Product: FInDO
Team: ENRS

Abstract

For those with reduced mobility moving around the home can be a challenge. We want to help in this regard by allowing peoples possesions to come to them, not the other way around. To help with this issue FInDO will be able to deliver them preselected everyday items on trays to locations around the house. The robot will be able to map out the layout of the house and navigate back and forth from the tray cubbies to the user. The user will be able to save delivery locations and FInDO will be able to navigate to those locations with tray in hand (or paw). It will be capable of storing and retrieving trays in the cubbies. Using image recognition, FInDO will be able to figure out what is in each of the trays for more intuitive instructing. Lastly, it will have an easy to use interface to control this functionality in the form of both an app and support for voice commands.

1. Goal description

For people living with reduced mobility moving around the home to get items can be a challenge. To reduce the need for this we propose a robot which can bring household items to the user so they do not have to retrieve them themselves.

1.1. Relevance of the system

In 2011/12 6.5 million people in Great Britain had some level of impairment to their mobility (dis). This shows a large need for such a system, and with the population in the UK aging (age) this need will increase in the coming years.

We have determined that an App is an appropriate interaction mechanism based on internet usage in the targeted age groups. In 2018 80.2% of 60-75 year olds had recently used the internet and 43.6% of those aged over 75 years old had recently done so (web). This shows that our choice of using an App to control the robot should be accessible to a large portion of our target market while also retaining the flexibility an App brings.

1.2. High-level description

A typical usage of FInDO will be similar to what follows. The user will select on the app what storage unit they would like to access, and where in the home they are located. FInDO will proceed to move to the relevant storage unit, and pick it up. The storage unit will then be brought to the user at a user specified location. The storage unit will remain in that location as needed. When the user wishes for the storage unit to be returned FInDO will proceed to pick up the unit again and take it back to the storage area.

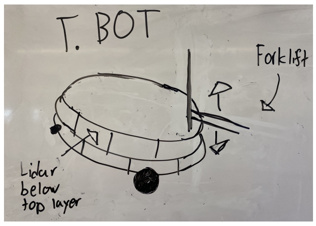

Figure 1. Sketch of FInDO

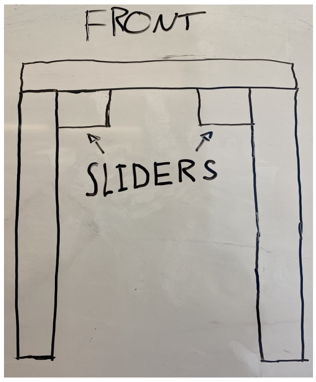

Figure 2. Sketch of front view of storage unit

1.3. User Stories

1. FInDO should be able to identify and collect the correct storage unit. The robot needs to associate items with given storage units and be able to retrieve the correct storage unit when needed.

2. The robot should be able to navigate its way around the home to get to the destination. We intend for the robot to have a mapped version of the flat/house/space it is operating in. With that, the robot should be able to make autonomous decisions on how to get from one place to another. This is useful for the user as this is what makes the robot capable of bringing the items to the user.

3. The robot should be able to detect obstacles and change route accordingly. It is important that the robot does not just follow a fixed route as this could lead to a failure to deliver items, or result in a collision. This gives the user confidence that harm will not result from use of the product.

4. FInDO should be able to bring storage units to multiple specified locations throughout the home. This gives the user flexibility to be in multiple places in the home rather than having to be in a specific location to have items brought to them.

5. The robot should be controllable by a mobile/web application. We intend for there to be a mobile/web application that would be used as a way to remotely control the robot. The user should be able to specify a location where they are located and an object they would like to access and have the correct unit brought to them.

6. The robot should have voice activation. We intend for the robot to be activated by voice if the user does not have their phone with them. Saying the words “Fido, fetch me item name to destination!” would activate the robot which would then identify the item in question and take it to the destination.

7. The robot should be able to identify objects placed in storage units so that they can be associated with them. This helps users as they do not have to input the items manually, which would be very inconvinient for many people and be a long process.

2. Task planning

2.1. Milestones

We’ve identified five main subgoals and their respective milestones. For each milestone we have also given the completion evidence that we plan to present as well as when we hope to have the subgoal completed.

A: Locomotion Subgoal:

1. Milestone: Able to plot a route and navigate around the house from cubbies to saved locations. Needs to be able to avoid collisions with unexpected obstacles.

