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Dementia Voice Assistant

Progress Report
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1. Introduction

Dementia is a leading healthcare concern throughout the world, most prevalent among the elderly, which causes the deterioration of cognitive functioning. People living with late-stage dementia require constant support to continue living safely, which burdens informal carers and healthcare services with considerable financial and resource strain. As the average age of the world's population is rising, the total number of cases is expected to triple to 150 million by 2050 (World Health Organisation 2019). The impact dementia has on healthcare services can be lessened by supporting individuals to maintain their safe independence for longer. This also has the desirable effect of improving the quality-of-life of the individuals through increased self-reliance, social interactions, a sense of control, and general well-being.

Various assistive technologies exist to enable the elderly with mild cognitive impairment to maintain their autonomy and slow the further loss of cognitive functions, such as telecare systems and smart homes (Li, Lu, and McDonald-Maier 2015). This project aims to create the basis of a smart voice assistant (VA) that can reduce the rate of cognitive decline in the elderly. Such a VA could provide support through mental stimulation exercises, environmental monitoring and control, or facilitating communication with carers.

2. Project Evaluation

The first step of the project was to conduct a review of existing literature around dementia care and assistive technologies (Appendix A). I initially searched for literature on Google Scholar, however the results were difficult to extract, and many of the papers found were inaccessible. A second literature survey was instead done through multiple search queries on ScienceDirect (Appendix B.1), which ensured a consistent quality and number of sources that were accessible. Although limiting the search to a single database risks introducing bias to the results, it was deemed acceptable as the survey was primarily intended to summarise the state of research in the field, rather than scrutinize particular findings. Of 215 shortlisted results, 51 were selected for the review, with only 21 papers excluded for inaccessibility (Appendix B.2).

Because of the difficulty finding potential users with cognitive decline, obtaining their consent, and current social distancing restrictions, it will not be feasible to test the final product with actual users. Instead, the developed VA will be assessed by the suitability of its design. It is difficult to generally evaluate the effectiveness of a VA because of the range of functions and features and the varying implementations of them between providers (Jiang *et al*. 2015). As such, each of the primary features will be assessed independently. The basic interaction will be measured by the accuracy and response time of its intent analysis component against a library of sample commands.

This project will be managed using Agile practices, modified for a single developer. As the most common factors influencing the evaluation of Agile software projects are velocity and effort (Kupiainen, Mäntylä and Itkonen 2015), these will be the qualities used to gauge how successfully this project is handled. Velocity refers to the speed of deliverable products and effort refers to the amount of work required to complete a task. A record will be kept of hours of work expected and actually required to reach milestones throughout

the project, which will be tracked in a table (Appendix B.3) and burndown chart (Appendix B.4). The burndown chart will aid the ongoing assessment of the project by representing the difference between the allocated and actual time required for each stage of the project. As the project is not funded, there are no budgeting goals to consider and financial return cannot be used as an evaluation metric.

3. Project Progress

Following early discussions with my supervisor, the idea and topic for the project was decided and the preliminary literature survey (Appendix A) was undertaken. By sorting and analysing common keywords (Appendix B.5) from the surveyed literature a concept map (Appendix B.6) was created to help structure the needs of the project. From this research, I learned about the barriers that limit the success of similar projects including the social stigma of cognitive decline and perceived complexity of technology that dissuade vulnerable persons from seeking help, and the high maintenance and cost of solutions which hinders wide-spread adoption. Although the scope of this project cannot fully address these issues, they were influential in determining the requirements of the VA.

Potential features and were then considered based on the acquired knowledge and the development stages of the project could be planned (Appendix B.7). The risks of the project were also considered during the planning stage (Appendix B.8).

As part of the design stage, an open-source VA – Mycroft (Mycroft AI Inc. n.d.) – was tested as a potential technology to power the proposed VA. A prototype (Appendix B.9) was created using Mycroft as an engine in a Docker container (Docker Inc. n.d.). This was created in an Ubuntu virtual machine I had prepared as a development environment. By creating this prototype and experimenting with Mycroft's existing skills, I was able to assess the practicality of developing a VA from nothing, which was my original intention. I decided that it would be more productive for the project to expand on an existing third-party VA – such as Mycroft or Jasper (Jasper Project n.d.) – and develop features specific to users living with dementia.

As this project will not be evaluated with actual users there are no ethical obligations to consider regarding the testing stage. The developed software will however take into consideration the ethical responsibility of safeguarding user data. As privacy concerns were found among all users of VAs, it is imperative that the VA is designed with complete data transparency, and in-line with data protection regulations such as GDPR.

4. Project Management

A general roadmap (Appendix B.7) of the project was created early on which divided the development into stages. This roadmap was later populated with more detail following preliminary research. The first stage includes the planning and general research that has been completed thus far and the following stages cover the development of the basic interaction functionality, a brain-training feature, design considerations for elderly users, and a companionship/comfort feature. Each of these stages includes its own research, implementation, and evaluation sub-stages.

The project will utilise elements of agile workflows adapted for an individual to manage development. The stages of the roadmap are loosely planned across development sprints, with one stage per sprint, and a closing sprint for any overflow work and the final evaluation and write-up.

All project resources are tracked using Git for version control and the repository hosted on GitHub. GitHub built-in tools have also been used for managing the tasks and timeline of the project including an automated Kanban board (Appendix B.10) that updates when GitHub issues – representing tasks to complete – are created, updated, and closed. Each stage of the project has a corresponding milestone on the GitHub repository to track the progress of that stage proportional to the tasks within it, which will be used for the final project evaluation.

