also the metrics collected and stored about the user. Through having this single collection of data all collated at once, it provides us with the ability to not only increase the analytics about the user/patient towards the carer but also identify real time dangers based upon the pressure applied into the system and secondary sources from IOT devices.

One clear example could be providing the user with a warning message after they have gone down the stairs applying heavy amounts of force. The reasoning behind this is, if the system detects the user has gone down the stairs heavy footed, it can then warn the user instantly after the fact that they were at a high chance of having a critical fall if they potentially mis-stepped while going down the stairs.

Warning the user straight after potentially dangerous actions rather than hours after that action will not only increase the user’s likelihood of taking onboard the suggestions but also more closely recall the situation as it currently just happened and adhere to the advice given then rather than later.

2.6. Potential Uses of AI in the system

Due to the nature of the graphene based system and the hive mind intelligence that we intend to use with connected IOT devices, we are able to leverage a variety of different types of artificial intelligence to provide not only insights into the data it collects but also predict and potentially provide improvements into an individual’s house. One clear example would be if the system detects that the user is stepping rather forcefully on the stairs provide information to take lighter steps as if they take a misstep it might result in a dangerous fall and then provide the probability of that fall being a critical fall.

Nevertheless, we need to realise and be realistic that the use of artificial intelligence at this point in the project and the current restraints put in place due to the covid-19 make it not only significantly harder to train and test but also implement into the system particularly due to the hardware restraints and the amount of data currently supplied.

However, we should keep in mind that the use of AI could and has the potential to significantly increase the systems performance and provide deeper insights into the data collected and stored such as through the use of machine learning techniques.

2.6.1. Machine Learning

One potential use of AI that we should leverage is the use machine learning. Currently a variety of machine learning techniques have been used and are prevalent in a number of health-oriented devices to detect and predict when a critical event might happen in a patient. However, in regard to predicating the likelihood of a fall, recent research has shown that they can accurately predict a fall through real time computer vision using a CNN (Coevolutionary Neural Networks) or through the use of accelerometer and gyroscope data using RNN (Recurrent Neural Networks). Due to the restrictions placed upon the hardware team and the access to the graphene-based sensor layer, the hardware team will be attempting to implement an RNN to predict a fall with gyroscope and accelerometer data from IOT devices such as a phone and smart watch.

Within the hardware teams fall detection system, it will categorise the user's actions into the following areas:

- Walking
- Falling
- Lying on the ground
- Going up stairs
- Going downstairs
- Standing to sitting
- Sitting to standing
- Jumping
- Jogging

3. Targeted Demographic

Due to the wide range of possible users that this product can possibly reach and the current supply and demand for IOT devices to report critical events in a home style setting, it is reasonable for us to assume that the target customers can be divided into two main groups of users who will take up roughly 90% of purchases for the graphene based sensor layer.

3.1. Primary Customer

The primary group of target customers will be aged individuals who currently live at home and want an extra level of assurance or a safety net that if a major or critical event happens, medical personnel, carers or loved ones will be notified without the need for them to contact them directly. For that reason, we can expect that the primary customers will come from the following sectors:

- Aged individuals living at home (alone or with others)
- Carers of aged individuals living at home
- Family of aged individuals living at home

It's expected that the primary customers will use this product to monitor aged people at home for their health and safety and for peace of mind for family members to ensure that their loved ones are safe at all times. Furthermore, we can also expect that health professionals will use this product to monitor the health of the patient if additional features besides fall detection are added such as heart rate monitoring tools, blood pressure monitoring tools and medication alert tools to ultimately allow them to provide a higher level of care towards their patients.

3.2. Secondary Customer

As stated above, it is predicated that two groups of users will use this product, the second group being nursing homes and carers/parents of individuals with disabilities. The reasoning behind this expectation is that the elderly are not the only at risk individuals of hurting themselves during a fall in the community, rather a wide variety of individuals of all ages with specific disabilities such as individuals with brittle bone disease are at a high risk of seriously injuring themselves from a fall. Therefore, secondary customers are predicted to come from:

- Individuals with certain disabilities/conditions such as brittle bone disease
- Carers and families of people with certain disabilities such as osteopenia
- Nursing/Aged care homes who look after aged individuals or those with disabilities/conditions such heart disease or other conditions that increases your likelihood to fall unexpectedly

3.3. Primary Personas

Persona 1 – Henrietta Boomer

Age: 77

Education: Year 10

Occupation: Retired (Hairdresser)

Location: Sydney, NSW

Spoken language: English

Family: Husband (in Nursing Home), 1 Son, 2 grandchildren

Primary Goals: To be able to peacefully enjoy her senior years doing things she loves and spending quality time with family and ensure that they will be alerted when she has any health concerns at home as she lives alone currently and the idea of her falling over significantly worries her.

Secondary Goals: To have peace of mind that there will be assistance from medical professionals if she has a critical fall or another critical event happens and that her husband will be notified as well.

Primary Challenges: Henrietta is getting older and her memory is fading making it harder to remember to charge any needed devices or learn new technologies quickly. As a result of her failing memory she has found that she is often falling over objects left on the ground when her grandchildren come over to play and her phone is constantly never charged.

Secondary Challenges: Installing new technology into her home as it is currently outdated and not set up to have new technology interconnected throughout the home as she currently only uses a dongle on her laptop to access the internet and her mobile phone data when needed.

Hobbies: Bingo, watching SBS and ABC on the TV and researching her family history tree

Computer Literacy: Very low to low, she often has struggles opening emails

Commonly Used Systems: Computer (Windows 10), iPhone 8

Bio:
Henrietta Boomer is retired hairdresser that has spent the last few years living alone at home since her husband went into a nursing home because he was suffering from dementia and she visits him regularly with her family on the weekends.

Henrietta suffers from osteo arthritis and is prone to losing her balance and becoming quite unsteady on her feet and has recently suffered from a stroke and has taken a rather bad fall in recent weeks which has left her in a wheelchair. She is currently looking at options to better improve her own personal safety in her own home without having the need to hire a part/full time caretaker or moving into an aged care home that she can use with her family. However, she is unable to find any cost-effective products on the market that meet her budget of $3000.

Image source: https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.123rf.com%2Fstock-photo%2Fmiddle_age_woman.html&psig=AOvVaw1iWe40x5Bin6PVKsgbk2kx&ust=1588785090674000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCNikruqbnekCFQAAAAAdAAAAABAD

Persona 2 – Jennie Corrie
Age: 35

Education: Bachelor of Nursing

Occupation: Aged Care carer/personal nurse

Location: Melbourne, Vic

Spoken Language: English

Family: Husband, Grandpa (living alone), 1 daughter

Primary Goals: Giving the best care she can to everyone she cares for, whether it be her own family or her wide range of clients she looks after on a weekly basis.
Secondary Goals: Ensuring that she provides the best possible service to her clients and to try to collect data on their conditions for her own research to implement into disaster recovery plans when they have critical injuries when she is not around.

Primary Challenges: Unable to manage multiple patients at once in a single day due to the distance she has to travel in between clients homes and would ideally like to check up on her clients daily.

Secondary Challenges: Collecting data on all of her patients due to a variety of them unable to manually enter data themselves as they often forget to or don't have the resources currently available to them to do so.

Hobbies: scrolling through social media, watching streamed TV shows, cooking and researching ways she can better improve her service to her clients

Computer literacy: Moderate

Commonly Used Systems: Smartphone, Computer (Windows 10), Smart home device (Amazon Alexa/Google Home)

Bio:
Jennie is a mother as well as an on-call nurse who mainly deals with elderly patients that are unable to make it to the doctors and need to have medical appointments from their own home. Many of her patients have many medical issues as well as live predominately by themselves.

Jennie has a smart home device at home and believes the use of a smart home device for aged people living alone would be very beneficial for their own safety and care when home alone. She has recently been researching and finding possible technologies that could be implemented into her client's homes as they all receive government funding and would be eligible to have such a system installed into their homes, however, she is unable to currently find any that meets the need to detect critical events without the need for extensive maintenance or a strenuous installation period.

Image Source: https://tm-women.org/nurses/

3.4. Secondary Personas

Secondary Persona 1 - Bob Bobson

Age: 30

Education: Year 12 VCE

Occupation: Retail Worker

Location: Burwood, Victoria

Spoken Language: English

Family: Mother, Father, Sister

Primary Goals: Looking after his mother who suffers from brittle bone disease and ensuring that she is safe when he is unable to be with her and monitor her condition

Secondary Goals: Enjoying life and ensuring that his family is always safe including his mother and sisters as well as trying to improve his mother's confidence when she is home alone.

Primary Challenges: His mother is very computer illiterate and has very little proficiency in using smart devices or any type of technology outside of making phone calls and texting

Secondary Challenges: Convincing his mother and family of new solutions/technology that could improve their quality of life as currently they are very sceptical of new technology and the stigma around AI and data collection due to what they have seen on the news.

Hobbies: Video games, Parties, Anime, working out.

Computer Literacy: High

Commonly Used Systems: Computer (Linux), smartphone, smart watch, Game console, smart home device (Google home)

Bio:
Bob is a Retail worker who is also the primary carer looking after his mother who has brittle bone disease and is struggling trying to keep a social life and make enough money to live to support his family and provide them with a meaningful and supportive life style.

