A software companion for ageing at home

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May 2018

Individual Project

Submitted in part fulfilment for the degree of
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Declaration

I herby certify that this material, which I now submit for assessment on the programme of study leading to the award of Degree of **Honours B.Sc. in Computer Science** in the Institute of Technology Blanchardstown, is entirely my own work except where otherwise stated, and has not been submitted for assessment for an academic purpose at this or any other academic institution other than in partial fulfilment of the requirements of that stated above.

Signed:_____ Dated: ____/_____/_____

Acknowledgements

After a tough year, I am happy to be writing this as my final part of my dissertation. It has been a long road to this point with bumps and bruises but here I am. Firstly I would like to thank my supervisor Stephen Sheridan for offering support and guidance on this project. Special thanks to Simon McLoughlin of ITB for his class on Android Development and showing what is possible through it. This class showed me I would like to further work in mobile development in my future. A very special thank you to my friends and family for being my rocks who helped me push through. A final thanks to my partner, she has pushed me from day one and never let me give up, for talking me through all the problems I have faced and showing me what is possible with a little hard work. You are all amazing, I thank you for everything you have done for me.

David Cushen

List of abbreviations

Older person	A person aged 65 years or older
Software	An application running on a hardware device
Smart home	A home equipped with electronic devices that can be controlled from your smartphone or computer

1. Abstract

The purpose of this study is to identify if software can be used as aid for ageing at home. Ireland has what is called an ageing population, in 2016 the amount of people aged 65+ increased by 19.1% compared to 2011 census [12]. Coupled with the ageing population, Ireland's infrastructure currently needs an investment of 2bn [7] to accommodate the older persons. This study aims to identify if it possible to live in your own home as opposed to nursing homes when you are aged 65+ .

2. Introduction

2.1 Motivation

As referenced above, there is a huge cost associated with ageing in a nursing home while also having detrimental effects for the older person. The average cost for a nursing home is about €1,000 per week. The cost varies depending on location, level of care and services (table here for cost). Coupled with the cost, Ireland does not currently have the infrastructure to deal with the ageing population. Nursing Homes Ireland estimated that it would cost the government €2bn to transform our current nursing homes and system [4]. Familiarity, comfort and independence are necessary for good mental health [6] which are better served at home. Ageing at home is not always an option however, for high dependence older persons. However, with this study I would like to identify if it possible to aid low dependence older persons through software on a mobile device.

2.2 Scope

The general purpose was to evaluate if software on an Android mobile device aided an older person living at home. The mobile device will be running Android 4.4 or higher, this software was designed for this study. The software is built in Android Studio and will allow a user to share a calendar and notes with chosen candidates, access the UI for a door sensor, have a fall detector and a memory game for cognitive aid. Older persons were interviewed and surveyed for input and direction of the application. Users will be interviewed after a trial to see if it has directly aided them in their daily life over 7 days. Only people aged 65+ were considered for this study as it defines an 'older person' in Ireland.

2.3 Research questions

1. Can assistive technology in software form aid ageing at home?

2.4 Assumptions and limitations

2.4.1 Assumptions

Older persons were interviewed and given questionnaires in a one-to-one environment with the author of this paper. It is assumed that the older person answered all questions truthfully to the best of their ability and had the mental capacity to willingly participate in this study. The central statistics office (CSO) identified in 2017 that 89% of households had access to internet at home [2]. It is assumed that the older persons using this application have internet at home before using the software. It is also assumed that the persons involved in this study actively tried to use the software for it's intended purposed. Finally, it is assumed that the persons involved had their health as a priority and see the possible personal benefits of this software.

2.4.2 Limitations

There is a couple of limitations that need to be addressed prior to this study. One major limitation is the data available. This is an emerging problem and while there are studies done I believe that more work can be done to solidify the need for older persons to age at home. Coupled with the literature available, participants in the study weren't always available for feedback or data collection due to health and personal issues. One of the main limitations stems from the unwillingness to learn or accept technology as an aid. Some pushback is expected which is discussed more in the literature review. To combat this limitation, training being provided prior to using the application is strongly suggested and may be a prerequisite. Alongside the data available, we are attempting to measure the effectiveness of personal benefit. This is unique to each person and their experiences with the software. What is true for one user may be the opposite for another.

3. Software Introduction

The software was built with expansion and cost as the primary factors for development. Android was chosen simply because it is a lightweight and versatile operating system with near nil development costs using Android Studio. Coupled with my comfort in Android application development. A study done in 2017 also found that Android has an 87% market share, which makes it the most common operating system on consumers devices [6]. The software will only act as an aid to the older person, if they are low dependency the software will help them with common tasks they face such as medication, appointments, security and well-being.

3.1 Feasibility

3.1.1 Technological feasibility

This project will be developed through Android Studio in the form of a mobile application which will run on Android 4.4 (KitKat) or higher. The selection of 4.4 is to keep the cost of the hardware as low as possible. Standard Android phones running Android 5.1 (Lollipop) are available for as little as 49.99 (Alcatel Pixi 3G), which will be the biggest cost to the end user of this software. In conjunction with the application, a database will be required to store information such as calendars, notes and miscellaneous information. For the database I will use a MySQL database, which is well documented and maintained. This will allow easy integration and transfer of data between users and hardware while using little resources.

The phone mentioned above also has an accelerometer like many other phones today. The ability to utilize this piece of hardware means a drop detector is technically feasible. This will work by calculating the average person's hip and head height usage of their phone and determining if the person has fallen by measuring the change in height and speed of the fall through the accelerometer. Work has already been done in this field and I will use existing projects and sources to contribute to this application.

Finally, integration of sensors for doors or windows is one of my aims for this project. For this a esp8266 WIFI chip will be used with an Arduino which will work over a WIFI connection. An esp8266 WIFI chip was chosen because it is inexpensive, high quality and easy to work with. The sensor software will be built through C and pass the notifications to a server through PHP before the application finally gets the door status from the SQLite server.

Regarding all the above requirements, Android development is well documented and accessible and something I wish to develop further and build upon. Although technically feasible, this project will have personal challenges as I continue to learn more about Android development and utilizing hardware such as the accelerometer, door and window sensors.

3.1.2 Social feasibility

One of the biggest barriers to the adoption of software is satisfaction for the end user. The people that are directly affected by this software will be the make or break. If it is hard to understand or use, older persons will quickly dispose of the software and carry on as they were. On a positive for the feasibility, the Pew Research Center in North America found that 46% of older persons owned a smart phone while 40% owned a cell phone but not smartphone in 2018[8]. This is up from 18% in 2013 [2]. Although it may be socially feasible, there are still limitations to getting older persons to adopt the software. This will be discussed in the limitations section of this dissertation.