A risk assessment document (Appendix B.8) was created which analysed potential issues that could impact the completion of the project and their consequences. Each risk was assigned values representing the severity of its effect and likelihood of it occurring. Taken together, these values were used to determine that the most significant risks were poor planning, loss of work, and technology integration difficulties. With the risks organised, mitigation

strategies were considered and prioritised. Data loss was mitigated through the use of version control and repository hosting, and the integration difficulties were addressed through the prototype investigation.

5. What Next?

With the research and planning completed for the project, the next step will be beginning the first sprint as outlined in the roadmap (Appendix B.7). This will involve implementing the basic speech-to-text, natural language processing, and text-to-speech architecture on which the remaining features can later be developed. Each of these three components will be based on open-source technologies.

Although one of the desired functions of the VA is the ability to maintain functionality while not connected to the internet, in the event that this is found to be impractical within the allocated timeframe an online only version based on the working prototype will instead be created as a contingency plan. This will minimise disruption to the remaining development sprints, and the offline functionality may be completed at a later date.

The upcoming sprints will continue to make use of the project management tools in place, in particular the Kanban board which will be updated with new tasks within each sprint. Additionally, at each of the discussed stages, sections the final report will be written covering the research for that feature, and details and evaluation of the work completed.

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Appendix A – Draft Literature Survey

1. Method

To assess the difficulties caused by cognitive decline and potential technologies that could mitigate them, a review of existing literature was conducted. The literature was gathered through multiple search queries on ScienceDirect using combinations of the following keywords: dementia, “caring for”, “home care”, palliative, helping, challenges, difficulties, needs, prevention, independence, enabling, preferences, “assistive technology”, “smart home”, capability, voice, assistant, “consumer product”, adoption, elderly, “digital immigrants”, design, “early onset”. Studies mentioning “social media”, student, or diagnosis were excluded. Each search query was refined until it produced 30 or fewer results and exclusion criteria were applied.

2. Dementia

Dementia is the impairment of higher brain functions such as memory and cognitive processing and is commonly caused by Alzheimer’s disease (AD). The World Health Organization (2019) estimated 50 million people worldwide living with dementia burdening individuals, caregivers, and healthcare services with an approximate global cost of US$ 818 billion in 2015. Dementia cases are expected to reach 82 million by 2030 and 152 million by 2050. This inflation is the result of a global aging population caused by increased life expectancy worldwide. Galende et al. (2021) assessed the social impact of dementia to advise healthcare policies in Spain, concluding that robust healthcare programs were essential. Their review found between 4% and 9% of people in Spain over 65 affected by dementia with rates increasing proportional to age. These proportions are typical of other countries.

The decline of cognitive functioning causes difficulties in safety, autonomy, and quality-of-life (QoL) affecting both patients and carers; and various focus groups, interviews, and workshops have attempted to formalise the design requirements of care services based on these concerns (Morgan et al. 2002; Thoma-Lürken et al. 2018; Lockerbie and Maiden 2020). Focus groups with formal and informal caregivers conducted by Thoma-Lürken et al. (2018) revealed 6 recurring domains of problems preventing aging-in-place for people living with dementia: Self-reliance, safety, social, behavioural, formal Services, and cognition; however they did not address the causal relationships between these domains. The most common issues raised were patients suffering a loss of independence and inability to perform activities of daily living (ADL). In a review by Alexopoulos et al. (2002), mid- and late-life depressions were found to exacerbate cognitive decline, and the increased loss of independence produced further depression. One study that focused on support for informal caregivers found that many felt they could continue to provide sufficient care for their dependant for longer if they were given better education and relief as they lacked appropriate training and were hindered by time constraints (Chi et al. 2020).

3. Assisted Living

As technologies such as robotics, the internet-of-things (IoT), and machine learning are developed worldwide, these innovations have been applied to improve the quality-of-life (QoL) for both the fully cognitive elderly and those suffering from cognitive decline (Li, Lu, and McDonald-Maier 2015). Traditionally, caring for people living with dementia would be performed at home by family members until they were unable and the dependent was moved into formal care (Kemp, Ball, and Perkins 2013); however financial pressure placed on both individuals and healthcare services has motivated research into assisted living (AL) technologies to promote “aging-in-place” and allowing

dependents to maintain their autonomy. These advances aim to relieve pressure on healthcare services and informal carers.

Telecare refers to technologies that provide remote healthcare directly to patients in their own homes such as monitoring sensors (Barlow, Bayer, and Curry 2006; Roberts and Mort 2009). These approaches are also referred to as telemedicine and telehealth inconsistently across different authors. Some of the earliest telecare solutions include the EU-ACTION project that began in 1997 – a system intended to introduce ICT into home environments to educate home carers and dependants in correct care techniques (Magnusson et al. 2002).