Bob believes that technology is the way forward in not only increasing his mother's mood and quality of life but also to ensure that it provides him more hours to be able to work. Bob has recently been searching and looking for a cost-effective method on how to do this with technology, however, has only found industrial based products that are significantly outside his price range and don't help him directly monitor his mother's condition or current state inside the house.

Image Source: https://www.pinterest.com.au/pin/18788523429460818/

4. Security and Privacy Laws Around Data Collection

Due to the nature of this project and collecting large amounts/sources of data from the user we need to ensure that we are only collecting and storing data that we are:

1. Allowed to by current Australian law standards
2. Allowed to by the current users

Currently the application will be collecting the following basic information from each user to be stored on the database not only for analytical purposes but also for the user to update frequently to provide their carer information on their current state remotely:

1. Age
2. Height
3. Weight
4. Sex
5. Health conditions, new and pre-existing
6. Carer

As a result of the extensive laws around data collection in Australia, it is essential that all data collection actions in this project are lawful. This specific section will be focusing on:

1. Introducing the current security and privacy laws in Australia
2. Analyzing the affects to this project
3. Providing the possible output on the project that these laws have
4. The type of data we are allowed to collect and what we are not allowed to

4.1. Current law

In 1988, the Australian government enacted the Privacy Act [8]. The Privacy Act provides a description on privacy principles in several actions, and applies the clauses to the government, the private sectors and the public sectors. Therefore, the Privacy Act will assist to limit the organizations data collecting actions, using and revealing of people's personal information. In this project, the data collection action mostly will follow the Privacy Act to protect the privacy of individuals and give them peace of mind around how their data is being handled and used.

In 2014, the Australia government passed the Federal Privacy Act [9]. This act provides people more rights on the protection of private information and security information privacy. This act sets strict clauses and penalties to the illegal data collection actions. According to the Federal Privacy Act, the company or organization which violates the clause will receive a fine up to 1.7 million dollars; for individual business or entity, it will up to 0.34 million dollars. This act will push the project to abide by the strict clauses during data collection, to protect the user's data and information as well as assist the user in understanding their own flow of the personal information within the application.

4.2. Current law effects of data collection

Current Australian law such as the Privacy Act will affect the data collection of this project severely. In order to collect data from an aged population, the project needs to follow related law, which will bring some affects. It reflects on several aspects:

I. Providing the identity of collecting data that is reasonably necessary for an agency's functions or activities.

Firstly, according to the Australian Privacy Principles (APPs) 3.16 in the Privacy Act [10], 'An agency may collect personal information that is directly related to one or more of the agency's functions or activities. To be directly related to, a clear and direct connection must exist between the personal information being collected and an agency function or activity'. To collect the data and information from users, the project team should identify our agencies functions, which 'involves examining the legal instruments that confer or describe the agency's functions' [10]. Within our project, the function and reasoning behind collecting this data is to provide health insights into the user's wellbeing and it needs to be noted that the user is able to restrict what data we can hold or use for their own health analytics purposes.

II. Collecting sensitive information

Furthermore, the project needs to collect health information from its user who are the aged population, which may involve the collection of sensitive information. According to APPs 3.43, 'An organization may collect health information about an individual if the health information is necessary to provide a health service to the individual, and either'. It requires our project team to understand the collection requirement under an Australian law (other than the Privacy Act) or rules established by competent health or medical bodies if the project need to collect sensitive information from users as an essential or optional service. Within this respect, the user is allowed to decide if they see the application as an essential or optional service as it will vary user to user depending on their health conditions.

III. Set standard for data collection

Furthermore, the current Australian laws set the standard for the data collection within this project. For example, the Privacy outlines when and how an APP entity can collect data and personal information, collect specific information where it is reasonably necessary for the organization's functions or activities and lawful and fair data collection ways. That will assist in how we understand how the data collection should be processed in this project, and what data we can collect and what data is off limits under the current Australia laws. This is important as it outlines that we don't collect or store any identifiable information that can be related to a health records as all health records for analytic purposes/research and evaluation have to only contain unidentifiable information about the user/patient under the My Health Records Act 2012 [32]

4.3. The possible effect on the project

According to the current Australian law, the project can collect data the data needed in order to make our unique functionality's work as it within the scope of law. It is possible that we can collect data and information from the smart home system in the future, which will be crucial for providing individual specialised home care to every user which will be generated by the application.

However, we need to be realistic for the output on the project. Due to the project being aimed at an aged population and the usage of IoT products in aged population home is low as a result a large number of the functionalities within the application won't be used. Whereas when we look into more personalised use for individuals with disabilities, we will see a broader spectrum of IOT devices where these functionality's will be used.

4.4. What data we can collect and what is the off limits?

The data we can collect in this project is the users' basic information, health information and daily activity information which collected by lawful and fair means in conjunction with the users permission will be lawful as long as if the user has any data collected pertaining to health records the users identity on the database will be anonymous when used for analytic purposes/research and evaluation as per the My Health Records Act 2012 [32].

As in line with the law, we will provide the data usage detail and data prevention policy to users before getting consents from individual users and collecting as well as storing data. The lawful and fair means of data collection is one that does not involve intimidation or deception and is not unreasonably intrusive upon the user. This is important to note as we need to ensure that we market the functionalities within the application as optional towards the user that won't negatively impact their care or health as a result of not including them within the application.

The data that we won't be able to obtain legally or that are outside the scope of the Australian law is the following:

I. Breach of legislation, e.g.:
- Data collection through phishing
- Data collection via hacking activities
- Data collection through telephone interception

II. Unfair means of collection, e.g.:
- Data collection from lost or unattended sources
- Data collection from disrespectful cultural differences
- Data collection by deception

III. Data not related to the project, e.g.:
- Data collection about ID information
- Data collection about financial information
- Data collection about social relationship information

IV. Data Relating to health records, e.g.:
- Data collection of current medication
- Data collection of pathology test result
- Data collection of current body scans such as X-rays

5. Market Research

Currently there is a stereotype that older people can't deal with technology however this simply is not true. According to NBN's 'GranTechies' report, it is found that 93% of Australian Senior citizens access the internet in some way [11]. Furthermore, according to a Pew research centre, 74% of people aged 50 and 64 and 42% of people over 65 own smartphones [12].

Continuing on, a recent UN estimation revealed that the number of people aged 60+ will reach more than 2 billion people by 2050. In 2018, the global product and service market for senior people exceeded $436 billion and according to forecasts, the global financial solvency of people aged 60 will reach $15 trillion by the end of 2020 [13].

5.1. Current Marketplace – Sensing Layers/Technology

There are three distinct development trends for sensor applications in the current marketplace today. They can be named as transducer sensors, smart sensors and device based distributed sensors [14]. The advanced architecture associated with the distributed approach brings elegant and superior features to sensor developments.

A successful deployment of a distributed sensor can be closely related to the use of distributed intelligence, which is regarded as one of the key technologies for a successful global technological development. The significant industrial and social development has triggered many viable new sensor systems for low cost mass production. With the population of wealthier people over 60 increasing, the existing boundaries of the housing market are being pushed towards a care intensive living environment where aged individuals can live independently rather than going into aged care homes.

Furthermore, various forms of body pressure, positioning, and placement of identification can be considered as help to many aspects towards the health measurements of a patient. Some of the distributed sensor layers which are currently in the marketplace are capable of doing this as shown below.

IR Technology – Infra-red (IR) technology is commonly used to get an estimation of absolute position However one downside of IR is it can't be used when there are other interfering light sources as it results in miss shaped data.

Ultrasonic sensors – Most commonly ultrasonic sensors are fixed on the ceiling of a room so that it can track a vulnerable person whose state of health is at risk and who is not able to call for help when they need it or if they fall. Active Bat designed by AT&T is an ultrasonic sensor technology which provides a 3D position and orientation information upon a targeted area (Patient) [14]. Similar technology is also implemented in cars to prevent parents leaving children in the backseat of the car.

Haptic technology – Haptic technology primarily takes advantage of a user's sense of touch by applying forces, vibrations and motions to the user. Current haptic technology focused around the use in aged homes is relatively in its early stages however has shown evidence of helping patients with dementia to remember/recall knowledge based upon the specific vibrations and motions applied [15]

Optical fibre sensing – fibre optic sensing solutions have enabled reliable, uninterrupted measurement of temperature, strain, vibration, pressure and humidity data over long ranges/distances in a variety of applications. The optical fibre is a sensing element without any additional transducers in the optical path. The interrogator operates according to a radar style process and ends in a series of pulses into the fibre and records the return of the naturally occurring scattered signal against time [16]. This allows the distributed sensor to measure at all points along the fibre.

Distributed acoustic sensing – even though distributed acoustic sensing is not widely used in an aged care environment, these sensors can detect vibrations. This technology is mostly used to detect vibrations on the ground nearby the top of a buried optical fibre deployed along a pipeline so that it can help to monitor activities near it [17].

Ambient sensors – ambient pressure sensors and floor sensors have been used to detect the falls and presence of patients on chairs or in bed.

Piezoelectric polymer floor sensor – a fall of a patient is detected by a single piezoelectric sensor. It generates a signal and it will go through a normalization calculation process and this will produce a signal which can be compared to a reference signal [18].