2. To be completed by Demo 2 (February 26)

3. Evidence: Put turtle bot in pre-mapped demo room, have it navigate from one predefined location to a few others. Place obstacles in path of robot and ensure it doesn’t collide with them.

B: Mapping Subgoal:

1. Milestone: Able to map house using SLAM (gma), locate itself in the house (amc), and remap on the fly if new obstacles are added.

2. To be completed by Demo 4 (March 30)

3. Evidence: Have turtle bot map demo room and show map to experts. Place new object in room and show live map regeneration. Place turtle bot in random position in demo room and have it mark its position on map.

C: Lifting Subgoal:

1. Milestone: Able to pick tray out of cubby, raise to present tray to user, and deposit tray back in cubby

2. To be completed by Demo 3 (March 9)

3. Evidence: Have turtle bot remove tray from cubby, lift it up and down, then deposit it back in cubby

D: Communication Subgoal:

1. Milestone: User can activate bot from app or by voice, instructing it which item to deliver and where to. Bot will be able to recognize what items are on trays through image recognition

2. To be completed by Demo 3 (March 9)

3. Evidence: Instruct bot to do simple locomotion task through app and voice command

E: Image Recognition Subgoal:

1. Milestone: Bot can recognize item on tray and deliver correct tray when instruction requests specific item

2. To be completed by Demo 4 (March 30)

3. Evidence: Place different items on a tray and have bot correctly identify them

2.2. Task decomposition

Please see Table 1 below for task decomposition, and Figure 3 for our Gantt chart.

The task decomposition contains our identified subtasks, along with the date on which they need to be completed, and which of the tasks are dependent on them. Also included is a short desciption of what the task will accomplish.

We have tried to keep tasks such that they only depends on other tasks within their subgoal, toward the end of the project this will no longer feasible but it should help with progress in the early stages.

2.3. Resource distribution

Please see Table 2 for time resource distribution. Included is the activity type and how long we expect each member to spend on it. These are likely to vary member to member (i.e different number of workshops attended), but we expect the average to be around what is stated.

Equipment:

- Turtlebot
- Lego Mindstorms EV3
- Lego
- 3D printer
- Wood/Shelving components
- Motors

Project Gantt Chart Plan **DATE** 1/21/20

WBS NUMBER	TASK TITLE	START DATE	END DATE	DURATION
1	**Submit Project Plan**			
1.1	Group Meetings	Mon, Jan 13	Fri, Jan 24	10 days
1.2	High Level Description	Mon, Jan 20	Fri, Jan 24	3 days
1.3	Milestones	Mon, Jan 20	Fri, Jan 24	3 days
1.4	Gantt Chart, etc	Mon, Jan 20	Fri, Jan 24	3 days
2	**First Demo / Report**			
2.1	Group Meetings	Mon, Jan 27	Fri, Jan 31	3 days
2.2	Submit Demo Report	Mon, Jan 27	Mon, Feb 3	6 days
2.3.1	Mapping (Build environment)	Mon, Jan 27	Wed, Feb 5	8 days
2.3.2	Mapping (Setup SLAM)	Mon, Jan 27	Wed, Feb 5	8 days
2.4	Lifting design	Mon, Jan 27	Wed, Feb 5	8 days
2.5	Basic SSH into raspberry pi	Mon, Jan 27	Wed, Feb 5	8 days
3	**Second Demo / Report**			
3.1	Group Meetings	Mon, Feb 10	Mon, Feb 24	13 days
3.2	Submit Demo Report	Mon, Feb 10	Mon, Feb 24	13 days
3.3	Saving Locations on map and navigation	Mon, Feb 10	Wed, Feb 26	15 days
3.4	Cubby implementation	Mon, Feb 10	Wed, Feb 26	15 days
3.5	App communication	Mon, Feb 10	Wed, Feb 26	15 days
3.6	Start on voice control	Mon, Feb 10	Wed, Feb 26	15 days
4	**Third Demo / Report**			
4.1	Group Meetings	Mon, Mar 2	Mon, Mar 9	6 days
4.2	Submit Demo Report	Mon, Mar 2	Mon, Mar 9	6 days
4.3	Insert trays into cubbies	Mon, Mar 2	Wed, Mar 11	8 days
4.4	Further App functionality (specifics?)	Mon, Mar 2	Wed, Mar 11	8 days
4.5	Voice activation	Mon, Mar 2	Wed, Mar 11	8 days
5	**Final Report and User Guide**			
5.1	Group Meetings	Wed, Mar 11	Mon, Mar 30	18 days
5.2	Submit Demo Report / User Guide	Wed, Mar 11	Mon, Mar 30	18 days
5.3	Remapping for new obstacles	Wed, Mar 11	Wed, Apr 1	20 days
5.4	Image recognition	Wed, Mar 11	Wed, Apr 1	20 days
6	**Final Demonstration**			
6.1	Group Meetings	Wed, Mar 11	Wed, Apr 1	20 days
6.1	Polish Robot	Wed, Mar 11	Wed, Apr 1	20 days
6.2	Polish UI	Wed, Mar 11	Wed, Apr 1	20 days
6.3	Fully integrate multiple destinations and tray management	Wed, Mar 11	Wed, Apr 1	20 days
7	**Trade fair with Industry Guests**			
7.1	Group Meetings	Wed, Apr 1	Fri, Apr 3	1 days