3.1.3 Legal feasibility

Legally speaking, because we are collecting personal information on sign-up and ongoing personal information is collected throughout the use of the software, we must adhere to the Data Protection act of 2003 as we operate within Ireland. To stay in line with data regulations, we must only use data on the subject that is obtained fairly, used for lawful purposes, keep this information safe, make sure the information is correct and up to date, collect enough but no too much data, keep data for no longer than needed and have the ability to give a copy of the personal information when requested. Data that will be collected through this software is first name, last name, date of birth, e-mail address and sensor data from the accelerometer and door sensors. This information should never be used outside of the original reason for collecting this data which the user will have to consent to in the beginning of use. [data protection 2003].

While all of this will be in line with the data protection act of 2003, on the 25th of May we welcome the General Data Protection Regulation (GDPR) which will significantly increase the amount of responsibility for an organization collecting, using and protecting the personal data of a person. The GDPR is an EU-wide initiative which aims to regulate what companies are using personal data for. With the GDPR oncoming, the data protection commissioner recommends every organization do a 'review and enhance' analysis. This means each organization gets comfortable with the new guidelines to avoid administrative fines of up to 20,000,000 euro or 4% of total annual global turnover which can be greater than the previous sum. The data protection commissioner has outlined 12 steps to adjust to GDPR.

1. Become aware – Every person in the organization should be aware that the law is changing to the GDPR and factor it into future planning.
2. Becoming accountable – This means all data being held should be examined under the following:
    - Why are you holding it?
    - How did you obtain it?
    - Why was it gathered?
    - How long will you hold it?
    - How secure is it? (Encryption, accessibility)
    - Do you share it with 3rd parties? If so, for what purpose.
3. Customers, staff and service users must be told why we are collecting their data, what it will be used for, who will have access to it and if it will be transferred outside of the European Union.
4. All procedures must be covered to ensure all rights of the individual are covered, including but not limited to how we will delete personal data or provide data in a commonly used format. The rights of the individual include subject access, correcting inaccuracies, object marketing and have info erased.
5. Access to data requests – Quite a few things change here. Companies must cooperate where possible within 40 days of the request. Companies may also not charge unless the cost is excessive. Although it will be possible to deny a request, the company must have clear refusal policies and procedures in place to demonstrate why they are refusing the request. If a request is successful, additional information such as retention periods must be included.

6. All data that is processed must have the legal basis for carrying out the process, while also being documented. This is especially important when consent is the only reason an organization would be processing data.
7. Consent as grounds to process data – Consent must be freely given, specific, informed and unambiguous. Users must be aware that they are consenting to their data being processed. It is of utmost importance that the user is made aware of the consent they are giving. It may not be inferred through pre-ticked boxes, inactivity or silence from the user.
8. Children's data – Although not a concern in the case of this project, organizations must get consent from a guardian to collect a child's data.
9. Data breaches – Procedures must be in place to detect, report and investigate a personal data breach. Although organizations are already obliged to report a breach to the data protection commissioners. This must be done within 72 hours, unless the data was encrypted. If it will bring harm to a user or older person, then an organization must be reported to the affected individual.
10. Data protection impact assessments – These are being introduced to assess the possible impact that a project such as this one may have on an individual.
11. Data protection officers – The new GDPR will require some organizations to introduce a data protection officer (DPO). This person must take responsibility for the data protection compliance and has the knowledge and support to adhere to GDPR effectively.
12. International organizations and the GDPR – If operating outside of the European union then a multinational organization must deal with a Lead Supervisory Authority (LSA).

Given all the points above, the GDPR is a positive movement for both individuals and organizations. It puts privacy and security at the forefront of things. This means that data protection and security should go hand in hand with every step of the development and not left to be an afterthought. Although this software will be in line with the data protection act of 2003 as of completion, additional steps outlined above must be followed if the software expands beyond into later stages.

4. Existing work

Currently there is a multitude of options available for living at home as an older person. These options range from fall detectors, door alarms, window alarms, pressure mats and motion sensors. The issue with most of these devices is cost, proprietary hardware and the need for hubs to have a lot of these. In this section, I will examine some of the devices available to the older person.

4.1 Door sensors

Door sensors come in all shapes and sizes. At its most basic form, an older person can purchase a door sensor for €7.50 which a pack of 3 magnetic door sensors. These sensors are fixed to a door and work on batteries. When the alarm is activated, and the door is opened, it will emit a 95dB alarm sound. These alarms only offer minimal help when the door is opened and may distress the older person. I will discuss the effects of noise on older people in the benefits of this software section.

Another sensor I examined is the iSmartAlarm Window/Door sensor which works again through a magnetic bond like a reed switch. This device can send a text message to the older person; however, it is capped at 320 feet from the sensor. It is however easily installed through double sided tape which can also be seen as a con as it is not tamper proof and can be easily removed. The cost is moderate for this device at a price of €50 for a two pack of alarms.

Samsung also provide a smart multi-purpose sensor at a price of €30 per sensor. This device works by detecting vibrations and motion around the sensor. However, it is only compatible with Samsung's SmartThings hub for these devices to work properly. This carries a heavy cost to the older person at €130 for the hub alone. All in, it is €160 for one sensor for one door which is excessive. This device also only has a range 30-50 feet for the sensor and your smart device.

Like Samsung, Panasonic also provide a solution to door security for a lesser price. The Panasonic Wireless Door/Window sensor is available for €30 but also needs a KX-HNB600W Hub to function, which carries another €50 cost to the older person. The benefits of this solution is that you can arm and disarm the alarm from your smart device, which is something a lot of other sensors do not offer.

4.2 Fall detectors

Similar to door sensors, there is many options available for fall detectors for an older person. Most commonly is a pendant alarm, closely followed by software on a mobile device. Most older persons opt for the physical pendant alarm, which in Ireland is supplied by CareLink. This system works through a CareLink base unit coupled with a CareLink alarm which is worn as a pendant. This is effective up to 100 meters and usually reaches outside of the home also. This pendant automatically detects a fall and communicates with the base unit which is connected through a telephone socket in the home. This unit is connected with the CareLink Response Center which is connected upon impact of the fall. The older person can then communicate the severity of the fall to the first responder. This system is effective and the most common choice, there is not many issues to be seen here. The only issue is familiarity with the person responding to the older person.

Software on mobile phones is the other option available to the older person. This is the route that was chosen for the purpose of this project. On the Google Play Store and Apple App store, there are hundreds of options available to the user. The most common issue with this avenue, which also appears in this software, is the detection of false positives. When removing the phone from pocket or bag, a lot of the time an alert is triggered. This is a hard issue to overcome as we must account for the height of the user, the preferred place the device is held and a multitude of other variables. It is not all bad however when compared to the pendant alarms as the fall detectors on a mobile device are not limited by range to a hub or base unit. They can be taken anywhere and work as long as you have cellular signal to send a message or call.