5.2. Current Marketplace – Mobile Applications

Currently we can highlight five main categories of applications which are potentially most in demand among aged individuals in the current marketplace when compared to the needs of an aged population:

1. Safety
2. Health
3. Reminder Systems
4. Leisure
5. Communication

Currently developers have designed a variety of applications that can increase the quality of life for aged individuals who live in aged care faculties or their own personal home. However, these are primarily focused around gaming, social media and photography. Nevertheless, there are a few specific apps designed directly at improving the quality of life for aged individuals in our current domain. These apps are the following:

Care app – this app aims to support residents to live well by better connecting aged care providers with residents' family and friends to share information on a residents' health and wellbeing.

My pain diary – this app helps to track and monitor chronic pains and it will create detailed reports on symptoms and triggers which then can be sent off to health care professionals to review.

Fade - this app uses sensors in the smartphone to detect falls such as the accelerometer and gyroscope

A better visit – this app is designed to interact with the people who have dementia. The main purpose is to spend time usefully when a person visits a patient and to make the visit as meaningful as possible

MyFitnessPal – this app has the features and tools that will allow to check the nutritional information and food items to help aid in weight management and track exercise.

Instant Heart Rate – this app provides accurate heart rate readings via the smartphone if a heart rate monitor is supplied to be used.

5.3. Current Marketplace - Smart floor systems

Some Smart floor systems which are currently on the marketplace are capable of doing a variety of actions, however the majority are rudimentary in terms of extendable modular functions. Nevertheless, the most predominant smart floors on the marketplace currently are:

SensFloor by SYNO Global – this system is designed to track movement, falls and spills within separate zones inside small and large areas. The special factor of this system is that the people who are monitoring can view in real-time the location of individuals without using any invasive devices such as cameras and motion sensors due to the technology used [24]. When comparing this technology towards the graphene-based sensor layer, they both have very similar functions they are capable of.

Smart Floor – this system consists of a super thin sensor foil and is used to place under the entire floor of a nursing home, gym, sports field etc. The system can produce visual and quantitative movement information. Parameters such as position, speed, acceleration, orientation can be monitored by this system. This system is mostly used in indoor and outdoor sport centres to track players movements.[25] One significant downside of this system, is that it requires end users to wear a wearable ankle sensor to track unique users on the floor.

5.4. Competitive Advantages – Graphene-based sensor layer

Graphene based sensors have been popular in the field of sensor research due to its advantages in mechanical, thermal and electrical properties. Some of the competitive advantages of using a graphene-based sensor over those identified above in section 1 are [19],

- Ultra-high carrier mobility
- Excellent electrical conductivity
- Superior thermal conductivity
- Large theoretical surface area
- High optical transmittance
- Mechanical flexibility
- Compared to other sensors, graphene-based sensor layers have superior sensitivity.

5.5. Potential Downfalls – Graphene-based sensor layer

- There still is a lack of systematic research on human health or environmental effects of using graphene-based sensors.
- Further development needs to be made into graphene-based sensor-layers until a final end product is possible and viable to be rolled out into homes
- Due to the type of sensor used, without the inclusion of additional sensor data or metrics the possibilities of the system might be limited to only detecting a fall as its critical event
- The installation of the product into an aged users' individual home might be a significant downside and affect the marketability if not installed in such a way that it is hidden and not noticeable
- If the graphene-based sensor layer has a lengthy installation and set-up period, it might turn away potential customers

6. Low Fidelity Prototype

The Low Fidelity Prototype consists of wireframes which provide a visual representation of the logical flow of screens that were designed by the UI/UX team. Prior to the development of the User Interface prototype, the required elements were analysed and mapped into segments using Lucidchart to provide a conceptual view. This map of elements was then utilised in the creation of the User Interface on Adobe XD. A sample snippet of the Lucidchart conceptual view can be seen below in figure 1.

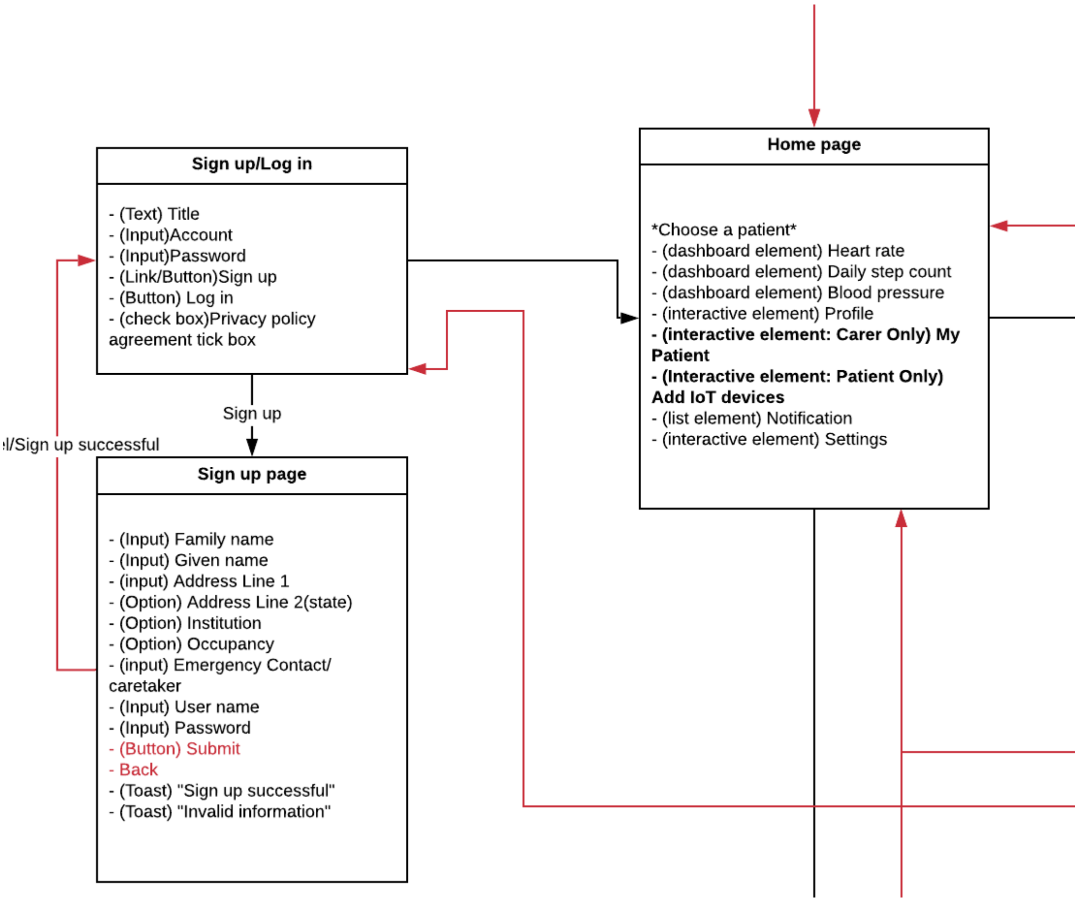

Figure 1: Lucid Chart Conceptual view, Sign up/Login page

The full layout can be viewed within lucidchart through the following link:
https://www.lucidchart.com/invitations/accept/7644ecec-91cd-40f8-8c6b-8bce25c03086

6.1. Wireframes

With the help of the above-mentioned chart, the User Interface was developed in Adobe XD. Ease of use was a prime goal during the design phase as patients will be using the app along with the caretaker. As a result, only essential features were included which will reduce the time to create a functioning high fidelity prototype. The User Interfaces designed in Adobe XD was then mapped into a wireframe outlining the screen flow along with possible processes that will take place in the backend when a certain command is executed with a touch of a button, this can be seen below in figure 2.