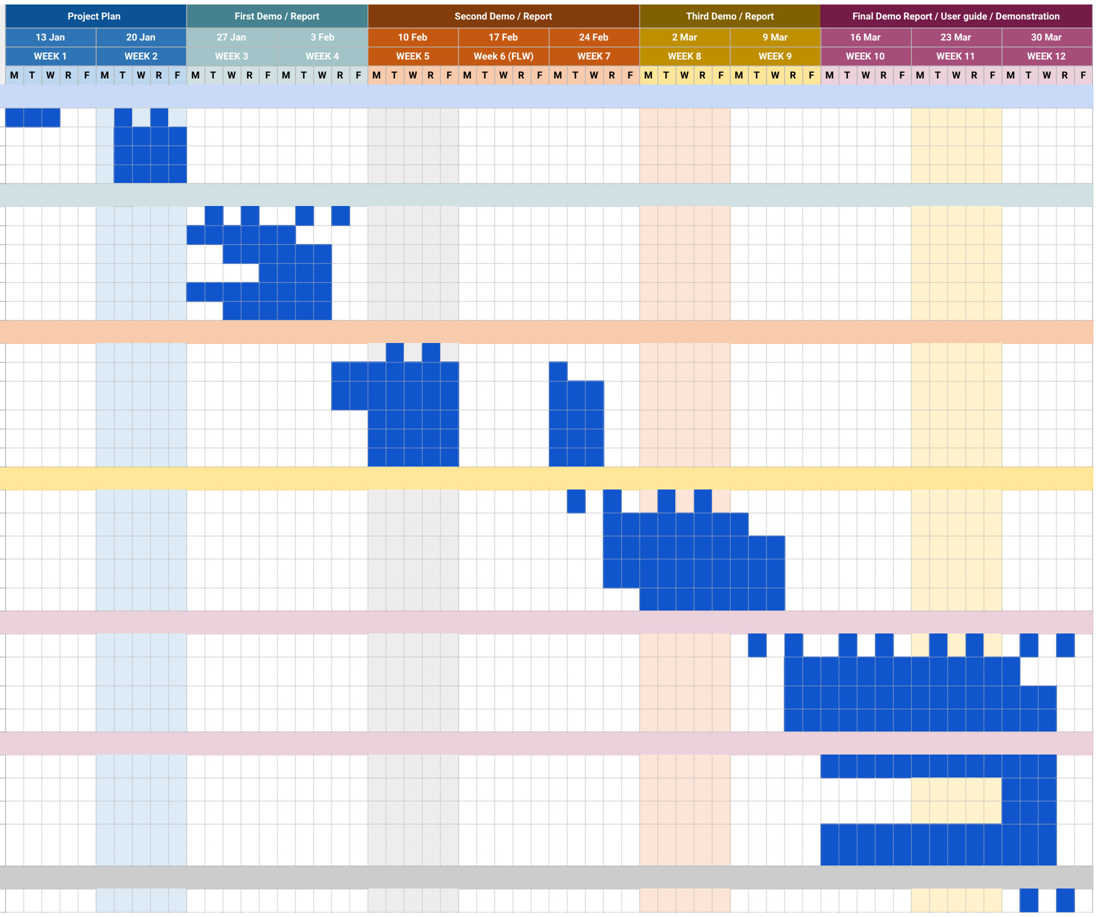

Figure 3. Gantt chart for main milestones

Task Name	Subgoal	Deadline	Dependencies	Rough description
Mapping house	Mapping	February 3	N/A	Generate map of house using SLAM
Forklift design	Lifting	February 3	N/A	Design the parts of the robot that allow it to lift trays.
Cubby design	Lifting	February 3	N/A	Design an effective stacking and storing system for the trays.
Tray design	Lifting	February 3	N/A	Design trays that can be stably carried by bot and stored efficiently
Navigation to point	Locomotion	February 24	Mapping house	Navigate on map to any given point within house
Forklift implementation	Lifting	February 24	Forklift design	Build forklift and ability to move it up and down.
Cubby implementation	Lifting	February 24	Cubby design	Build cubby
Tray implementation	Lifting	February 24	Tray design	Build trays
App interaction	Communication	February 24	Navigate to point	App can activate and instruct bot
Interact with cubbies	Lifting	March 9	Cubby imp. Tray imp. Forklift imp.	Able to retrieve and store trays in cubbies
Voice interaction	Communication	March 9	Navigation to point	Reacts to voice commands through smart home equipment
Continuous map generation	Mapping	March 30	Navigation to point, Mapping house	Able to remap as it navigates to account for new obstructions
Identify items on trays	Image Recognition	March 30	Cubby imp. Tray imp. Forklift imp.	Able to recognize what items are on trays through image recognition

Table 1. Task decomposition for the system

- Raspberry Pi
- Arduino
- Shelving components

Skills:

- Front end web development experience
- Database experience
- Python
- Java
- C++

2.4. Risk assessment

Lack of Hardware Experience

The majority of this team are more proficient in software with limited hardware skills. We have identified this weakness and have a team that will focus heavily on hardware. Appropriate resources will be used, including the provided experts, at the early stage of this project in order to allow for a learning curve and any other hidden problems. Also the earlier completion of the hardware will allow the software team to understand the capabilities that they will be dealing with.

Team Cohesion

There is a lack of experience of working on a large project like this, as such there may be problems in management and effective time allocation of team members. We have split the team into general areas of hardware and software(On robot and App) in order to give a clear focus on their role within the project. Flexibility between areas is also implemented in case extra/less hours are required for certain parts of the project. General meetings will be held regularly and open communication between all team members through slack, github etc, will update the team on the condition of the project. This will allow input from all members and checks in the quality of the product.

Sell Factor

This project will be focusing on a helper bot that works as

Activity (per member)	Estimated Time Consuming(hrs)
Opening Session	3