4.3 Benefits of this software

As discussed above, there is already many options for having assistive technology in your home. However, the benefits of this software empower older persons to take a hands-on approach to living independently in their own home. The biggest benefit of this software is the cost- reduction when compared to current options. The software is easily transferred from device to device with no proprietary components

involved. From the door sensor to the software itself, everything is easily moved or changed if needed. The average cost to access and run this software is €85, this price includes one mobile device capable of running the application, one door or window sensor and a mobile data plan for when the user is not at home. While usability and cost are two benefits, a third benefit is overall peace of mind for the user. With this application, they no longer will have to feel as though they are a burden on their family which may feel the need to visit or check in regularly. With this software, the family can see how the older person is doing, what events are on their calendars and know if they have fallen.

As mentioned above however, the ability to measure these benefits are difficult as it will vary depending on a few things. The engagement with the application is one of them, while the ability to use the application will also affect how beneficial this software can be.

5. Methodology

5.1 Research

For the purpose of this study, surveys and questionnaires were given to older persons. The aim of these were to identify the issues users have with technology, their grasp on technology and their input into software that they could ultimately see a benefit in their daily life from. No person under 65 was used for this and the test group included older persons close to me, those living in assisted living and those living at home by themselves. Alongside field research, the literature review section delves into existing literature on a range of topics including existing software, older persons and adoption of software for older persons.

5.2 Research instruments

5.2.1 Survey

This survey was created through Google Forms and given to older persons. The total responses for this form of survey was 11 people. The questions were designed to see what possible users already utilize in terms of technology, new technology they would like to see in their lives and their difficulties with technologies to attempt to overcome them in this software. The survey will be attached in the appendix A at the end of this paper.

6. Literature review

6.1 Introduction

Technology and older persons have long been researched since the adoption of technology in the home. The safe alarm system was one of the first implementations of ICT. The adoption was slow, with 16% of the UK and Ireland using it. While Nordic countries sat around 10% and mainland Europe at 3% [3]. With an ageing population in Ireland (600,000 people over the age of 65), we must look at how we can aid these people in ageing at home as opposed to private or public nursing homes. It is accepted that ICT is a useful solution to the problem of ageing at home. Using existing research, I will examine the question “How can software be used as an aid for over 65s age in place?”. What I expect to find is that there are many challenges we face. These topics will be examined under headings or themes, such as privacy and usability. By the end of this literature review, I hope to

have an answer to the research question. For this literature review I will omit research done on groups under the age of 65.

6.2 Privacy

With today's technology, privacy is now more important than ever. Not just to the younger generation, but privacy is an obstacle to overcome when pairing an older person with software and information technology. Every person values their privacy, invasive software and data protection are important when developing an application for an older person. Remote monitoring is one of the main objectives of home assistive technology. In a pilot program, Lively and Eskaton [2] found that 80 percent of the 14,000 caregiving participants found that there was a significant reduction in the amount of stress and anxiety they experience being a caregiver. However, Lesa Lorenzen-Huber et al found that older persons are less interested in daily monitoring and more invested in critical event monitoring [4]. Critical event monitoring meaning falls, stroke or otherwise harmful situations for the older person.

In the same study, Lesa Lorenzen-Huber et al also found that an older person expressed desire to control which person can see their data [4]. For example, the older person would rather have one daughter who can see their status over their daughter-in-law. In the same study, they also found that the amount of data being collected and shared was not only intrusive to the older person, but also to the caregiver who is receiving the data. The older person found the overall idea of the application intrusive to their caregiver and eventually felt as if they were a burden [4]. Giving the user the choice of what is done with their data, what data is being collected and who sees it is important to overcome the privacy objection to IT in the home.

6.3 Single person approach

When creating an application, a developer's main aim is to have a flexible, working product that can serve as many people as possible. However, this approach may not be optimal for targeting older persons. L. Magnusson et al found that the 'design for all' approach must be questioned and may be ineffective in truly helping older persons. To combat this, they propose a 'user sensitive inclusive design'. This would allow a developer to take the end users opinions on board and apply them as they see fit. L. Magnusson et al go on to mention that besides a single person approach, training will be necessary to help adopt the technology. Likewise, Boátjan Kerbler also found that for an older person to adopt new technology "ICT innovations must therefore be planned for the users and with them". He also goes on to state that is the main reason that ICT and innovations are not accepted even after a successful implementation. The topic of including the older person in the development process has been established and must be adhered to if we want to develop software as an aid for older persons.

6.4 Independence

Independence, autonomy, the ability to look after one's self. These are important for every person. If we do not have independence, we may feel as if we are a burden. It will ultimately impact your life negatively. Lesa Lorenzen-Huber et al said that "older and disabled adults are deeply concerned about independence and autonomy". Sixsmith [5] found that our perception of independence is not one single thing, but made up of multiple factors, the ability to look after one's self, the capacity for self-direction and not being under obligation

to anyone. Lesa Lorenzen-Huber et al and Bostjan Kerbler agree when they say that even with cultural differences, independence is important for everyone [3, 4]. Developing an application that is non-intrusive, allows independence while still being a good aid is a challenge which is not easily dealt with and somewhere researchers have failed to create a solution.

6.5 Usefulness and usability

This is one of the biggest factors when getting an older person to adopt a new technology. We must measure the usefulness of the application and ensure its usability is very basic and simple. The usability of an application comes down to many factors. All the research done agrees that the perceived usefulness and usability will ultimately decide if a user adopts the technology. To support the adoption, Grace Andruszkiewicz et al suggests that an interface design employed with the best practices in accessible design must be used to garner the best results [2]. Grace Andruszkiewicz also notes that all end users will not be at the same level of physical health [2]. Older persons may suffer from visual disability or dexterity impairments. These must be considered when designing an application, if a user cannot use the application, then it has no real purpose. In agreement, Bostjan Kerbler and L. Magnusson et al believes that training is necessary to further support the use of this technology [1, 3]. L. Magnusson et al also state that "older peoples' negative attitudes towards using ICT services can potentially be modified if they receive appropriate training".