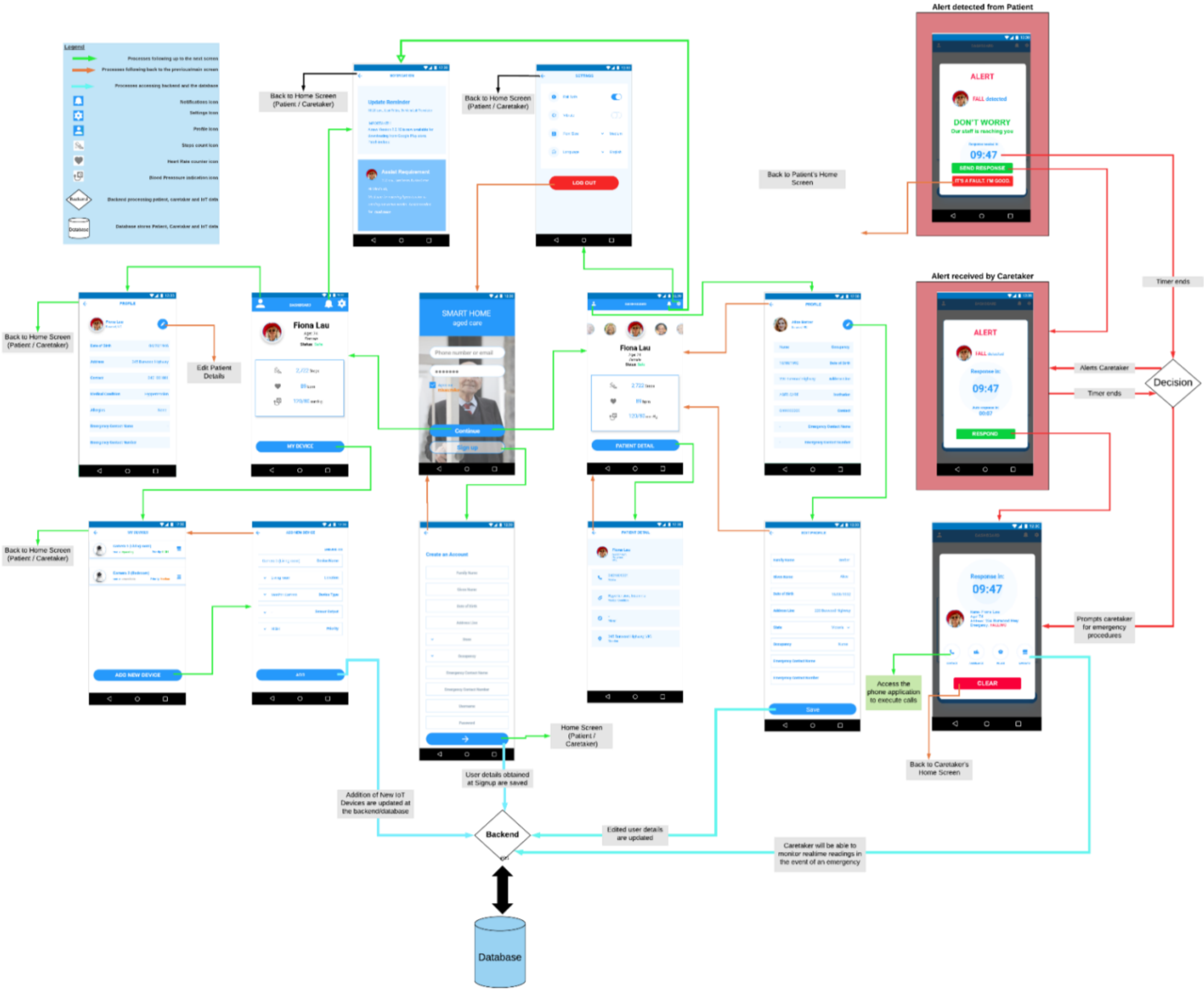

Figure 2: Wireframe screen flow chart

The wireframe screen flow chart can be seen in further depth from the following link: https://www.lucidchart.com/invitations/accept/0c597eaf-ebb2-4a19-add8-615854201ae3

6.2. Screen flow explained

The Adobe XD file in which these screens were developed in, can be found through the following link: https://deakin365.sharepoint.com/sites/DeakinResearchTechTranslators/Shared%20Documents/MInD%20Lab%20Translators/Prototyping%20-%20UI-UX/UI-UX%20version5.xd

6.2.1. Login Page

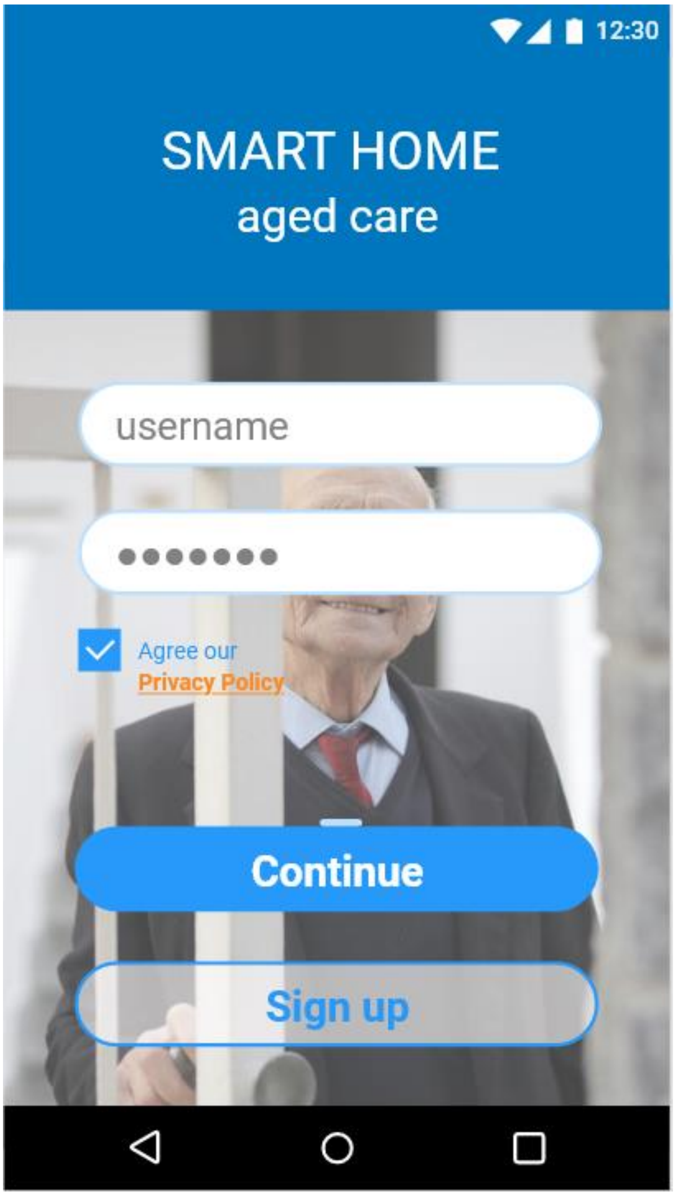

Figure 3: Login Page Screen

The first page of the app will include the sign in feature. Users will input their username and the password and click continue to sign in. New users who are not registered will have to sign up with the help of the sign-up feature whereas pre-existing users will be able to automatically sign if enabled.

6.2.2. Sign up Screen

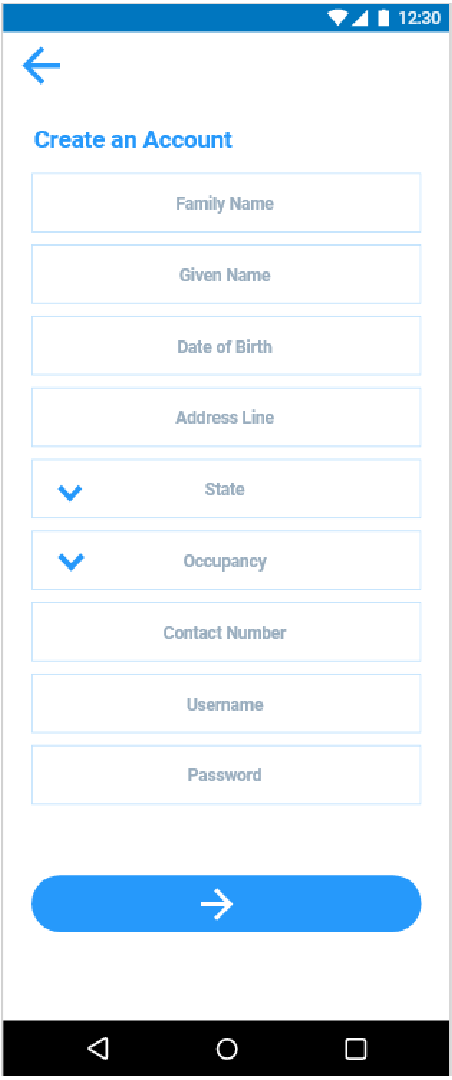

Figure 4: Sign up Screen

The sign up screen will be presented when the user presses the "Sign up" button on the Login Screen. New users who do not have an account are able to sign up here through the application

Here the "Occupancy" dropdown menu will help to determine whether the user is a caretaker or a patient and as a result will be taken to different sign up pages based upon their occupancy once they continue through the sign up procedure.

6.2.3. Home Page

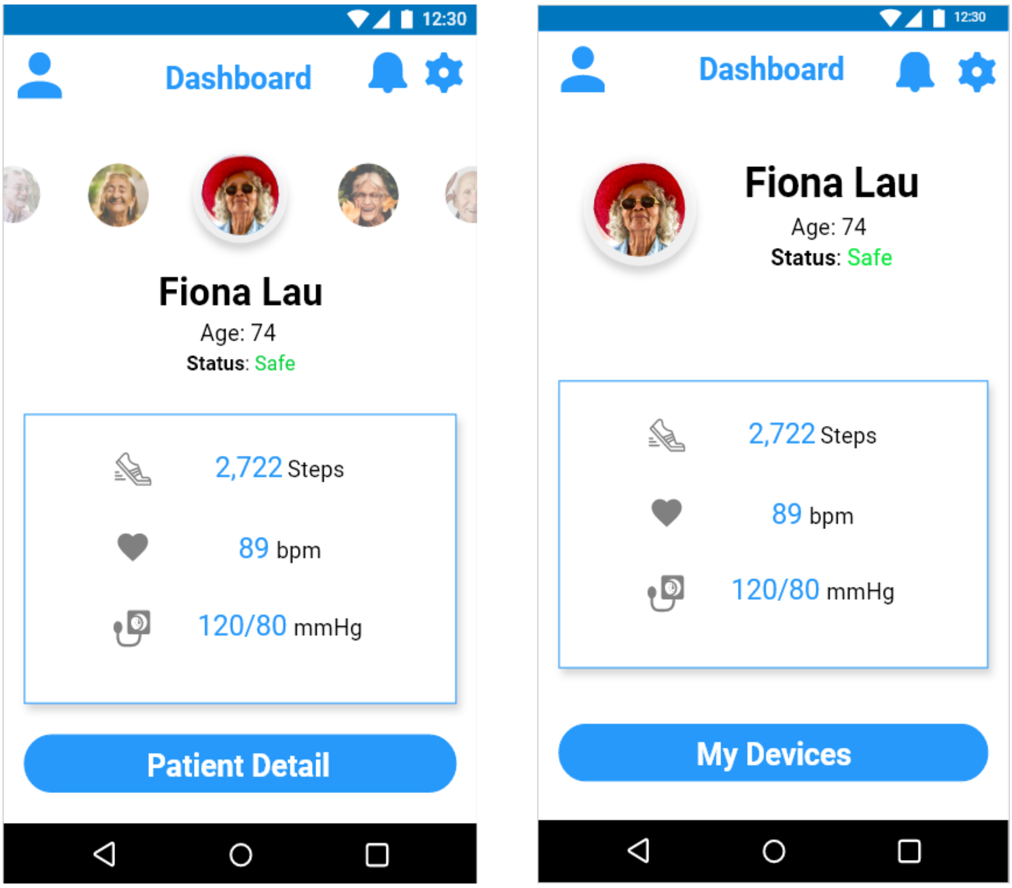

Figure 5: Home Page for carer and patient

Two homepages were created for the patient and the caretaker. The backend will determine the occupancy selected during the signup and will display the appropriate screen for the user. Both Home screens consists of a dashboard which shows readings acquired from patient's sensors in real-time (i.e. heart rate, blood pressure, step count etc.). They also provide access to notifications, settings and profile pages.