The ubiquity of IoT devices has led to the notion of intra-connected smart homes in which multiple sensors and devices can communicate and be controlled through a unified interface such as a voice assistant. Cooper et al. (2008) describe “intelligent environments” similar to the newer idea of smart homes, noting how they could assist individuals with cognitive impairments using reminders, directional guidance, or monitoring. They recognise the importance of technology understanding the context of a situation (such as a user’s location or task), an issue that has been addressed more recently with machine learning. Other early work on smart homes also foresaw their use in telecare for elderly and disabled people including those with cognitive impairment (Chan et al. 2008; Chan et al. 2009). Belley et al. (2015) present a practical algorithm for detecting erratic behaviour in people with cognitive decline by analysing power usage of smart devices. Liu et al. (2016) also focused on the benefits of health monitoring of elderly in smart homes, however they conclude that smart homes were not capable of completely supporting the elderly. Rumeau et al. (2020) investigated co-living spaces for elders to reduce isolation with a tangential experiment related to smart home technology.

Shishehgar, Kerr, and Blake (2018) outline a variety of robotics projects for supporting elders including companion robots, mounted mechanical arms, electronic wheelchairs and walking assistants, domestic cleaning robots, and health and time management robots. Wilson et al. (2019) discuss how these robotics projects can be integrated with smart homes.

Despite the number of care projects that have been created, few have seen widespread adoption or made it past early pilot stages due to poor evidence of cost-effectiveness (Obi, Ishmatova, and Iwasaki 2013; Clarkson et al. 2017). The effectiveness of these solutions is difficult to measure because the majority of studies use qualitative means of assessment or failed to apply their findings to a formal framework (Siegel and Dorner 2017). Dodd et al. (2020) were also unable to find an existing measure for assessing the effectiveness of care solutions with respect to the key desired outcomes of stakeholders. Limited study sizes also question the validity of any positive findings in these studies. Among those projects that were deployed, adoption is likely hindered by the deep-rooted social stigma related to dementia and AL technologies; particularly in rural areas (Morgan et al. 2002).

End-of-life care should preserve an individual's dignity and QoL. Östlund, Brown, and Johnston (2012) reviewed palliative care studies to assess how well recipient's dignity was addressed. Palliative care includes solutions to ease the pain of conditions without addressing the cause of the problem. Dementia care is considered palliative as it improves the comfort of the patient and may reduce deterioration, but cannot reverse any existing damage. None of their reviewed studies addressed patients concerns regarding the impact of their own death on their surviving friends and family. Rich relationships, autonomy and control, knowledge, and improved mental health were identified as the desired outcomes of care solutions (Dodd et al. 2020). Lockerbie and Maiden (2020) created a model for defining the QoL goals for people with dementia through workshops with four experienced UK care workers, also concluding that

improving independence and social connectivity were desirable outcomes of support. Gómez (2015) discusses the nature of autonomy for elders and the sustainability of solutions that support their independence, arguing that autonomy should not be accepted as a guaranteed improvement to QoL. Hersh (2014) developed a framework for assessing the outcomes of ICT support.

4. Digital Divide

The concept of a digital divide between elderly (digital immigrants) and younger (digital natives) users of technology is well documented. Digital immigrants are characterised by their struggle or resistance to adopt technology because of decreased learning capabilities, a rapidly changing industry, limited or poor experiences, or lack of confidence; instead using technology only when necessary.

Mobile phones have the capability of improving QoL for elders (Plaza et al. 2011). Many applications are available for encouraging personal health and wellbeing.

Despite the existence of tech-savvy elders and the inevitable generational shift as digital natives continue to age with technology, it is crucial to consider the difficulties caused by natural aging and late-life disabilities that are barriers to assistive technologies (Fischer et al. 2014). The results of a survey into motivations behind elder's technology adoption by Sintonen and Immonen (2013) found that prior experience with technology their own physical limitations are key deciding factors for frail elderly. Their population had an approximately 1:2 split of frail and well-coping elderly. Hawley-Hague et al. (2014) found that concern for their own safety was a another crucial factor in elders adoption of AL technology. A review by Song and van der Cammen (2019) was concerned with how AL technology affects elders living alone.

The needs and preferences of elderly users should be considered before designing any AL technology. Jacelon and Hanson (2013) discuss the benefits of involving elders in the design process for smart homes to ensure they meet the practical needs of this specialist group. Gkouskos and Burgos (2017) also highlight the importance of involving elders in the design process of any AL technology.

Detweiler and Hindriks (2016) formalised a taxonomy for value sensitive design of AL technology and raise the issue of limited coverage of research into all permutations of their identified values, technologies, and contexts.

After interviewing elders who consider themselves technologically savvy, Kania-Lundholm and Torres (2015) question the importance of age as a factor in the Digital Divide; instead finding socio-economic explanations. The elders interviewed were generally highly educated and had used computers as early as the 1970s.

Castilla et al. (2013) created a software tool for the elderly that streamlines common computing features such as email and telecommunication. They realised that simply enlarging icons and text was insufficient for making software accessible. To better aid user's synchronous learning of what capabilities were offered and how to perform them, they concluded that no more than three options should be available at any time. Similarly, Iancu and Iancu (2020) suggest principals to be considered when designing mobile phones for Elders and found that multiple paths of completing the same action were confusing to users. They recommend familiarity and consistency in the design of tasks. Alternative human computer interaction (HCI) technologies have been considered to facilitate digital immigrant's engagement with modern devices.

Hsiao et al. (2017) present natural hand motion controls for desktop applications with limited success. Other means of natural HCI that have been used include voice control and eye tracking (Li, Lu, McDonald-Maier 2015).

5. The State of VAs

Recently, consumer VAs such as Google Assistant and Amazon's Alexa have become familiar presences in households and on mobile devices (McLean and Osei-Frimpong 2019). These consumer VAs are frequently tasked with performing web queries and making online purchases. Current VAs are still somewhat limited, despite considerable advances in natural language processing, however, privacy concerns are a common factor restricting their usage (Ho-Sam-Sooi, Pieters, and Kroesen 2021).