Finally, personal usefulness is one of the main factors that decides if an older person will adopt the technology. L.Magnusson et al state that if we can show the perceived personal benefit, instead of the overall benefits, it will be easier to incorporate ICT into an older person's life [1]. Lesa Lorenzen-Huber et al agree, they found that a lot of older persons thought of somebody else who may use the technology, even though they would also have a need for it [4]. When showcasing or pitching software to an older community, we should not focus on the ability of the software. Instead, we must find out the personal needs of the older person and show how software can aid the person in every day. Lesa Lorenzen-Huber et al also found that users were more concerned with the perceived usefulness than the issue of privacy [4]. Although it doesn't speak for everyone, it does showcase that if we can develop an effective application with good privacy practice, then our end user will ultimately be happy to use an application.

6.6 Conclusion

Ultimately, the literature points out that there is a need for software to help ageing at home. However, the design and implementation must be closely monitored and built with older persons input. There are many objectives to overcome, such as privacy and usability. On these topics, I believe the researchers have done most of the ground work, but I would like to work closely with older people and build software which is easily adopted. The above discussion has shown that there is room for improvement, however there is a foundation to build upon. Through this literature review I have found that a simple, well-structured design is important, as well as what data I monitor and what I decide to do with this data. Objections will come up in time when working with the older person, but I now believe I am equipped to calm their fears and deliver a working piece of software which I hope will ultimately benefit the quality of life for the older person.

7. Software analysis

7.1 Introduction to program

By the end of this project, I hope to have a solution to these research questions. I believe that software can help the elderly age at home successfully if they are low risk. The project will take the form of an Android application written through Android studio with various technologies which will be introduced later. The purpose for this application is to serve as an aid to an older person. They will have access to a fall sensor, a door and window sensor, a shared note and a shared calendar for friends and family or doctors. I believe this application will positively impact on the older persons life as it will allow them to maintain their independence while not feeling like a burden to their surrounding support.

From the start of this application I involved older persons to get their input on what they think is a good application and what would drive them to use it. The feedback given initially will be taken on board to find an answer to my research question. Further feedback will be taken when a prototype is developed, which again the older persons will be hands on with to get the purest feedback.

7.2 Analysis

The problem older people face is being dependent on somebody else a lot of the time. This takes many forms and is usually split into low and high risk. A low risk older person may have some slight mobility or motor issues, while a high dependency older person may have serious mental health issues or be with restricted movement in which they need intervention from an older person. This application is catered to the needs of the low dependency older person. A software solution seemed apt as most people today have a smart phone, which makes the smart phone the perfect companion for the older person. Through interviews and questionnaires, I found that a lot of older people are able bodied however there are some aspects of their life which software can aid them in their home. Software which allows an older person to be in contact with others is hugely beneficial to both parties, it allows the older person to maintain contact without feeling like a burden to their family or friends.

Another aspect of older life I noticed could be aided in was a fall detector. As of now, the most popular fall detector is a pendant alarm which is paired with their phone, on impact their phone will then alert a designated person that the user may have fallen. This is the most common wearable for older people, so it made sense to integrate this into my application. The second most common application the older persons used was a calendar app. They need to keep track of appointments, visits, deadlines for grants, medication timing and a whole host of other stuff. This is usually done on pen and paper or through their phones calendar. We can cut out both of those and offer a new solution: a shared calendar. The idea of a shared calendar came about when an older person said they would they like their kids to be kept more in the loop. By the end of this project, a user will be able to view their calendar and select a date, if the date has an event tied to it, it is displayed. Roles will be introduced in the future allowing a family member or doctor to update the older persons calendar so they don't miss anything.

Through my research I found that every older person I interacted with owned a smart phone. The difficulty in using the smart phone was varied from 'easy' to 'I find them very difficult'. However this was combated when the older persons were asked if training was provided, would it help them adopt the application? This resulted in 100% of users saying yes. So although there may be a barrier in adopting the application, we can help aid the older persons life through software and follow up training on how to use the

application. I believe this training must be personal, in groups of 3-5. This will allow the older person to ask questions, use the application, encounter issues and solve those issues. When every older person owns a smart phone and they are trained in using the application, I believe this solves the problem of offloading older people onto families or into private institutions even though they are mentally well and able bodied.

7.3 Design Specifications

Functional requirements

- Log in for older person, carer / family member, doctor
- Dashboard for all users
- Check door sensors
- Memory test section
- Shared calendar with events logged
- Shared note section for carer and doctor

Non-functional requirements

- Data collection and logging

Hardware specifications

- Android device running 4.4 or higher
- Reed switch
- ESP-8266 WiFi chip
- 100nF Ceramic Capacitor
- Solderless breadboard
- Dupont cables
- FTDI 232 USB to Serial Programmer

Architecture of software

This system will consist of the following parts

1. Database
2. Android application
3. PHP Scripts
4. LUA or C scripts

This application is designed to interact with both the door sensor and a database which will store all information on the users. Using PHP scripts, we will query the database through the application receive stored information such as the calendar events, notes on persons and login details. The reason for choosing an Android device is

simple. They are inexpensive or as expensive as you like, well documented and have varying form sizes (tablet or phone).

This database will contain the following:

1. User table that will hold a UserID, full name, roll of user (older person, doctor, carer or family member), an email and password for authentication checks.
2. Notes table will contain a NoteID for accessing notes, a UserID which we will get from the User table to check for notes for that user and finally the note itself which will contain a string.
3. Sensor table will consist of taking in the UserID and then a Boolean value which will check the status of the sensor (open or closed) and relay that to the application.
4. Calendar table will take in the UserID for checks, a date and time will be available to display to the user and an event held in a string to attach to the date in the calendar which will be viewable to the selected persons.

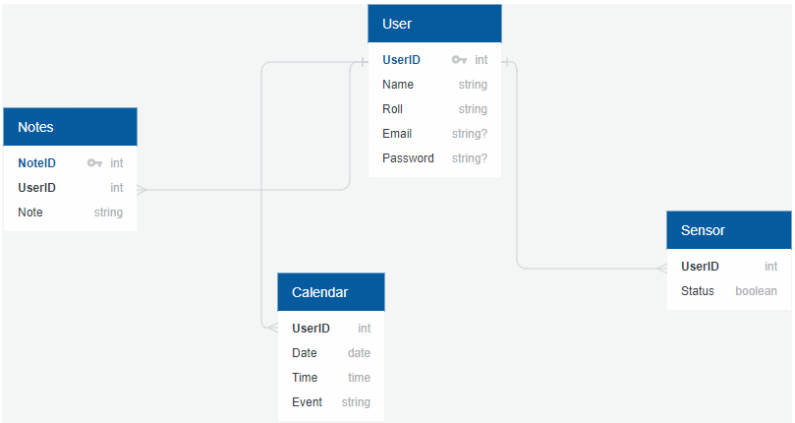


Figure 1 - Database layout

7.4 Functional description

1. User launches application
2. User enters username and password
3. User is taken to dashboard containing buttons to different parts of the app
4. Dashboard will contain a greeting message with time and weather on dashboard