Differentiation in Access, patients are able to access their current IoT device settings that are connected to the application as well as add more IOT devices through this view. Whereas the carer's home screen has the option to swipe through multiple patients assigned to them, as it is expected a carer will look after more than just one patient. From this view, they are also able to access the patients details.

6.2.4. Patient Details

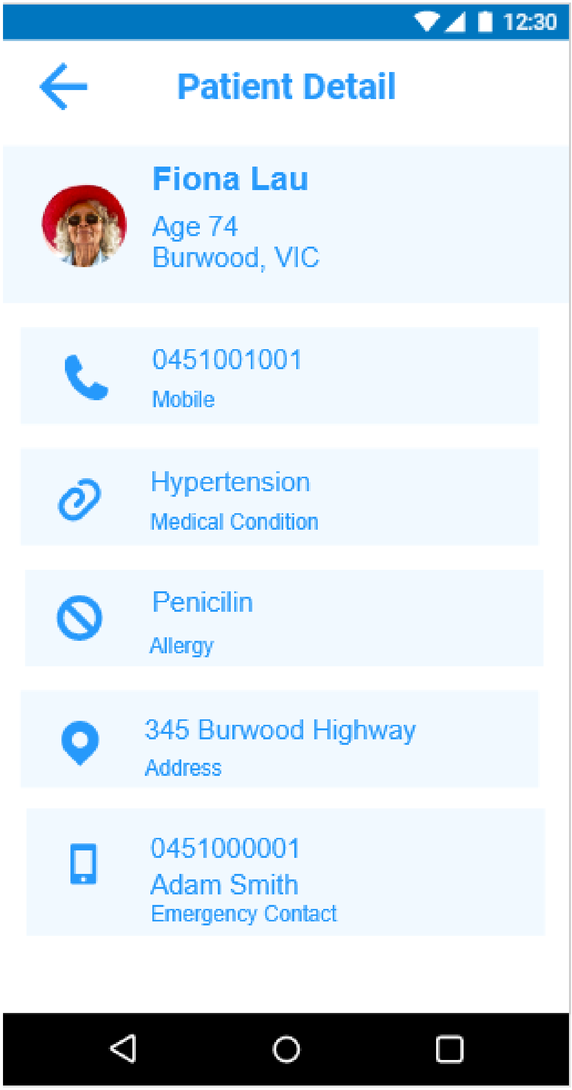

Figure 6: Patient detail screen

The carer is able to instantly access the Patient details screen from the homepage as shown above in figure 5. This screen provides the carer an overview of the patient such as age, address, contact details, existing medical conditions and allergies. Furthermore, in future iterations they will be able to access and view the patients current IOT devices connected such as camera's if the patient enables this option.

6.2.5. Notifications

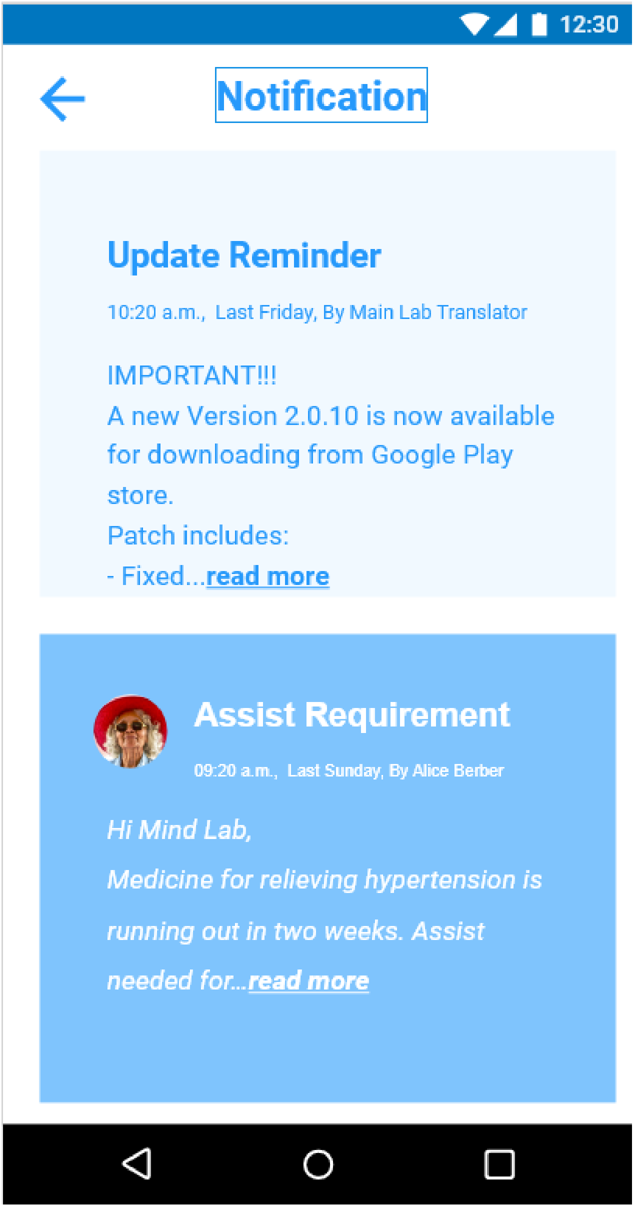

Figure 7: Notification screen

Both the carer and the patient are able to access the notifications page. This specific screen will show information such as pending updates, as well as pending alerts for either the patient or carer. A sample scenario is that the patient will be sent a notification when a connected IOT device goes down as shown in section 6.2.9. Whereas the carer will see any alerts coming from the patient outside of the alert screen.

6.2.6. Settings

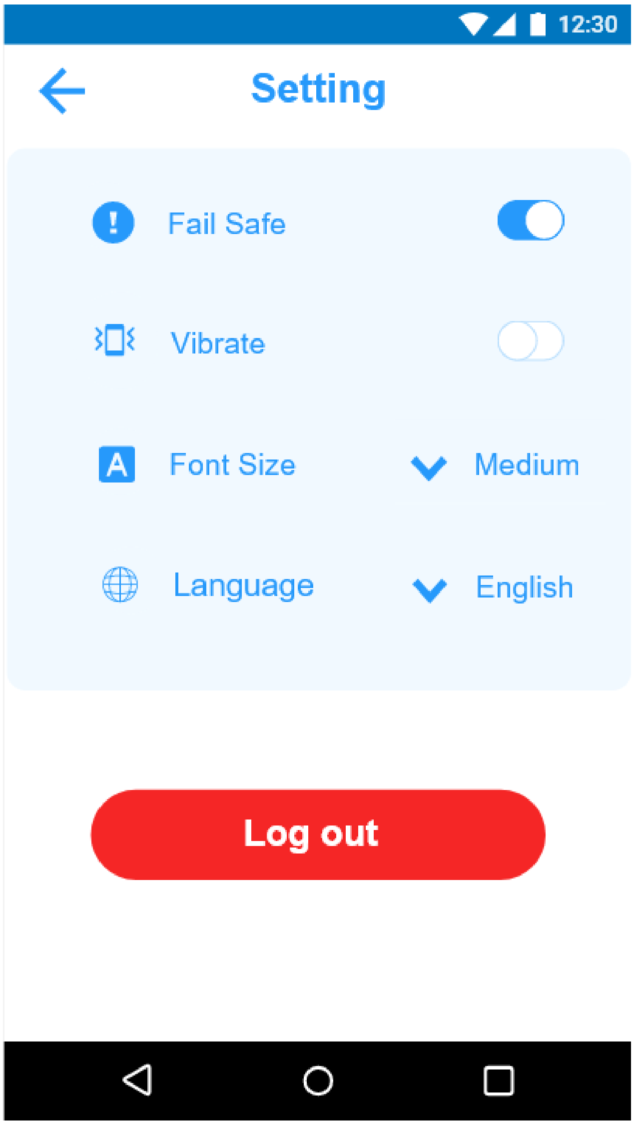

Figure 8: Settings screen

The settings screen will be accessible by both the patient and the caretaker. This will allow the user to customise certain features such as the vibrate setting (during an alert), adjusting the font size and selecting the language shown. Whereas patients will have the option to activate the failsafe mechanism which means that if an emergency is detected, a verification will be prompted for the patient along with a countdown timer for the response. This function is described further below in section 6.3.