VAs are able to integrate with Smart Home technology and provide a conversational means of controlling the devices within. Conversational controls are accessible even for elders with cognitive decline. Chatbots and natural language interaction computers have been used for various healthcare services (Adamopoulou and Moussiades 2020).

Trust in the VA is an essential requirement as carers and family members will be unwilling to place their dependent's well-being in jeopardy. Poushneh (2021) explored the perception factors of artificial personalities in mobile voice assistants. Hu, Lu, and Gong (2021) investigate how user interactions with and trust of AI are affected by human-like qualities, determining that the humanness of voice output does not impact competence-related trust. However, Hu et al. (2021) found evidence that improving the perceived intelligence of VAs results in more frequent use. Chattaraman et al. (2019) conducted a usability experiment with elders and found that for users with cognitive impairment, an informal personality in a VA was less effective and caused difficulty.

Intent detection involves translating a natural language command into a digital instruction and is a crucial component of a VA. The varying nature of natural language in its terminology, intonation, speed, and context makes this a difficult task that is accomplished only through machine learning such as the

multi-layered neural network used by Firdaus et al. (2019) or the deep neural network used by Lin and Xu (2019) to learn new intents.

Mulfari et al. (2021) approached the task of designing VA system for users with speech disorders by using keyword spotting algorithms for intent detection. Kumar, Deepak, and Santhanavijayan (2020) propose an efficient emotion detection algorithm, although limited. As dementia significantly impacts speech, an appropriate method of understanding a user's request or inferring their need is crucial.

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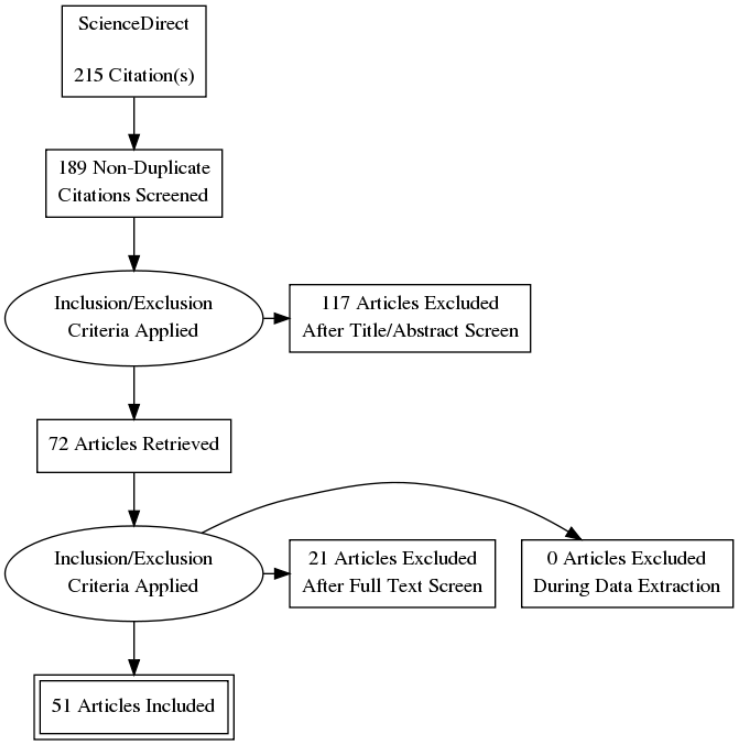
Appendix B – Evidence

