Walking Aid Reminder Device for Dementia Patients

Bangor Health Clinic Group

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Chapter 1

Topic

Within this chapter we will detail the problem our project aims to solve along with the limitations that could effect our project and an analysis of the current solutions our project would have to compete with. We will provide some background research on dementia patients and their issues with forgetting their walking aids when moving and how wearable devices can have a psychological impact on them. Finally, we will detail our current progress consisting of two initial meetings with our client, and our takeaways from these meetings.

1.1 Background

1.2 The Problem

Upon completion of our initial meeting with the client, we clarified the motivation behind this project and the problem that we are working together to solve. That problem is to develop a solution that detects when a dementia patient is moving without their walking aid, and reminds the patient (with a recorded message by a friend or a relative) to take their walking aid with them. Initial discussions between ourselves and the client identified current issues with dementia patients feeling uncomfortable in being forced to wear foreign objects, meaning we would need to take this into account when developing our solution. We also clarified that dementia patients get easily alarmed and frightened by generic alarms, often associating them with danger notifying alarms such as fire alarms, with the client suggesting that we facilitate a recording feature within our solution that would allow recognisable voices to the dementia patient to remind them to use their walking aid.

1.2.1 Similar Solutions

Current solutions include the use of locator systems that allow dementia patients to easily track down valuables such as keys or a wallet. Such systems include the Tile ecosystem which allows a dementia patient to attach a Tile device to their valuables and then use a smartphone app to fire an alarm from the Tile device that notifies the patient of the location of their valuable. As previously mentioned, dementia patients can get frightened and disorientated by the sounds of alarms often associating them with danger rendering these forms of solutions unsuitable for our problem. This is without considering how difficult a dementia patient mind find navigating through a smartphone device to open an application and request their Tile device to ring an alarm to help them identify the location of their valuable. Other more old fashioned systems that carers may use to notify themselves that their patient is moving include hanging items from door frames that clatter together when the patient walks through the door, or adding pressure pads under door mats that sound an alarm when the patient steps on the door mat. But what we are trying to expand upon with our solution is the protection of dementia patients that are alone and wanting to move around their home or ward. Meaning that door mat pressure pad solutions and methods for alarming a carer would be insuffient.

1.2.2 Limitations

Our main limitation for our project is that we need to develop a discrete device that will not make the dementia patient feel uncomfortable in any way. Early plans for the device lean towards a watch style device that the patients can wear on their wrist to track their movement. But if we are to create a wrist wearable device then we would need to ensure that the footprint of device is small enough to be worn on a wrist. This limits the hardware that we can feasibly use for our project. We also need to consider the number of devices being used and how they can all be fit within a wrist device. The head of the Embedded Systems module within our department has kindly offered to supply us with ESP32 based TinyPICO devices which would be suitable for this project due to its small form factor. We would need to consider how an accelerometer could be attached to the TinyPICO to allow both devices to fit within a watch casing. Other limitations for the wrist device part of the system is that it should not contain any LEDs, vibration motors or alarms to avoid startling the dementia patient. Avoiding the use of LEDs would actually be of benefit to us here as it would allow the watch device to save battery during operation. On the topic of saving battery, another limitation to the watch device is that it would need to be power efficient in order to avoid the dementia patient needing to frequently charge the device to create a more user friendly experience for them. The ESP32 chips included on the TinyPICO boards utilise a system called 'deep sleep', which effectively powers down certain modules connected to the board. We could theoretically create a system here that fires an interrupt when the accelerometer detects movement, then forcing the ESP32 to wake up and handle the interrupt. Thus meaning that when the patient is static, the device can be in a 'deep sleep' state to save battery.

Limitations for the device being fitted to the walking aid are far less. With this device, we do not need to consider a small form factor as it is not being worn, but will be using a TinyPICO for this device too for consistency. Our limitations with this device is to also disbale the use of LEDs to avoid startling th patients, and to include a speaker and microphone in order to allow a relative or carer to record a voicenote which will be played to remind the patient to take their walking aid with them when moving. The TinyPICO boards include a very minimal amount of storage space and so we may need to include an sd card to store the voice notes on. We will also be limited to the budget of £150 that we have been assigned, and must ensure that all the devices needed to build the system can be purchased within our budget.

1.3 Current Work

As stated earlier in this chapter, we have held initial meetings with the client where we have clarified the problem they aim to solve with this project and outlining the project scope. On the 18th of Novemeber we held an introductory meeting with the client where we gained an understanding of what the problem is and what kind of system the client was expecting to be produced. We clarified that we would need to gain our supply of hardware ourselves and that a budget of £150 would be allocated to us to aid with the procurement of the necessary hardware devices. However, within this initial meeting we failed to identify the final direction the client wanted the project to head down and instead came away with the option of either developing a wearable device that would detect when the dementia patient was moving, or to use a non-wearable device such as a pressure blanket that would detect when the patient had got up from where they were static. We agreed with the client that we would schedule a second meeting for the 25th of Novemeber and within that time analyse the advantages and disadvantages to each method of developing the solution. We then agreed that we would return with a solution that we thought would best suit the design brief and that would best suit the development talent available to us within our team.