6.2.7. Profile

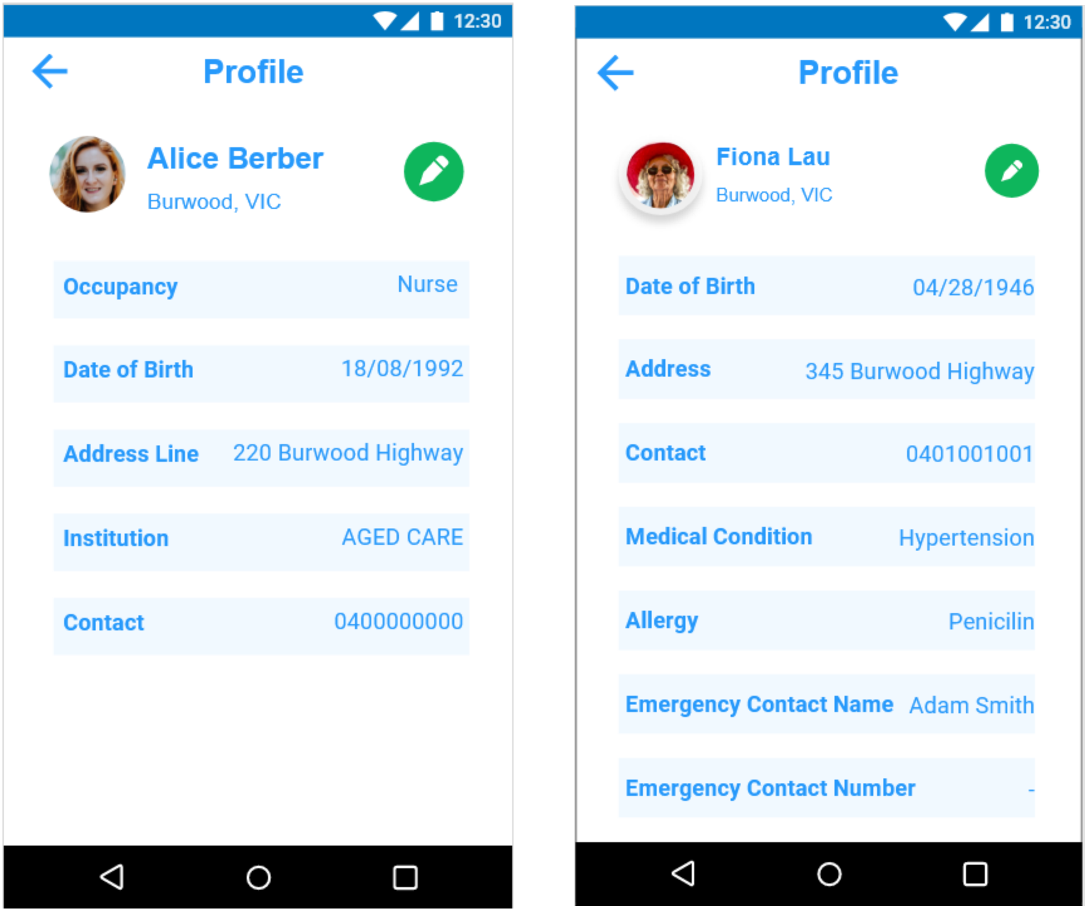

Figure 9: Profile screen, carer and patient

The profile screen is accessible by both the patient and the caretaker all through the press of the profile icon located on the home screen page. This will allow the caretaker to edit their details such as DOB, Address, Institution, contact etc whereas the patient is able to make changes to his/her details such as next of kin, medical conditions and allergies etc.

6.2.8. Edit Profile

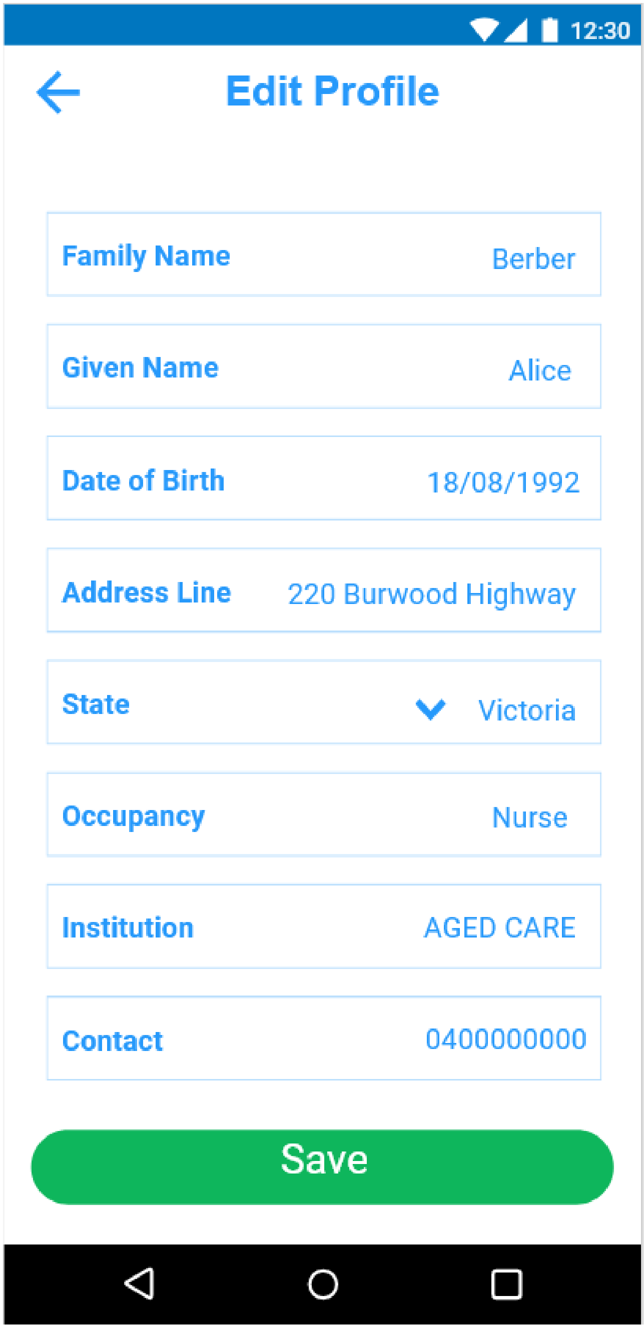

Figure 10: Edit profile screen

When the user clicks on the edit profile (Pencil icon) from the profile page, they will be able to make changes to their details. This example illustrates the edit profile page for a caretaker, this page will predominantly be used for updating details.

6.2.9. IoT Devices

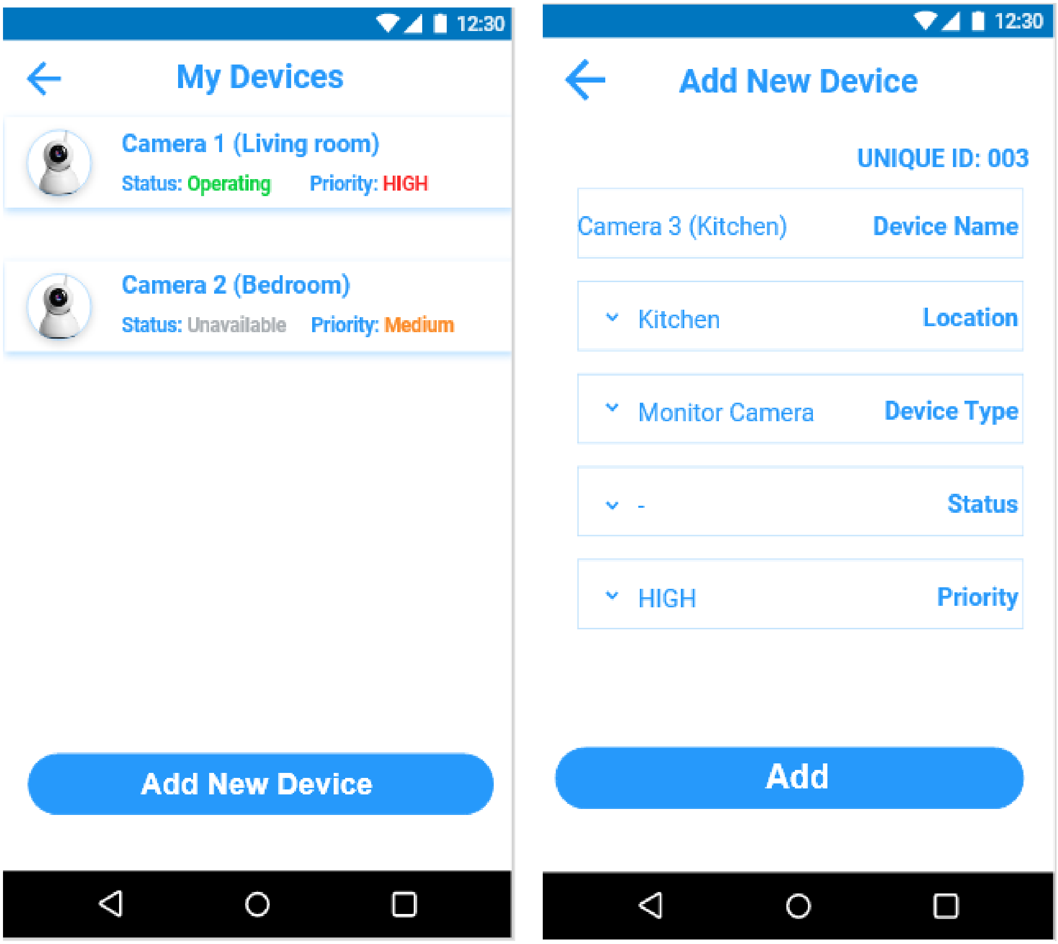

Figure 11: IOT Devices, viewing and adding a new IOT device

Within the IOT devices screens, the patient is able to directly access their IoT device settings from the Homepage by pressing on "My Devices" button. Within the "My Devices" page, it shows the patient all devices currently connected to the application as well as if it is operating and sending data to the database as well as how important that device is through the priority setting.