1. Search Queries

Query	Results	Source	Performed on
dementia	168,250	ScienceDirect	22/01/2021
dementia helping	5,728	ScienceDirect	22/01/2021
dementia helping challenges	2,993	ScienceDirect	22/01/2021
dementia helping challenges caring	2,501	ScienceDirect	22/01/2021
dementia helping challenges needs	2,214	ScienceDirect	22/01/2021
dementia helping challenges needs palliative	439	ScienceDirect	22/01/2021
dementia helping challenges needs palliative independence	124	ScienceDirect	22/01/2021
dementia helping challenges needs palliative independence preferences	91	ScienceDirect	22/01/2021
dementia helping challenges needs palliative independence preferences care	91	ScienceDirect	22/01/2021
dementia helping challenges needs palliative independence preferences enabling	26	ScienceDirect	22/01/2021
dementia "assistive technology"	408	ScienceDirect	22/01/2021
dementia "assistive technology" difficulties	239	ScienceDirect	22/01/2021
dementia "assistive technology" interaction	264	ScienceDirect	22/01/2021
dementia "assistive technology" difficulties independence	136	ScienceDirect	22/01/2021
dementia "assistive technology" difficulties independence preferences	64	ScienceDirect	22/01/2021
dementia "assistive technology" difficulties independence preferences enabling	30	ScienceDirect	22/01/2021
"digital immigrants"	327	ScienceDirect	22/01/2021
"digital immigrants" usability	0	ScienceDirect	22/01/2021
"digital immigrants" design	264	ScienceDirect	22/01/2021
"digital immigrants" design NOT "social media"	171	ScienceDirect	22/01/2021
"digital immigrants" design NOT "social media" NOT student	27	ScienceDirect	22/01/2021
"digital immigrants" needs	244	ScienceDirect	22/01/2021
"digital immigrants" voice	72	ScienceDirect	22/01/2021
"digital immigrants" voice NOT student	15	ScienceDirect	22/01/2021
dementia "caring for"	64,046	ScienceDirect	22/01/2021
dementia "caring for" elderly	26,733	ScienceDirect	22/01/2021
dementia "caring for" elderly difficulties	10,586	ScienceDirect	22/01/2021
dementia "caring for" elderly difficulties "early onset"	817	ScienceDirect	22/01/2021
dementia "caring for" elderly difficulties "early onset" independence	159	ScienceDirect	22/01/2021
dementia "caring for" elderly difficulties "early onset" independence prevention	99	ScienceDirect	22/01/2021
dementia "caring for" elderly difficulties "early onset" independence prevention "home care"	22	ScienceDirect	22/01/2021
"voice assistant"	153	ScienceDirect	22/01/2021
"voice assistant" capability	46	ScienceDirect	22/01/2021
"voice assistant" capability adoption	23	ScienceDirect	22/01/2021
"smart home" assistant	990	ScienceDirect	22/01/2021
"smart home" assistant "consumer product"	20	ScienceDirect	22/01/2021
"smart home" assistant dementia	78	ScienceDirect	22/01/2021
"smart home" assistant dementia NOT diagnosis	52	ScienceDirect	22/01/2021
"smart home" assistant dementia support NOT diagnosis	50	ScienceDirect	22/01/2021
"smart home" assistant dementia independence NOT diagnosis	26	ScienceDirect	22/01/2021
"voice assistant"	163	ScienceDirect	08/02/2021
"voice assistant" "language processing"	57	ScienceDirect	08/02/2021
"voice assistant" "language processing" technology	50	ScienceDirect	08/02/2021
"voice assistant" "language processing" technology features	40	ScienceDirect	08/02/2021
"voice assistant" "language processing" technology features comparison	26	ScienceDirect	08/02/2021