Workshops	5 (depends on individuals)
Project pitches	2
Group Meetings	20
Report Writing	15 (depends on individuals)
Demonstrations	10 (depends on school timetable)
Demo Prep	5
Individual Working	125
Trade Fair & Others	15
Total	200

Table 2. Resource distribution

an aid to those that struggle with getting everyday items. As the audience target market would include the elderly and infirm, we realize the high quality of standard/service that our project must have in order to be recognized as a feasible product. We understand that this would be a tough market to break into and will plan our functionality accordingly with use of provided experts and internet research/statistics.

Lift Mechanism

The lifting mechanism of the turtle bot is critical to this project. Main areas of problems will arise with the balance of the bot and the stability of taking out a tray down to the bot. To combat this the bot should be under the tray that it is using and we will ensure proper caution is given to the planning that will heavily incorporate solutions to these obvious problems. Opinions will be sourced from the technicians at various stages with multiple potential prototypes in order to find an optimal solution.

3. Group organisation

To communicate within the team we are using Slack for messaging, to manage the project we will be using Github Projects. To share code we will be using a central GitHub repository for all of the projects code - using a single repository will ensure all members will have access to the latest version of the entire codebase for reference.

We plan to have meetings 1-2 times per week to check in on progress throughout the team and discuss any issues that need to be resolved. A member of the team will take on the role of chairperson each meeting to keep the meetings on track.

Members have been split between 3 sub-teams for each of the 3 main areas of the project. Hardware design, software design (Robot side), and software design for communcation (app and voice activation). Members have been assigned to these teams based on experience and preference for the relevant tasks the teams will tackle. These teams are not concrete and we anticipate a large degree of flexibility and interworking during the project. Tasks within these sub-teams will be assigned to members based on ability, and current workload from other tasks they have taken on. As tasks are completed we anticipate moving members around to different teams as work demands.

We will be tracking progress using Github Projects, which presents a Trello-like card interface which is nicely integrated into Github. We will be asking members of the team to update any progress they have made daily. This will allow for early detection of issues with task progress, so members can help troubleshoot and resolve issues. During meetings we will also check the projects overall progress compared to the milestones highlighted early in the document to ensure that we are on track and make changes accordingly.

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