7.5 Interface design

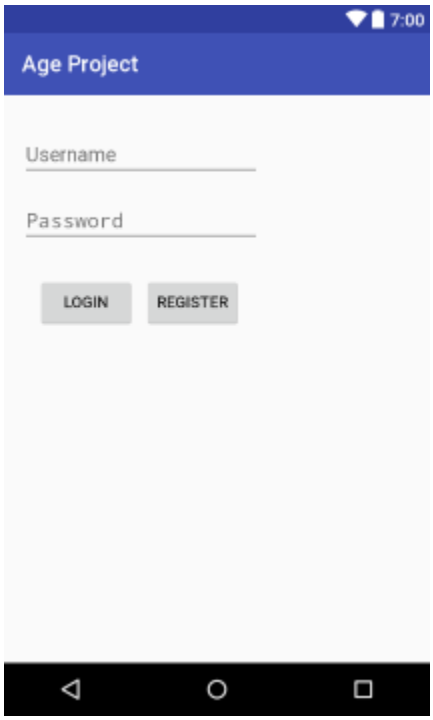


Figure 2- Login screen when opened

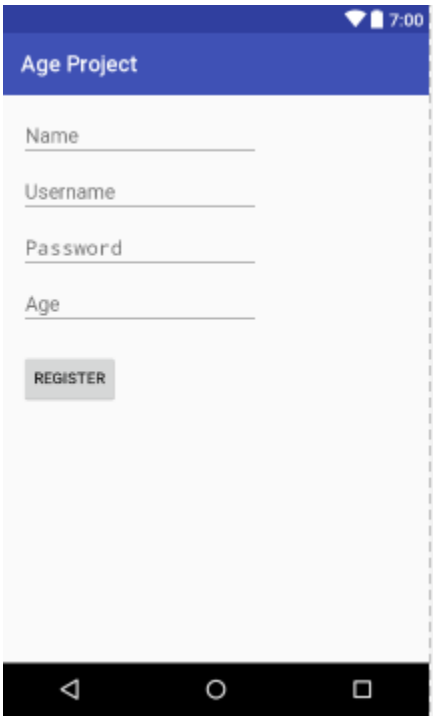


Figure 3- Registration screen

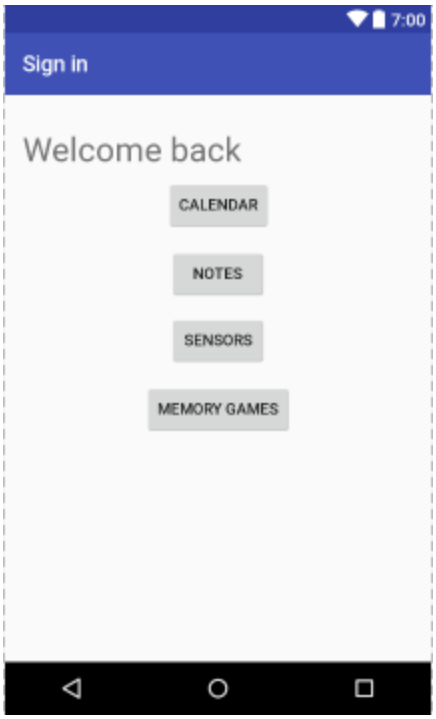


Figure 4- After a successful login, the user is shown this menu (WIP) which displays their name after "Welcome back"