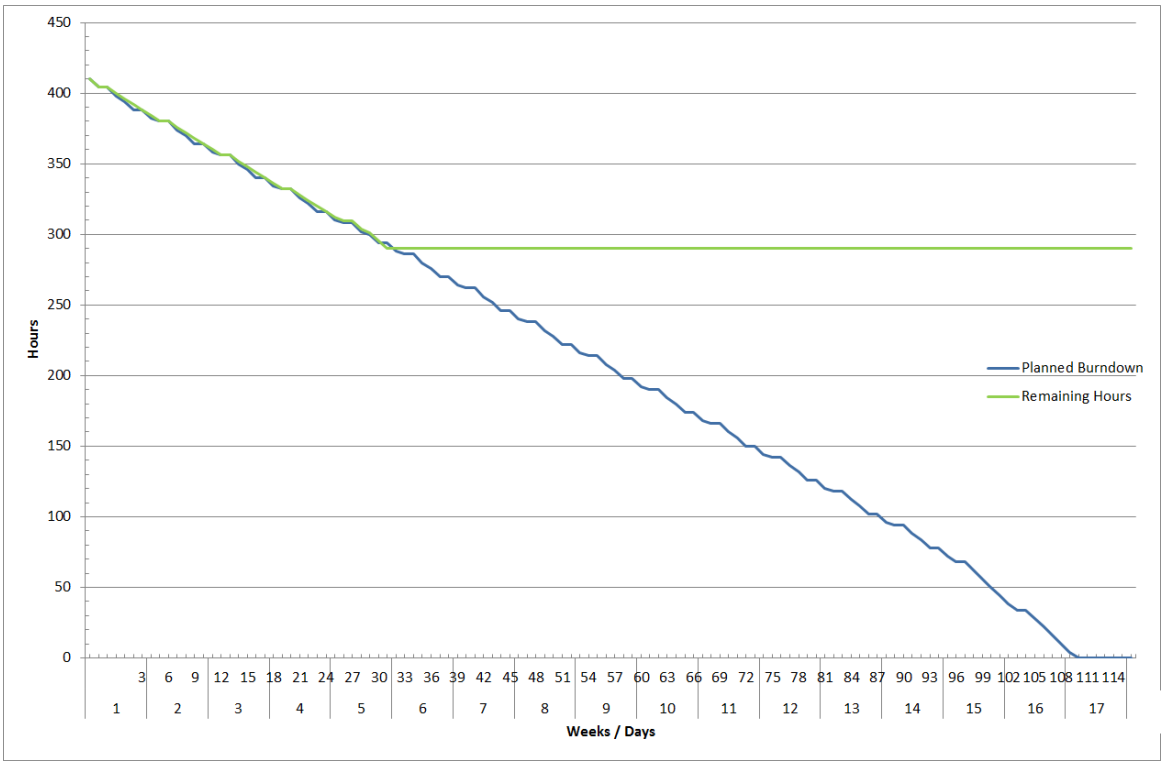
2. Literature Review



3. Project Plan

			Week	Day	Plan	Notes	Planned Hours	Total	Actual Hours	Total
January	18	Mon						0		0
	19	Tue						0		0
	20	Wed						0		0
	21	Thu	1					0		0
	22	Fri		1	Paper Gathering		6	6	6	6
	23	Sat		2			6	12	6	12
	24	Sun		3			0	12	0	12
	25	Mon		4			6	18	4	16
	26	Tue		5			4	22	4	20
	27	Wed		6	Lit Review		6	28	4	24
	28	Thu	2	7			0	28	4	28
	29	Fri		8			6	34	4	32
	30	Sat		9			2	36	4	36
	31	Sun		10			0	36	0	36
Febuary	1	Mon		11			6	42	4	40
	2	Tue		12			4	46	4	44
	3	Wed		13	Lit Review		6	52	4	48
	4	Thu	3	14			0	52	4	52
	5	Fri		15			6	58	4	56
	6	Sat		16			2	60	4	60
	7	Sun		17			0	60	0	60
	8	Mon		18			6	66	4	64
	9	Tue		19			4	70	4	68
	10	Wed		20	Requirements/Plan		6	76	4	72
	11	Thu	4	21			0	76	4	76
	12	Fri		22			6	82	4	80
	13	Sat		23			2	84	4	84
	14	Sun		24			0	84	0	84
	15	Mon		25			6	90	4	88
	16	Tue		26			4	94	4	92
	17	Wed		27	Prototype		6	100	4	96
	18	Thu	5	28			0	100	4	100
	19	Fri		29		Actual hours before this date are approximates	6	106	4	104
	20	Sat		30			2	108	2.5	106.5
	21	Sun		31			0	108	0	106.5
	22	Mon		32			6	114	6	112.5
	23	Tue		33	Progress Report		2	116	2.5	115
	24	Wed		34			6	122	6	121
	25	Thu	6	35			0	122	5	126
	26	Fri		36		Progress Report Due	6	128	5	131
	27	Sat		37			2	130		131
	28	Sun		38			0	130		131
	1	Mon		39			6	136		131
	2	Tue		40			4	140		131
	3	Wed		41	Sprint 1		6	146		131
	4	Thu	7	42			0	146		131
	5	Fri		43			6	152		131
	6	Sat		44			2	154		131
	7	Sun		45			0	154		131
	8	Mon		46			6	160		131
	9	Tue		47			4	164		131
	10	Wed		48	Sprint 1		6	170		131
	11	Thu	8	49			0	170		131
	12	Fri		50			6	176		131
	13	Sat		51			2	178		131
	14	Sun		52			0	178		131

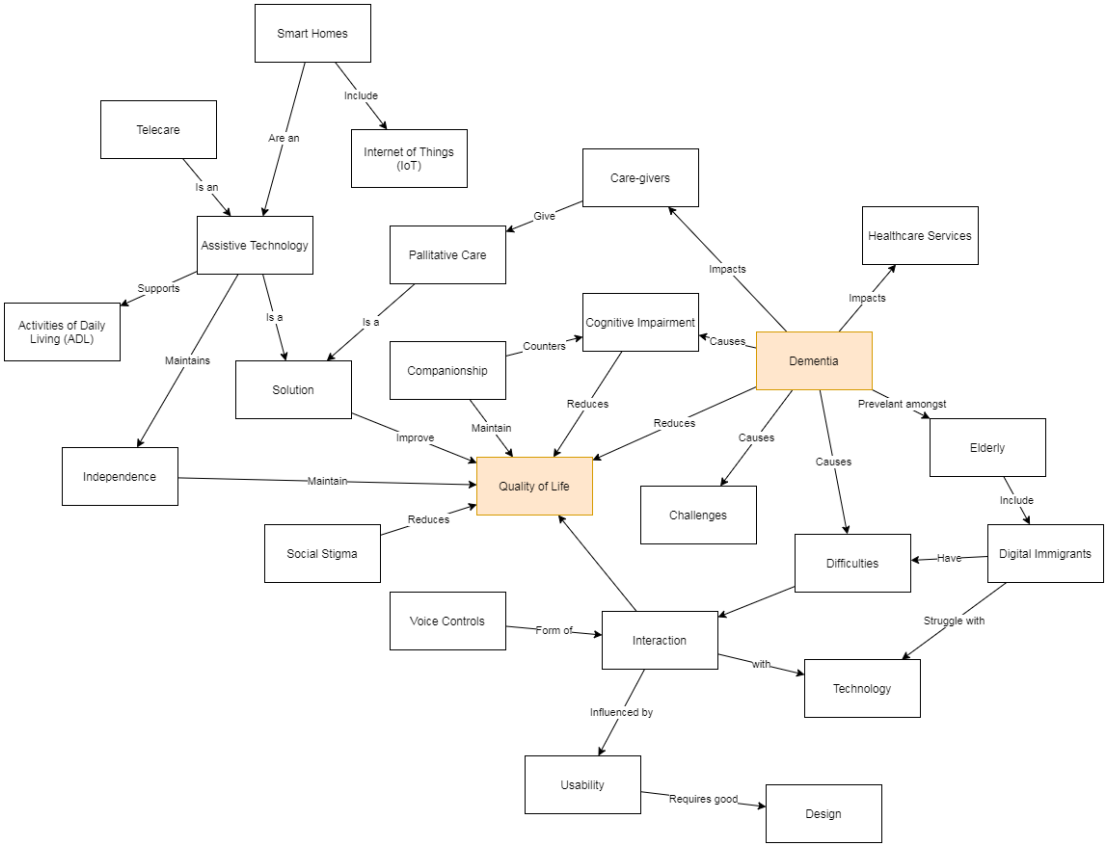
4. Burndown Chart



5. Keywords

Keyword	Occurrences
Elderly	12
Smart home	7
Aged	6
Assistive technology	6
Dementia	5
Machine learning	4
ICT	4
Telecare	4
Quality of life	3
Artificial intelligence	3
Technology	3
Assisted living	3
Palliative care	2
Internet of Things (IoT)	2
e-Health	2
Family caregivers	2
Community-dwelling	2
Robotics	2
Disability studies	2
Digital divide	2
Cognitive impairment	2
Focus groups	2
Frail elderly	2
End-of-life care	2
Voice assistants	2

