



Product: FInDO
Team: ENRS



Abstract

For those with reduced mobility, moving around the home can be a challenge. We want to develop a system which can help in such cases by bringing a person's possessions to them, not the other way around. FInDO will be the home assistant that can deliver collections of everyday items to different locations around the home. These items can be stored out-of-the-way on trays in the paired shelving unit somewhere in the house, and FInDO will be able to autonomously collect and deposit trays at this unit. After being installed, FInDO will map out the layout of the house, and thenceforth be able to navigate between the user's locations and the tray cubbies. Using image recognition, FInDO will be able to figure out what is in each of the trays, so that users can request an item without having to remember which tray it is in. Lastly, the human-interfacing components will be easy-to-use and accessible, comprising an app and voice commands.

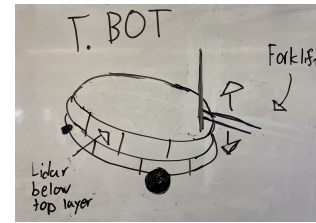


Figure 1. Sketch of FInDO

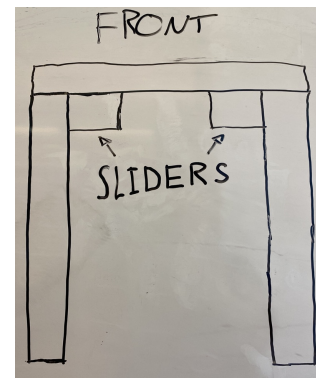


Figure 2. Sketch of front view of storage unit

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 were living with some level of impairment to their mobility ([dis](#)), and at the moment there is an aging population within the UK ([age](#)). It can be seen that there is need for a robot like FInDO, and such need can only increase in the coming years.

We have determined that an app is an appropriate controller for the end user, based on internet usage statistics among 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 a webapp-like interface to control the robot should be familiar to a large portion of our target market.

1.2. High-level description

A typical usage of FInDO will be similar to what follows: the user will select on the app which tray of items they would like delivered, and where in the home they are located; FInDO will proceed to move to the relevant storage unit, and pick up the specified tray from it; the tray will

then be brought to the user's location. FInDO, with the tray, will remain in that location for as long as needed, and when the user wishes they can dismiss FInDO and FInDO will carry the tray back to the storage unit, and return it into its place.

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 inconvenient 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.
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 description 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 be 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

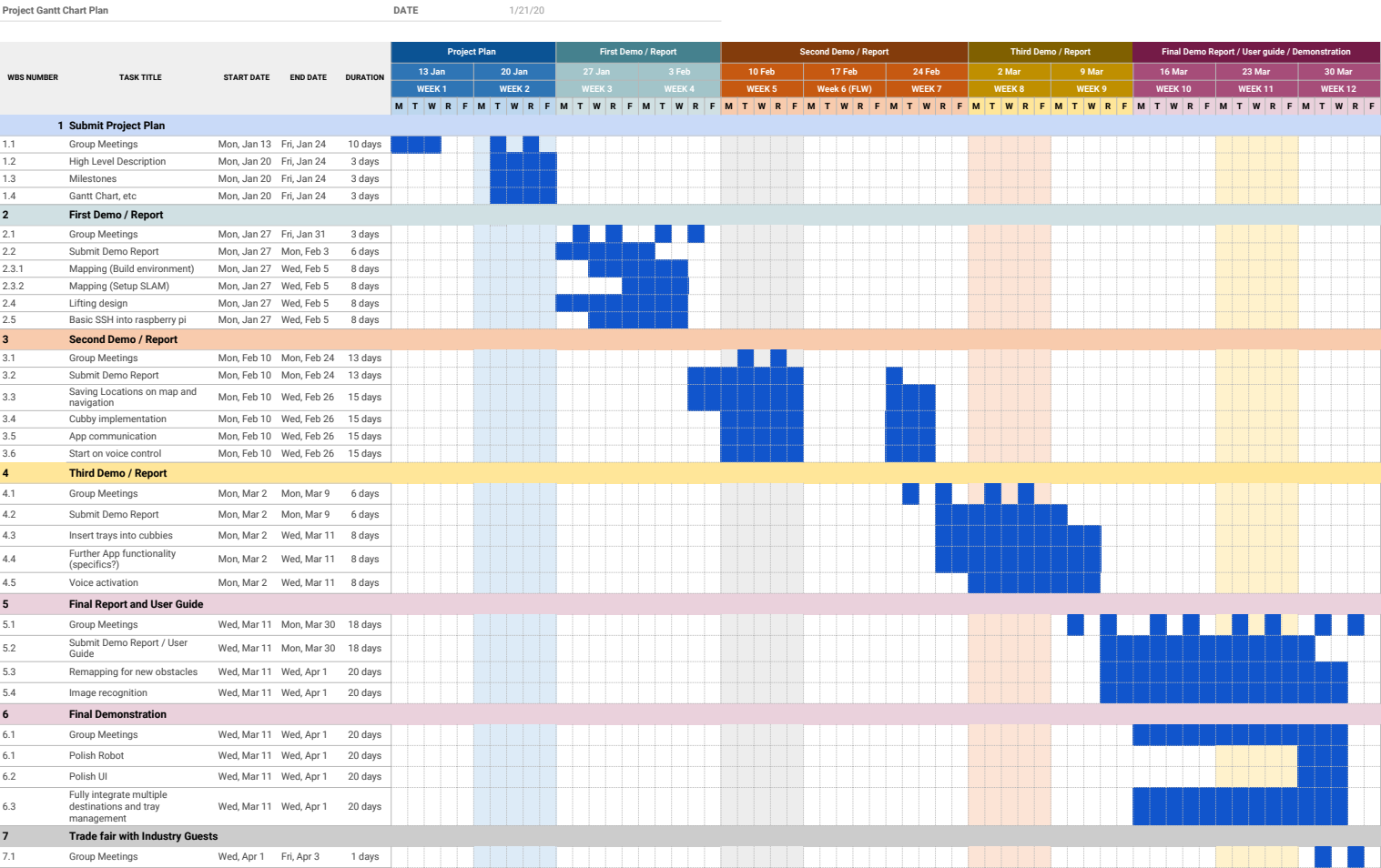


Figure 3. Gantt chart for main milestones

| 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

- Motors
- 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.

Autonomous Navigation

We are currently unsure if we are able to get the bot to learn the environment and then navigate to desired locations by itself. Should this turn out to be too difficult, we plan to have the user teach the bot fixed paths by moving it with the app.

Mobile App

From our preliminary research, it seems that TurtleBot-Android communication could be problematic. Should we not be able to get it working, we will try to implement a web app instead as there seems to be greater support for this.

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 communication (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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