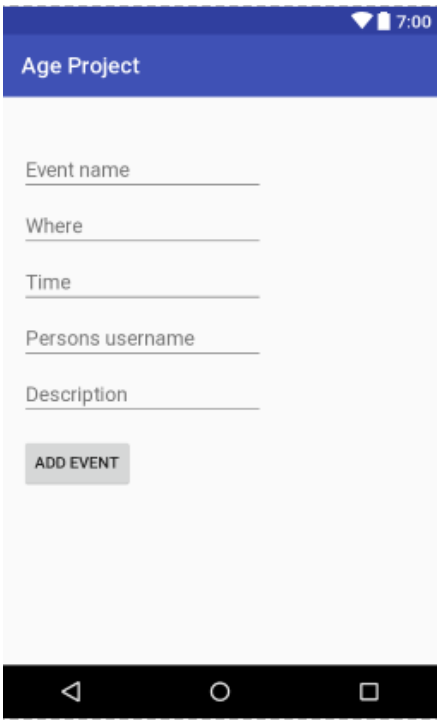


Figure 5- Adding an event to the calendar

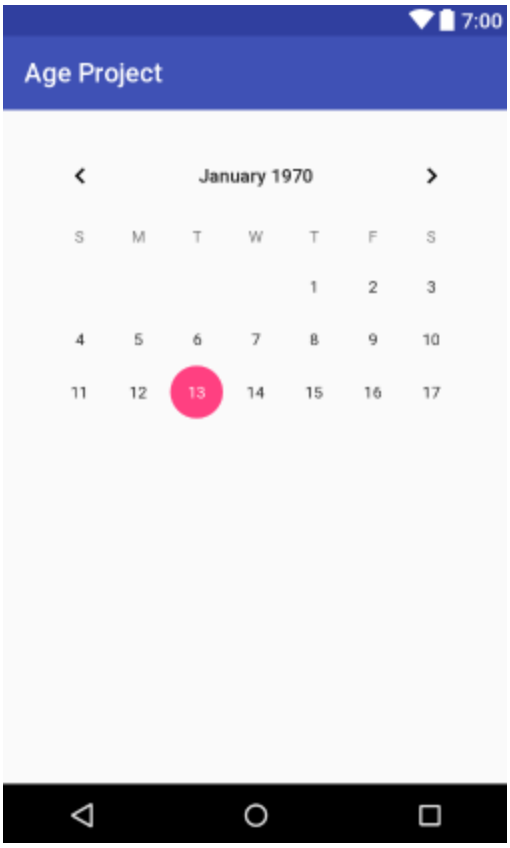


Figure 6- Selecting a date on the calendar to show the events for that day

7.6 Semester Two work packages

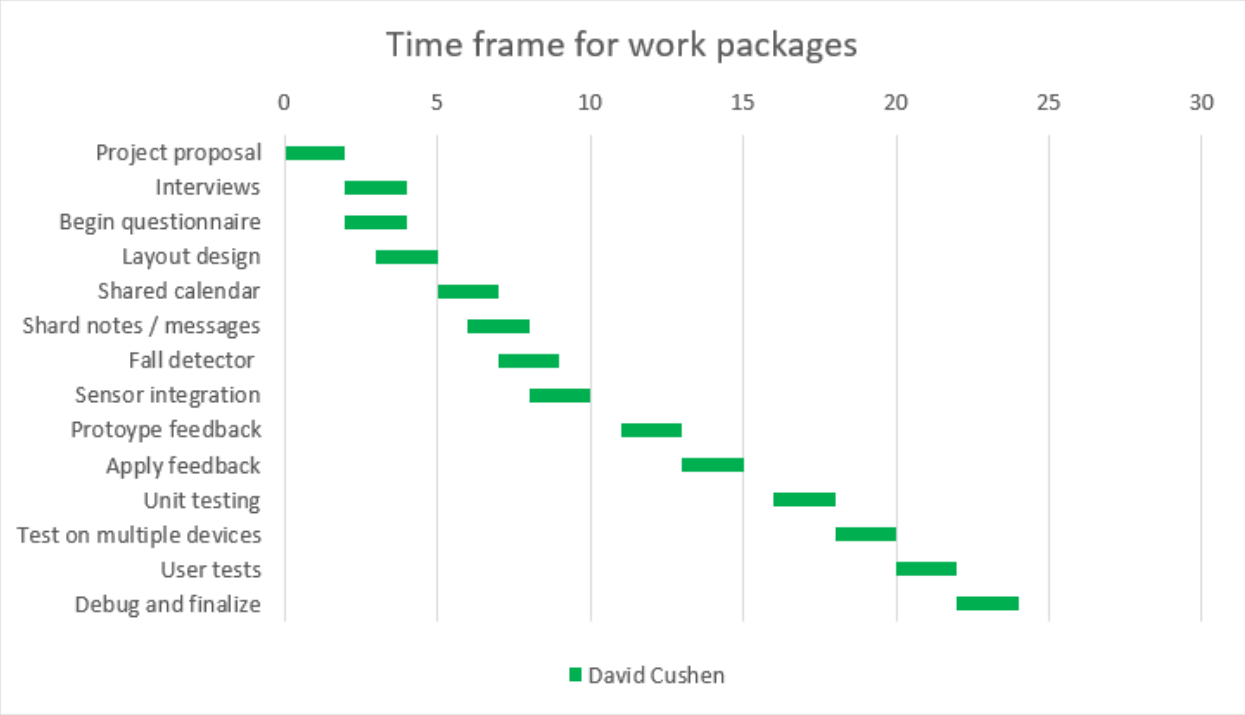


Figure 7- Original work packages from proposal

Fall detector	Fall detector to be delivered using phones accelerometer (Huawei Y5). Will be able to detect a change in height, take in the speed of the fall and determine if a user has fallen over. Will send a message or call to designated contact.
Sensor integration	Sensor will be integrated into the application with the ability to check the status of doors or windows within the application. For example, “Hall door – Open / Closed”, “Bedroom 1 Window – Open / Closed”
Prototype feedback	A working prototype will be delivered to a test group, users will spend a couple of days with the software and then fill out a questionnaire with feedback for me, the developer.
Apply feedback	Feedback will be taken into consideration and appropriate changes will be made.
Unit testing	Unit testing performed on each class to ensure each class is doing the correct job and no interference with other classes
Test on multiple devices	Application will be tested on multiple Android devices, as accessibility is important to keep the cost down, tests will be running on Android phones running KitKat or higher.

User tests	Users will have more time with the application, will be asked to log any bugs or issues alongside logging inside the application.
Debug and finalize	All known bugs will be fixed here, and software will be finalized.

8. Barriers to development

Possible barriers to development are sure to arise. To speculate on them now, I see the accelerometer and fall detector causing the most issues. The issue faced is false positives. Detecting a legitimate fall is something that can only be done with a strong algorithm and a multitude of tests. For the tests, the phone will be dropped, thrown, jumping onto a mattress. I will need to find the correct values for the 3-way axis to determine if a user has suffered a fall. If false positives do arise, an alarm will be put onto the fall detector. The alarms will function as follows:

- Person falls
- Alarm begins counting down from 3 minutes
- If button is not pressed after 3 minutes
- Call or text designated person(s)

With enough tests, although a barrier, this can be overcome quite easily.

Another possible barrier to the deployment of this application is getting the sensors to work correctly. I have chosen a reed switch which is a magnetic switch (open or closed) which will then relay the information to an ESP-8266 WiFi chip which is flashed with an Arduino. Currently the documentation and tutorials I have found on this setup suggest using 3rd party programs such as IFTTT (if this then that) which is a logic based program to do one step after certain conditions are met. To integrate this setup into my application, I will have to relay the information to my database and then send that information to the phone. Due to latency it may be slightly slower than other fleshed out applications, however development over time will minimalize this. The integration of a 'hub' or place all switches statuses are stored is also possible to work around this, which will take multiple sensors statuses and only relay them when something has changed. This will take load off the server and mobile device as they will not be checking all the time.

Another barrier I see arising is the refusal to use the application. If the application is too convoluted or hard to read, it will pull users away from using it. This was echoed many times in the questionnaire (Appendix A), older persons want an easy to use, non-obstructive application which they can use so the design has to be right at the time of deployment. Training will help people adopt the software (Appendix A).

Finally, monetization could become a barrier. Although a college project, monetization must be thought of. The decision between a subscription model or a buy-once model is a question to be looked into. Everybody enjoys free things; however servers and development costs must be paid for. To break down the barrier for this, I believe an incentive must be offered. The incentive I have in mind is basic features for free (calendar, notes), with the door sensor being available at a fee as they cost money to implement every time. Along with more features, the amount of data being collected will be colossal. This data can be mined or interpreted to come to

patterns or conclusions on users. The data is valuable to the older person, doctors and family members. If the data was available as both raw logs or in an easy digest graph, this is a feature people would pay for therefore breaking down that barrier.

9. Conclusions

9.1 Sensor

As proprietary hardware rarely benefits the end user, this sensor was constructed with easily accessible parts and configurations while maintaining a low cost. The chip chosen for this software was an ESP-8266 WiFi Module built by Expressif. This was chosen for many reasons which will be listed below.

1. Inexpensive – ESP-8266 is available from as little as €5, a battery back for €2 and a magnetic reed or door switch for €3. This allows use to build one physical sensor for as little €10.
2. Range – The range of this chip is 60-140 meters which means covering distance in a house in an easy task.
3. Documented – There is a big maker following of this chip meaning there are many tutorials, projects and a community to seek information from. Among these is a multitude of textbooks such as Learning ESP8266 by Alasdair Allan, Internet of Things with ESP8266 by Marco Schwartz and SparkFun ESP8266 Thing Development Workshop by Agus Kurniawan.
4. Over-The-Air – The chip also has OTA ability, which makes applying any updates possible without physically removing the sensor.