6. Concept Map



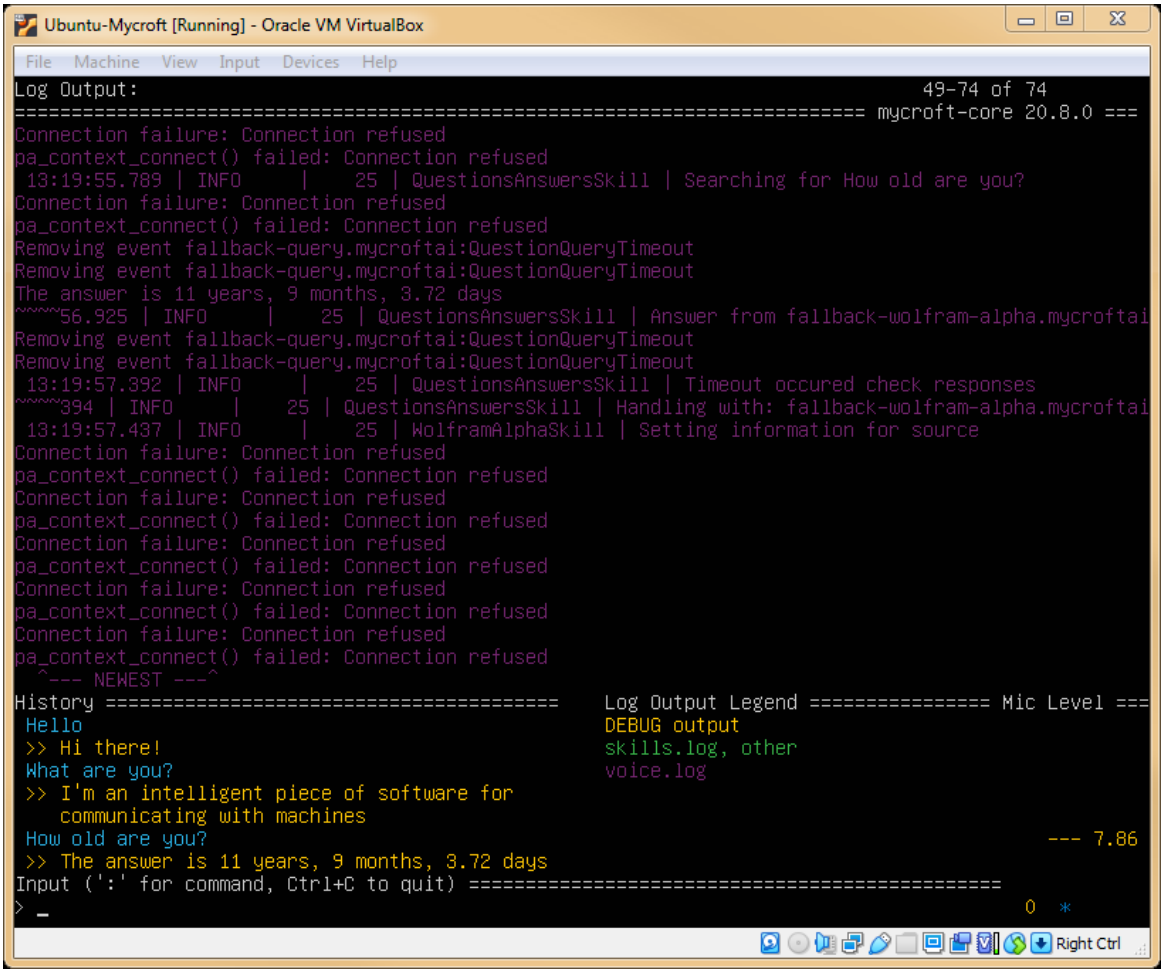
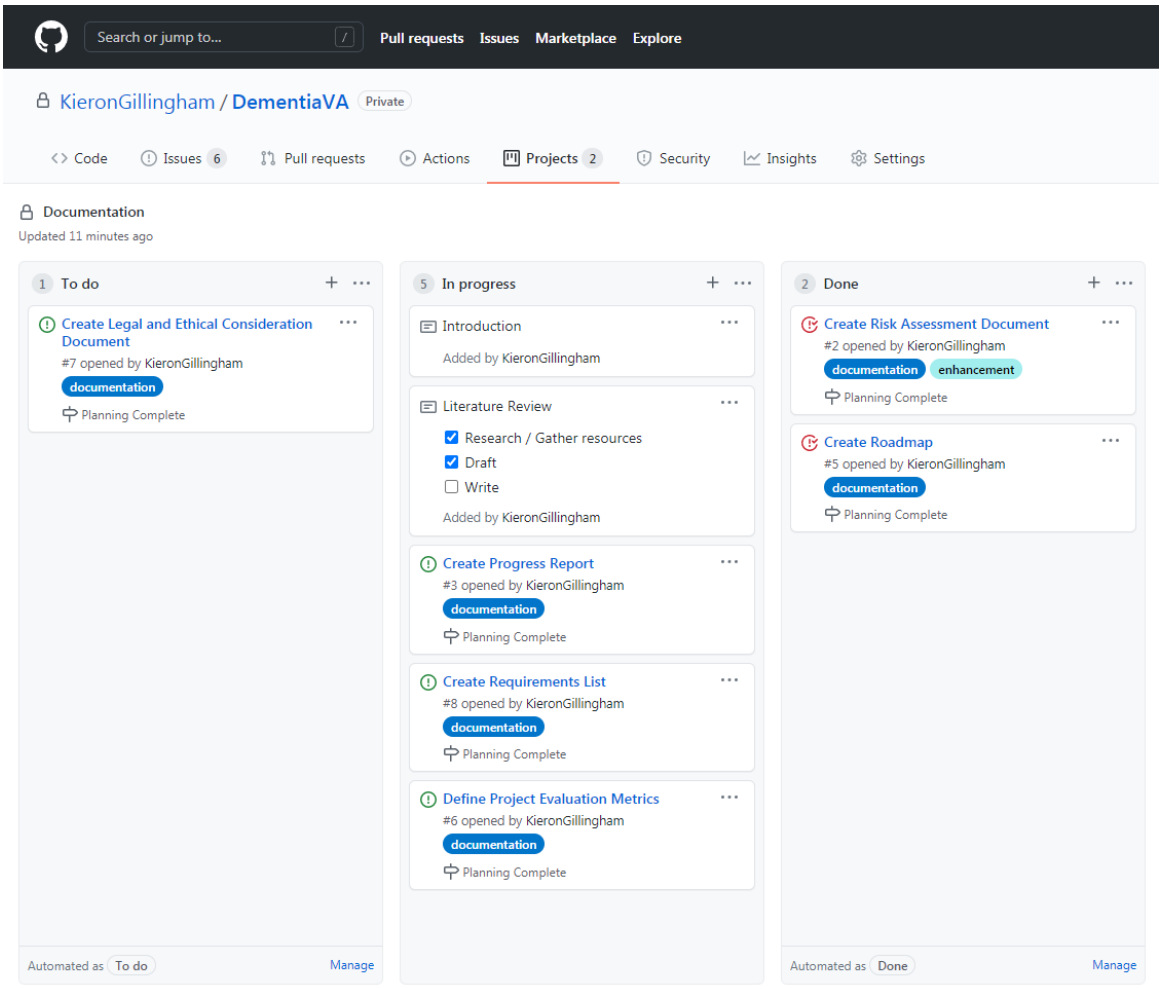
7. Roadmap