Furthermore, patients will be able to add more devices into the application through the "Add New Device" button. Within the "Add New Device" screen, it will allow the user to provide the device a specific name, its location in the house, type of device as well to set its current status and priority.

6.3. How the alerts work with the fail-safe

When an emergency is detected such as a critical fall, the in-built alert system will be triggered within the application. This will be prompted to the user, an example of this is that the graphene-based sensor layer detects a high unusual impact that it classifies as a fall. If the fail-safe system is active, the patient will be first prompted to verify if the emergency is legit or a false alarm and this is to ensure that the carer doesn't receive multiple false positives from the system while it is still in development and the algorithms are being refined. This can be seen below in figure 12:

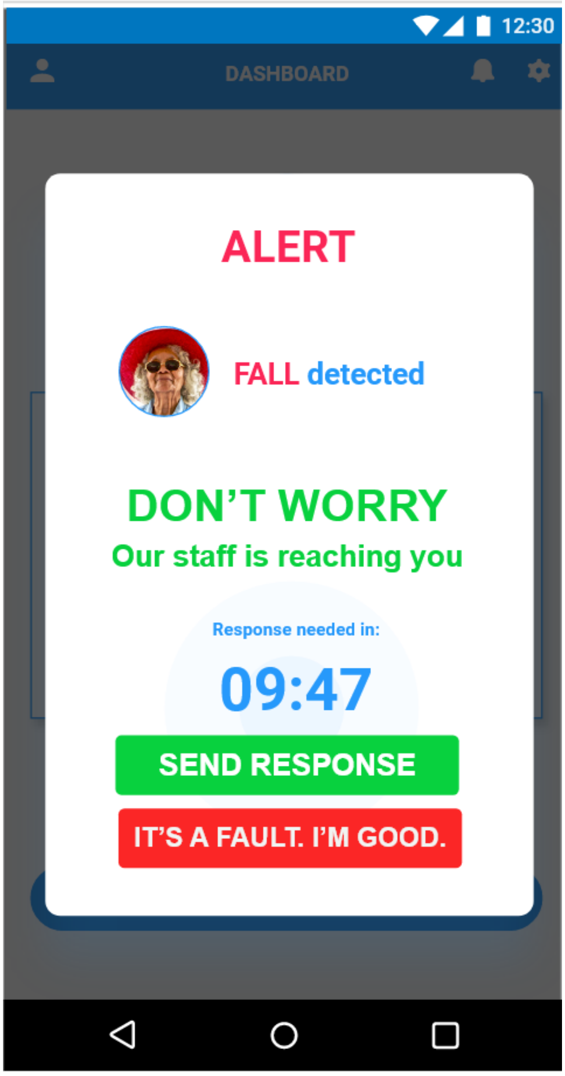

Figure 12: User's alert fail safe

The prompt consists of a countdown timer for the patient to react with a response, this can also be seen by the caretaker simultaneously. Failing to do so will trigger the backend to notify their respective caretaker of the critical event. However, if the situation is a false positive the user can cancel the alert.

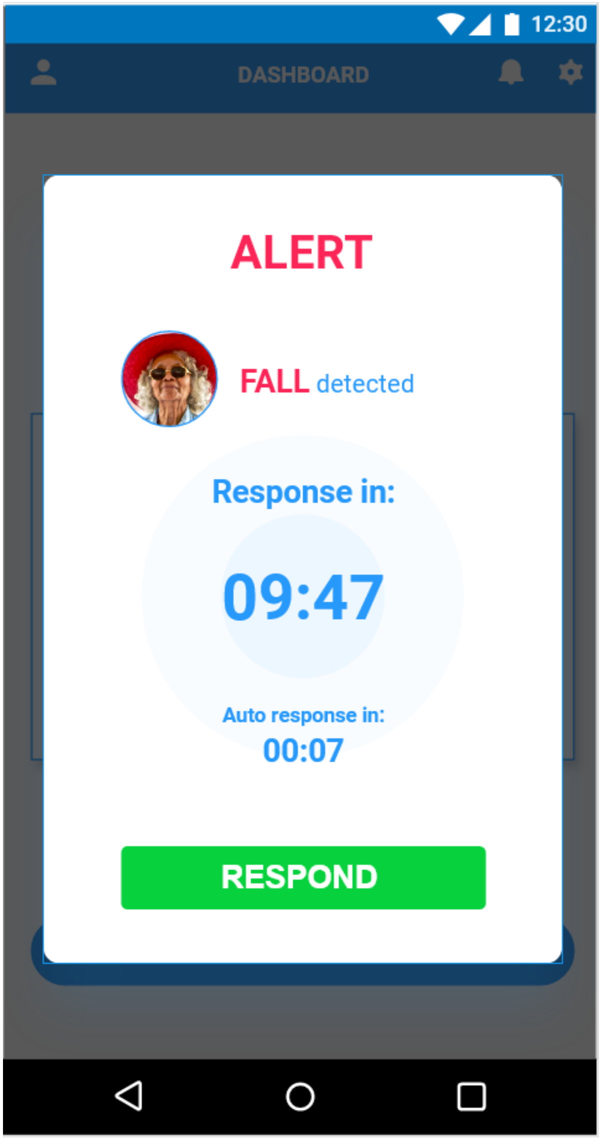

Figure 13: Carers alert screen when a critical event has been detected

The caretaker will also be prompted with an alert due to a possible emergency detected. The alert will show patient's response to countdown timer in real-time. Furthermore, the caretaker can respond without having to wait for patient's verification if they feel like it wasn't a false positive.

When the caretaker responds, they are able to see the brief details of the patient (such as age, address and the possible type of emergency). This screen also shows a collection of emergency response options (such as calling an ambulance, police or even contacting the patient directly) which will trigger the backend to make the appropriate calls by accessing the built-in phone application on the smartphone.

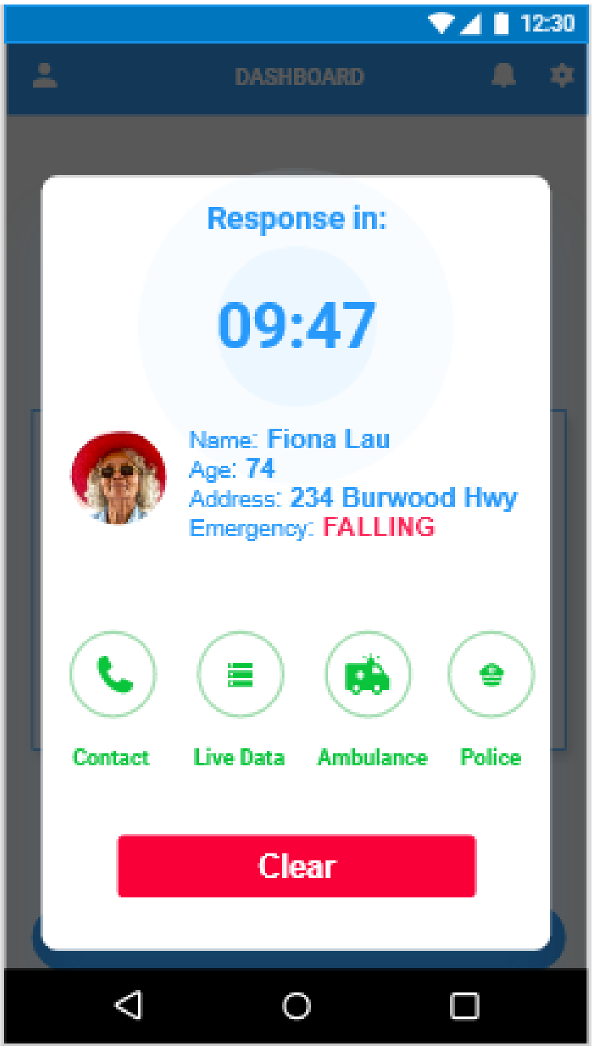

Figure 14: Carers possible responses screen

The caretaker will also have the option to monitor the sensor data in real-time by pressing the "Live Data" button. This will allow the caretaker to have a closer view of the patient such as any connected cameras as well as live data from all IOT devices connected. Once the carer believes they have taken the appropriate actions, they are able to clear the alert and return to the page they were last on.

7. Proposed Features of the Product

Due to the nature of the product/application requiring the use of specific IOT devices connected in-order to have the ability for all functions to be enable, we have severely more non-functional features than functional features in our product. Further detail is provided below around specific functions whereas IOT devices intended to be used are seen within section 2.