The sensor is deployed by attaching it inside of a plastic casing alongside two AAA batteries for power. A rechargeable battery pack may also be used to further save on the cost of batteries. A reed switch is fitted to the door and attached to the sensor. When the switch is opened, it is relayed to the WiFi chip which in turn sends a notification to the mobile device indicating a door or window has been opened. The sensor has proven to be an effective, low-cost introduction to the smart home and provides great benefit to an older person.

9.2 Information collected

The information collected throughout this project was mostly personal inputs on design of the software (Appendix A). Data collected through the sensor was the amount of times the door was opened. When the door was opened with the sensor attached, the time of opening was logged. This allows us to view whether an older person has opened the door recently and further diagnose if there may be an issue. An example of this would be to check the current date against the last date logged from the sensor. Further work would allow us to trigger an alert for authorized users which would tell them it has been x days since the door was last opened.

9.3 Future work

To build upon this software further there are a lot of things to be added given the time and resources. One of the biggest additions that could be added is more smart home features. This includes but it is not limited to the integration of smart home lighting, temperature monitors, pressure mats and cameras for outside of the home. Initially, temperature monitors would the most important addition. This would allow someone to see the temperature of a person's home, this is especially helpful around winter time when it could be identified if the older person is using their heating at home. If they are not using their heating, why is that? This could lead to the discovery of financial problems for the older person or issues with the heating system itself. This helps protect the older person going forward. Pressure mats would also be a significant addition. In

this scenario, a pressure mat is placed bedside or bottom of the stairs, upon trigger it is recognized that the older person is awake and mobile in their home. This gives peace of mind to the people monitoring or assisting the older person.

Because a lot of data is being collected in the background either through the fall detector or the door sensor, a multitude of conclusions about the older person could be reached. For example, if the main door of the home has not been opened in 3 days but the sensor is active, this could identify an issue with isolation or loneliness. While we can attempt to diagnose these issues, the data can also be compiled to output graphs or diagrams about the older person. How often do they leave the house? How often is the heating turned on? How often does the older person fall, do they need outside assistance?

In the future, this software could become a widely used companion software to the older person. At the age of 65, this software could become recommended to all as a companion software or aid to life at home without an expensive cost attached. If allowed, integration of doctors could be included. This however is difficult to obtain as doctors and patient primarily discuss very sensitive information about themselves. This would have to be handled with utmost care and the best practices in security implemented to avoid a data breach or breach of privacy for the persons involved. Medication can also be incorporated into the software either through the form of a reminder or an allergen note for the older person. This would allow the older person or family to quickly check allergic reactions to medications they may be taking by having it always on hand in their mobile device. Medication reminders can also be built in a smart-home way. This would involve creating a module in the software to input times and the medication to be taken at those times. An alarm would sound with the description of the medication to be taken at that time. When the alarm is turned off, the software would then log that the medication was taken at that time. This would involve good-faith on behalf of the person using the software as we have no physical way to check if they did take it.

10. Discussion / Evaluation

The evaluation of this software is difficult to measure. Because this software will aid users in different ways, their satisfaction and benefits they see will be different overall. However, at the core, they should see an improvement in daily life which is measured by the person. The results given through interviews show a positive reaction to the software for the individual users. This is in line with what was expected at the beginning of this project. The interviews are important as results as we are measuring personal benefit. The results are also in line with the research done by Fike, G. A. [3], Kerbler, D. B [4] and Lesa Lorenzen-Huber [5]. What these researchers found is that to have older persons adopt and utilize technology they must be included in the development phase with their input taken every step of the way to the final version of the software. From the offset, this research was an attempt at identifying if software could be used as an aid to age at home as opposed to a nursing home.

11. Bibliography

[1]A literature review study of Information and Communication Technology as a support for frail older people living at gome and their family carers. (2004). *Technology and Disability 16*, 223-235.

[2]Central Statistics Office. (2017, July 13). *Information Society Statistics - Households 2017 - CSO - Central Statistics Office*. Retrieved from cso.ie: http://www.cso.ie/en/releasesandpublications/er/isshh/informationsocietystatistics-households2017/

[3]Fike, G. A. (2015). Emerging Technology Trends and Products: How Tech Innovations are easing the burden of family caregiving. *Journal of the American Society on Aging* , 64-68.

[4]Kerbler, D. B. (2012). Ageing at home with the help of information and communication technologies. *Acta geographica Slovenica*, 166-179.

[5]Lesa Lorenzen-Huber, M. B. (2011). Privacy, Technology, and Aging: A proposed framework. *Ageing Int*, 36:232-252.

[6]Moon Technolabs pvt ltd. (2017, Mar 1). *Apple vs android - A comparative study 2017*. Retrieved from android.jlelse.eu: https://android.jlelse.eu/apple-vs-android-a-comparative-study-2017-c5799a0a1683

[7]Nursing Homes Ireland. (2013, July 9). *Crisis Looming Warns Nursing Homes Ireland*. Retrieved from nhi.ie: http://www.nhi.ie/index.php?p=news110

[8]Pew Research Center. (2017, May 17). *Tech Adoption climbs among older adults*. Retrieved from pewinternet.org: http://www.pewinternet.org/2017/05/17/tech-adoption-climbs-among-older-adults/

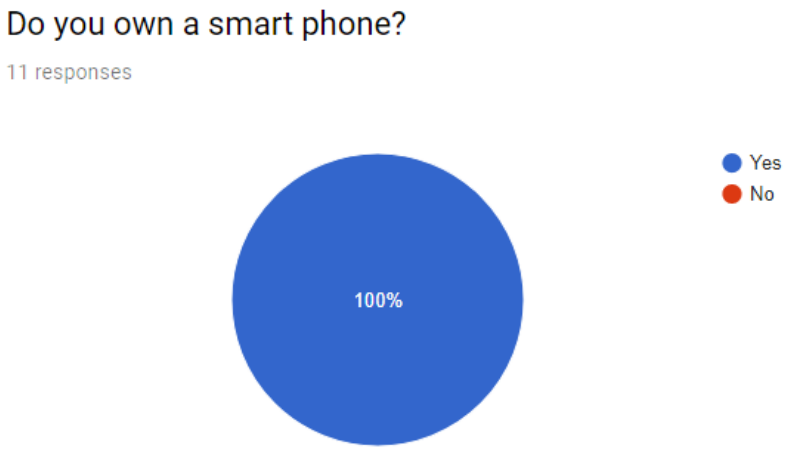
[9]Social Care Institute for excellence . (2015, May). *Noise levels - Dementia-friendly enviornments* . Retrieved from scie.org.uk: https://www.scie.org.uk/dementia/supporting-people-with-dementia/dementia-friendly-environments/noise.asp