Within our own intra-team meeting we decided upon building and developing a wearable device solution over a non-wearbale solution due to the extra features that could be included into a wearable device such as a fall detection system, a system recommended to be included by the client. We felt that despite a non-wearable device being a plausible route to take the project down, that factors such as a dementia patient moving off a pressure pad without actually standing up and walking would diminish the effectiveness of our solution.

On the 25th of November we hosted our second meeting with the client and established the team's preferred route for the development of this project. The client was content with this and agreed that the solution should be developed as a wearable device. We finalised the £150 budget with the client and agreed that our next steps would be to complete our milestone 1 document, including user requirements, and compiling a list of necessary hardware to develop the project. Our next meeting with the client is scheduled for December 16th where we will finalise the user requirements and compile a list of hardware to be purchased with the budget made available to us.

Chapter 2

Project Definition

In this chapter, we'll go through the Project in further depth. There will be a brief introduction to the Project's goals and services, as well as the solution that demonstrates how the entire system will operate. The evaluations that will be done will justify if the project functions normally, thus we will outline how we will assess the project.

2.1 Context

The challenge of this project is to develop an effective system that interacts with users, who are dementia patients. The reason we need to make an app like this is that dementia patients must be reminded to take their walking aid with them.

2.2 Description of the Project

This project will support the development of a wearable device including an application. The dementia patient or user will be encouraged to use the walking assistance in this application. A recorded message from a family member or relative will act as the notification. The device will detect if the user is sleeping and only then activate, since we do not want the device to begin notifying the user while he is sleeping, as the user might be startled by the notice.

2.3 Project Solution

2.4 Project Aims

2.5 Project Success and Evaluation Criteria

Chapter 3

Requirements

In this section, we will detail the project's functional and non-functional requirements, which will be broken down to higher-level user requirements as well as lower-level specifications that will detail the process our team will go through to ensure the user requirements are met.

3.1 Functional Requirements

Table 3.1: A table of functional requirements split into user requirements and their relevant specifications needed to meet those user requirements.

Code	User Requirement	Specification
FREQ1	The wearable device should detect when a patient has walked more than 1 metre before communicating with the walking aid.	We can use a tri axial accelerometer to detect changes in acceleration that are indicative of the user moving or being mobile. Once movement is confirmed, we will then commuicate with the walking aid device to ensure the user has successively reached and engaged with it, prior to alerting them to use it.

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Code	User Requirement	Specification
FREQ2	Patients should be alerted with the voice of a friend, carer or relative to avoid startling them.	The device to be attached to the walking aid should include a microphone and speaker that will allow the user to record a voice note and store it on the device. We may need to include an SD card within this device that will store the voice note if need be.
FREQ3	The wearable device should include a solution for deaf people that still reminds them to take their walking aid with them without the need for an audio alarm.	The wearable device could use a vibration motor here that vibrates to remind the user to use their walking aid. We can also utilise the LEDs on board the TinyPICOs to flash to remind the user also. There are issues here with potentially startling the patient with the use of vibration and LEDs, however we feel this is most feasible method for meeting this user requirement.
FREQ4	If development time allows, the system should include fall detection as a stretch goal feature.	Using the tri axial accelerometer mentioned in the specification of FREQ1, we could detect acceleration and movement along the negative side of the y-axis in attempt to detect when the patient has fallen. An alert system can be used in accordance to alert a nearby carer or relative.
FREQ5	The wearable device should communicate to the walking aid device to let it know when it's started moving.	To meet this requirement we investigate the use of 433MHz Rx/Tx modules for low power and low level communication between the 2 devices in the system, this technology should allow for the basic level of communication required, with minimal power use and minimal complexity.

3.2 Non-Functional Requirements

Table 3.2: A table of non-functional requirements split into user requirements and their relevant specifications needed to meet those user requirements.

Code	User Requirement	Specification
NONFREQ1	The watch should be a small enough form factor to fit on the wrist of the patient.	Deciding to use TinyPICO devices as the main board of the device will allow us to keep the device to a small form factor given the TinyPICO is 18mm x 32mm. We will also take into account the form factor when deciding upon extra hardware to add to the devices.
NONFREQ2	The devices shall be power efficient to avoid the patient needing to charge them often.	The TinyPICO devices we will use as the main boards for the devices include an ESP32 chip capable of using deep sleep cycles. These cycles allow the ESP32 to power down non critical components in order to save power. We can create an interrupt within the code here that powers the devices on when an alarm needs to be fired due to the patient moving. This means that the devices will only need to be fully powered on when movement is detected.
NONFREQ3	The devices shall avoid startling the patients with the use of LEDs and vibrations unless they are deaf.	In this case we would power down the LEDs and Vibration motor at all times to avoid startling the patient. Powering down these devices will also allow us to save battery.