Planning
Research
Problem and potential solutions
Project management techniques
Implementation
Literature review
Setting up management tools
Project prototyping
Evaluation
Amend plans
Reconsider aims
Sprint 1 - Self-contained Voice Assistant
Research
Open-source voice assistants
Hardware requirements
Implementation
Create a container to run the voice assistant
Evaluation
Consider feasibility of self-contained voice assistant
Sprint 2 - Brain-training
Research
Cognitive decline reduction exercises
Implementation
Implement brain-training feature
Evaluation
Review usability of feature
Sprint 3 - Convienience Features
Research
Difficulties of elder tech use
Considerations for simple user interactions
Implementation
Improve day-to-day interactions
Evaluation
Assess improvements to usability
Sprint 4 - Companionship
Research
Benefits of companionship for reducing cognitive decline
Implementation
Create companionship feature
Evaluation
Effectiveness of the companionship approach chosen

8. Risk Table

ID	Risk	Likelihood 1 – Unlikely 4 – Very Likely	Consequence	Impact 1 – Low 4 – High	Risk Factor Likelihood x Impact	Mitigation Strategies
1	Poor planning	3	Project overruns / Fails to meet milestones	4	12	Use project management software / Follow a planning process
2	Loss of work	3	Work must be repeated	4	12	Use back-ups / Cloud storage / Version Control
5	Difficulty intergrating technologies	4	Chosen technologies must be reconsidered	3	12	Create prototypes and integration tests
14	Persistant programming bugs	3	Tasks take longer to complete than planned	3	9	Provide lenient development time to address bugs
6	Unclear goals	2	Unnecessary work may be completed	4	8	Clearly define needs and scope of project
7	Chosen technology is unsufficent	2	Chosen technologies must be reconsidered	3	6	Create prototypes and integration tests
11	Developed solution is not suited to live environments	2	Solution may require rework	3	6	Ensure requirements are clear
13	Digital developer environment is not suitable	2	Tasks take longer to complete than planned	3	6	Ensure environment is set-up beforehand and is comfortable
15	Underestimated difficulty of task	2	Tasks take longer to complete than planned	3	6	Allow time near end of project to catch-up
16	Solution is cost in-effective	2	Solution may require rework	3	6	Ensure requirements are clear
3	Loss of back-ups	1	Work must be repeated	4	4	Use multiple back-ups
9	Users unavailable for testing	4	Solution cannot be verified by real users	1	4	Select evaluation strategy that does not require live users
10	Requirements are insufficent	1	Solution may require rework	3	3	Ensure requirements are clear
8	Project requirements change	1	Previous plans may become irrelevant	2	2	Follow an adapatable workflow such as Agile
12	Prolonged loss of access to online resources	1	Supplementary research cannot be completed	2	2	Complete research sub-stages early
4	Unclear commit messages	1	Reviewing code later may become difficult	1	1	Follow a standard or convention for commit messages

9. Prototype



10. Kanban Board