7.1. Features of the product

When considering and detailing all features we intend to implement into the end product to be used with the graphene-based sensor layer, we need to split them up based upon the requirements needed in-order to work within the system. As a result, we have the following two categories to categorise our functions:

- Functions that rely off of the graphene-based sensor layer
- Functions that rely off of connected IOT devices

7.1.1. Functions That Rely off of The Graphene-Based Sensor Layer

When considering what functions are functional and non-functional requirements in-order for the system to work as intended for the user, all functions that are functional requirements in this product have to only rely purely off of the graphene-based sensor layer. The reasoning behind this, is we cannot guarantee that users will always have IOT devices in their home that are going to be connected to the system for the system to utilise. As a result, the functions that we propose to make that rely purely off of the graphene-based sensor layer are the following:

- The ability to detect when critical falls occur and automatically sending a warning message to the user/patient’s carer/family member
- Visualizing the graphene-based sensor layer within the application and providing real time input into visualization from the user/patient in the form of a real time heatmap
- The ability to assign specific quadrants of the graphene-based sensor layer unique names such as kitchen and living to provide further clarity to the carer/family member when a critical fall occurs
- Providing the carer’s and family members the ability to manage and view multiple users/patients through a single view
- Providing the carer/family members the level of severity of the critical fall that occurred and the option to call triple zero and provide them with the data in real time
- Storing all critical falls and analysing what caused them and providing potential ways to prevent them in the future to both the user/patient and carer/family member
- The ability to show “hot zones” which reveal to both the user/patient and carer/family member where the most amount of force has been applied over a period of time. This will be shown through the use of a heat map.
- Allowing the carer/family member access to the microphone and speaker on the users/patient’s phone to listen as well as potentially talk to them if their current condition allows it after a critical fall has occurred

7.1.2. Functions That Rely off of Connected IOT Devices

However, when we are considering the functions that rely off of connected IOT devices in order to work as intended, we need to further break down the categories as we cannot assume the user will have all types of IOT devices connected towards the system. As a result, we have broken it down into the following sensor metrics:

- Accelerometer and Gyroscope data
- Live camera feed
- GPS positioning data
- Unique data

7.1.2.1 Accelerometer and Gyroscope data

When considering functions that require both accelerometer and gyroscope data in-order to function as intended, we need to understand that this data can come from a variety of sources such as smart phones, smart watch’s and so on. Nevertheless, the functions that require both accelerometer and gyroscope data are:

- Secondary frame of reference for validating a fall for the graphene-based sensor layer as described above in section 2.6.1
- Categorizing the potential danger of the fall that happened based off of the angle of the gyroscope
- Categorizing and graphing the users most frequent actions throughout the day, such as how many times they stand up and sit down in a day. See section 2.6.1 for full list of categorized actions
- Providing the carer/family member a categorized view of the accelerometer and gyroscope data when a critical fall occurs such as the direction of the fall and the speed at which they fell
- The ability to track the user’s total amount of steps and rough distance travelled when other metrics are not provided through IMU data or additional sensors

7.1.2.2 Live Camera Feed

When considering functions that are require the use of a live camera feed data, they are all focused around using computer vision to predict the users/patients current condition regardless if a critical fall has occurred, providing the carer/family member a current view of the user/patient when a critical fall has occurred as well as saving the fall in a mp3 file if in sight of the camera and breaking down the events that led up to the fall, for both the user/patient and carer/family member to review. Nevertheless, the functions that we intend to implement that require the use of alive camera feed are the following:

- Recording all falls that occur in sight of the camera and breaking them down into single second time stamps for both parties to review what caused the fall
- The ability to provide the carer/family member access to a live camera feed if computer vision detects the user/patient in sight of a camera when a critical fall has occurred
- Providing analytics into the user’s current state such as if they dehydration through the pigmentation changes in their skin through computer vision
- The ability to share the live camera feed to other parties if needed and allowed by both user/patient and carer/family member
- Utilizing computer vision techniques to detect the specific individual that has had a critical fall when multiple users are assigned to a single graphene-based sensor layer

7.1.2.3 GPS Positioning Data

When reviewing the functions that become available when GPS positioning data is provided from either independent GPS devices or from smart phones/smart watches the following are present in the system:

- The ability to distinguish the exact user that had a critical fall on a graphene-based sensor layer when multiple users are assigned to a single sensor layer
- The ability to track a user/patient when they leave their place of residence
- The ability to track the total distance a user has travelled in a single day and estimate their daily steps and calories burnt when other metrics are not provided

7.1.2.4 Unique data

When reviewing the functions that require a unique data type it is best described as a case by case basis based upon the user's current condition and medical diagnosis as these individuals will have specific devices that collect unique data that is not commonly found in an aged home or nursing homes. One possible feature is showing the user/patients current heart rate to the carer/family member at all times if the individual is prone to irregular heartbeats.

Nevertheless, as a result of how unique these types of features/devices are in an aged home or nursing home, we won't be considering them during our development period due how few people will be able to access them. Nevertheless, for future development we should consider creating an expandable module where the user themselves will be able to add these functionalities into the mobile application themselves.

7.2. Functional and Non-Functional Requirements

Described below are the 10 most predominant functional and non-functional requirements that the system will need to use and take advantage of in-order to provide the most benefit to not only the accuracy of the system but also to ensure that the carer/user will be able to use the application in-conjunction with the graphene-based sensor layer and IOT products for a variety of needs based off of the want/need of the user.

Furthermore, it is expected that all function requirements will be implemented by the end trimester 1 and at least half non-functional requirements are also implemented into the application.

Functional Requirements	**Non-Functional Requirements**
Be able to detect when the user sustains a critical fall	To distinguish between the different types of falls such as an elevated or same-level fall
Be able to send a warning message to the user's carer/family member when a critical fall occurs	Be able to show a live feed of the patient's current condition through IOT connected cameras and other connected IOT devices such as heart rate and blood pressure from smart watches
Be able to record the time and location of where the critical fall occurred	Pair other IOT connected devices together to re-create the fall and play it back step by step through sensor data or live camera feeds to understand why a critical fall occurred
Initial user data is collected such as email and login details	More in-depth user data is collected and stored in system to provide more in-depth information into the metrics such as daily step counters and calories burnt

Graphene-based sensor layer is installed in the user's home and connected to a stable internet connection	All IOT devices in the user's home is paired up to the application and recorded to the DBS when critical events happen
The carer/family member has the app installed on their and can receive the warning message about a critical fall occurring	The carer/family member is able to manage multiple users through a single screen within the application
The application has to store all critical falls and be able to show to the carer where the critical falls occurred in the house	The application has to produce a heatmap revealing where the most amount of pressure was applied over a period of time and predict the probability of a critical fall happening in each quadrant
The application has to display the graphene-based sensor layer's layout in the user's home	The application has to provide the ability to the user or carer to name specific quadrants on the graphene-based sensor layer such as kitchen, living room etc.
The application has to be able to connect at least one IOT device if available in the home	The application has to be able to connect all IOT devices in the home and automatically categorize them based upon their sensor output
The application has to have the ability to show a live camera feed if supplied by the user	The application has to use computer vision and sensor data available to predict if any other event occurred to cause a critical fall such as a heart attack

8. Resources and Technology Required

When considering the resources and technology required, we have to take the same approach as we did with our proposed features as we cannot ensure that the user will have all IOT devices required for all features. As a result, within this section we will only be describing the hardware and technology required in order to achieve functional requirements as listed above

8.1. Resources Required/Hardware

As stated above, due to this section only identifying the hardware needed for the functional requirements, the only hardware required is the installation of the graphene-based sensor layer installed into the user/patient's home and set up to allow for the following actions/features:

- Recording of critical events
- Publishing when a critical event occurs such as a dangerous fall towards the firebase server
- Quadrants of the sensor layer are set up in a meaningful formation
- An active internet connection within the user/patient's home

The reasoning behind not including the user/patient having a mobile phone is that the system can operate as intended when they don't have a mobile phone. Furthermore, we expect to run into a number of individuals who either don't own a mobile phone or their specific mobile phone is outdated and as a result is unable to run our application on it.

8.2. Technology Required/Tech Stack – Application

When considering the technology required into ensuring that the functional requirements are able to be met, we have included a variety of technology to achieve the functional requirements. Nevertheless, we have decided to go with the following:

<u>Operating System – Android</u>

We have decided to go with an android application over IOS simply due to the restraint of needing to have access to a MAC OS installed in order to develop in IOS. Therefore, for the longevity of this project, we have decided to make an android application as we cannot ensure that all developers that may take over on this project have access to a MAC OS to develop in IOS. However, once the product is developed in android it is expected to also be developed in IOS in later iterations.

<u>Front End/Backend – Android Studio (Java)</u>

We have decided to develop our application within the Android studio IDE (Java) as it allows us to handle all front-end related tasks that relate to the applications design and usability as well as a majority of the backend tasks required to handle the required functionality's as listed above

<u>Database Solution – Firebase Realtime Database</u>

We have decided to go with firebases Realtime database as our database solution (DBS) as it allows us to not only store data in real time onto the cloud but also retrieve it back as well in milliseconds. Furthermore, through the use of firebase, it allows us to run more computation heavy functions in the cloud as well as make use of their authentication, hosting, and machine learning frameworks to implement a variety of the functions listed above in 7.2.

Nevertheless, firebase also provides quality of life functions such as crashlytics, performance monitoring, testing servers as well as dedicated distribution services for others to test the application while it is in development and we believe this will not only reduce the development time required but also increase error logging and monitoring capabilities for those with minimal IT skills.

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