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Code	User Requirement	Specification
NONFREQ4	The wearable device should be discrete enough that it does not make patients uncomfortable wearing it.	We intend to design the device to make it as close the design of a watch as possible, keeping it small and sleek so that it looks like a fashion accessory rather than a medical device. Using small hardware devices we can keep a small form factor so that the device is not overly noticeable on the patient's wrist.
NONFREQ5	Security of devices should prohibit outside devices from communicating with the network.	A possibility here is using an agreed upon 'sync word' between our 2 devices that only reads communcations from devices using the same 'sync word'. This would stop other devices being able to communicate with the network unless they knew the sync word being used.

Chapter 4

Risk Analysis

Within this section, we will perform a risk analysis upon the proposed project by providing a list of possible risks associated. Along with the list of risks, we will provide mitigation strategies for said risks. Finally, we will provide a matrix which will be used to detail how likely a risk is to happen and how big of an impact that will risk will have on the project should it happen.

4.1 Risk Identification and Mitigation Strategies

Table 4.1: A table of risks along with strategies to mitigate those risks.

Code	Risk	Mitigation
RSK1	One or more of our hardware devices may fail and will limit how much testing can be done.	To mitigate this risk we will choose to use low cost but still effective hardware, which will allow for extra funds within our £150 budget should we need it to replace hardware during development. We also have the opportunity to attain TinyPICO devices from the University for this project, allowing us to minimise the effects on our budget.

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Code	Risk	Mitigation
RSK2	The Rx/Tx modules could fail and would disable the communication feature between the wearable and walking aid devices.	The replacement of these modules should not be much of an issue due to their low cost. The real issue would arise when an Rx/Tx module fails whilst in operation for a patient. We would need to form a protocol here that detects when communication is unable to occur between the 2 devices, and can alert the patient's carer of this.
RSK3	Code that we upload to the TinyPICO devices could brick the TinyPICO devices and cause them to not function at all.	Should this occur, we could attempt to reflash previosuly working code onto the TinyPICO. If this fails, we would be left with the occurrence of risk RSK1.
RSK4	GitHub could experience a failure which could cause the loss of our repository.	Mitigating this risk is difficult. It's unlikely this will happen and that we would lose our repository as GitHub likely uses a vast backup storage solution. But, should it happen it would be catastrophic and so we should mitigate against this risk. To do this, each developer within the team will store a clone of the repository on their personal system and the team will be able to piece the code back together should this risk arise.
RSK5	We could over-project what features can be included in the project before the given deadline, potentially leaving the client disappointed at project handover.	To mitigate against this risk, we have discussed our user requirements with the clients and feel that we have decided upon a set of features that we confidently implement within the time frame given to us. We will prioritise the most important features to ensure that stretch goal features are added when critical goals have already been met.

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Code	Risk	Mitigation
RSK6	Other work of the University curriculum could impact and delay the development of the project.	We have attempted to account for this within our schedule in chapter **??** by allowing for slippage at the end of the schedule, which can be used for developing incomplete features.
RSK7	Compatibility issues between Arduino libraries and our hardware devices could cause setbacks when developing code.	To mitigate against this risk, we will use hardware devices that have libraries developed for them and hardware that the team have previous experience for successful development in our code.
RSK8	The fast growth of an unknown competitor could fill the void in the market that we are aiming to fill with this project.	It would be difficult to specifically mitigate this risk. We shall ensure that the developed product is made to the highest quality producable by our team.
RSK9	Natural disasters could bring about the loss of hardware and software being used for the development of our product.	The use of low cost hardware in this system will allow us to replace any compromised hardware if need be. We have decided to store the team's code in a GitHub repository which will allow our code to be protected in an off cite facility. The loss of developer computer systems is by far the biggest risk here, where our budget would not be able to cover the replacement of such computer systems.
RSK10	Especially in the current coronavirus climate, our developers may be unwell for a period of time that has a negative impact on the development of the product.	Within our schedule we have included time for slippage that to allow for any time needed by the team to be take off due to illness. Should a developer need to self isolate and should they not be experiencing symptoms, they could continue to work on the product from a remote location using the GitHub repository.

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Code	Risk	Mitigation
RSK11	An Inadequate testing strategy could allow unidentified bugs to be released in the product when handing it over to the client. This could lead to a disappointed client.	To mitigate against this risk we have devised a testing strategy that ensures thorough testing is carried out throughout the development of our product. We are confident that the proposed testing strategy will allow the team to identify and correct errors in the system before the product is released to the client.
RSK12	Poorly developed code could mean that despite substantial testing, many bugs could still be included in the product at the conclusion of the project lifecycle.	To mitigate this risk, we will be following our testing strategy outlined in this document to allow for integration testing. This means that testing will take place every time a new feature is added to the system, allowing us to detect bugs quickly as features are implemented.

4.2 Risk Likelihood and Impact Matrix