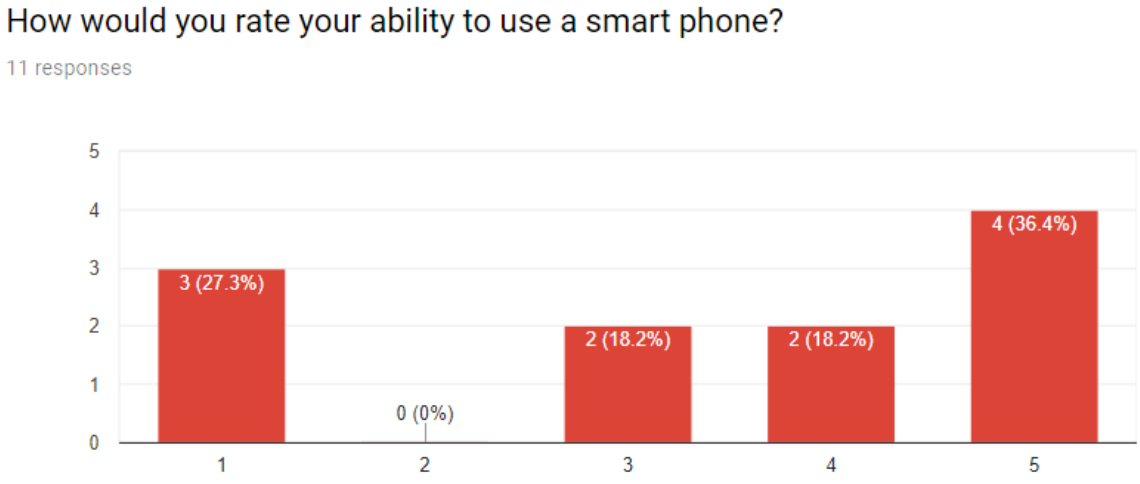
[10]Understand together. (n.d.). *Statistics - Dementia*. Retrieved from understandtogether.ie: http://www.understandtogether.ie/training-resources/resources/stats/

[11]Pollock, Annie & Fuggle, Liz. (2013). Designing for dementia: creating a therapeutic environment. Nursing and Residential Care. 15. 438-442. 10.12968/nrec.2013.15.6.438.

Appendix A

(Survey of older persons done through Google Forms)





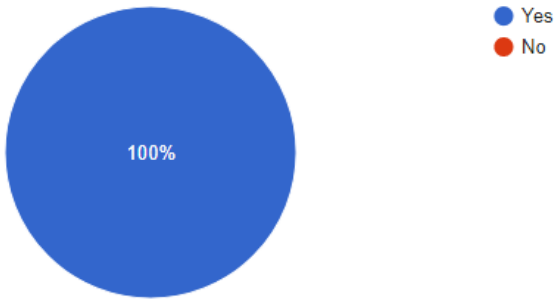
If you find them difficult, what are the difficulties?

4 responses

Space
Memory card Internet How to turn your 3g on
They're new to me, no instructions
It is a big change to my regular phone

If training was provided for a smart phone and app, would it help you adopt it?

11 responses



Do you currently use any apps in your home? (Fall sensors, window alarms, SMART homelighting, calendar applications). Please define which ones.

11 responses

No (3)
cal app
no
Messenger ,facebook,dublin bus
None
Pendant alarm
Pill box alarm
Calender
I use a calender for my appointments

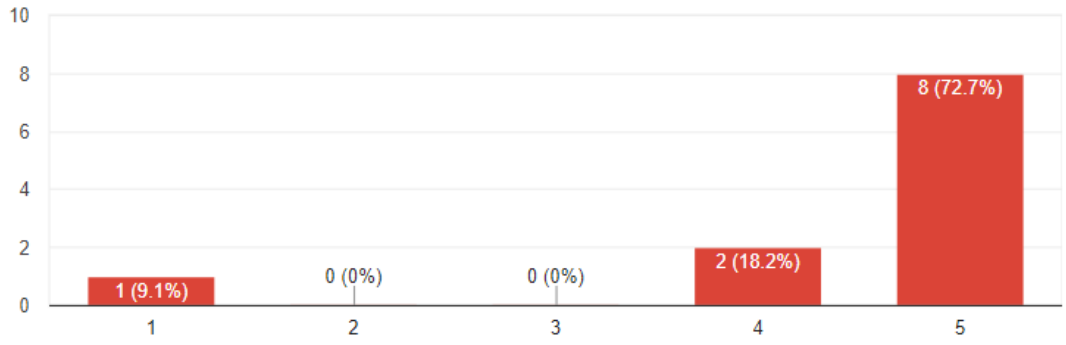
If an app was designed to help you age at home, what features would you like to see?

6 responses

pill and shot reminders
A app that I no my Heaton is on
Built in alarm system connected true your phone
Safety alarm if I fell, I like the door sensor
Ability to contact someone if I needed help urgently.
A place my family can check in on me, a way to talk to people if I need help

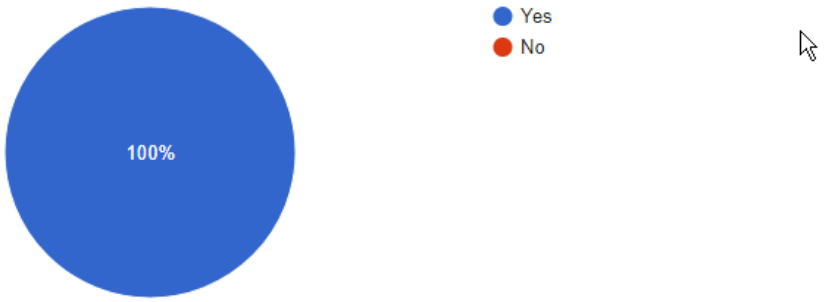
How important is data privacy to you personally? (Name, age, email etc)

11 responses



Is checking if a door or window is open through a phone a feature you would like to use?

11 responses



What in your mind, is a good app? Is it easy to use? Accessible? Privacy? Write down what is important to you if you were to use an app.

9 responses

privacy
Having my children be able to see that I am using the app would be helpful.
Easy to read
Its private
Accessibility
It should be easy to view the screen and clear what I am doing
Privacy and easy to read for me. Bad eye sight.
Confidence that it works correctly and not overly complicated. Privacy is very high on my list.
Easy to use, bad eyesight so it has to be very easy to read

Appendix B

Sample interview questions

A. How did you find the software aided you, if at all?
B. What were features you used most?
C. Is this something you would use daily?
D. What did you dislike about the software?
E. Which feature would you like to see added?
F. Was the training sufficient to use this software?
G. Would you recommend this to a friend?