# Project Final Report: The Bettybot

**Brendan Dueck**
University of Calgary
Calgary, AB, Canada
*bsdueck@ucalgary.ca*

**Hadiya Firdaus**
University of Calgary
Calgary, AB, Canada
*hfirdaus@ucalgary.ca*

**Debbie Macrohon**
University of Calgary
Calgary, AB, Canada
*dtmacroh@ucalgary.ca*

**Edrienne Manalastas**
University of Calgary
Calgary, AB, Canada
*edriennefranciamarie@ucalgary.ca*

## Abstract
More and more seniors require assistance in their home, and Bettybot is a proposed solution to this problem. Bettybot's initial design and scope has undergone changes. The scope has been modified and updated in order to better solve original goals, like building trust, but with more specific limitations addressed based on a better understanding of the robot. The design has evolved a lot to include considerations about: passive interactions and their implicit effect on trust-building, proxemics, aesthetics, and the major vector of interaction: dialogue. Each interaction workflow has been further fine-tuned to achieve the initial goals of Bettybot. We look at strengths and weaknesses of the current iteration of the robot. This is also evaluated using the robot taxonomy discussed in class. This has resulted in improving development of more meaningful interactions and better understanding the problem-space.

## Author Keywords
Pioneer robot; elderly; retirement; pill reminders; medicine; HRI and elderly; Pioneer P3-DX.

## Problem
Falls are one of the main causes of mortality, immobility, and early nursing home placement in the elderly. The combination of high incidence of falls, high susceptibility to injury, and occurrence of clinical diseases can make even a mild fall dangerous for the elderly. Falls often cause healthy independent elderly people to lose mobility and require constant care. [1] Hence, it is very important that elderly people who have fallen receive immediate care so that they can be treated and so have minimal effects on their later quality of life. Thus, getting them immediate help when they are on their own and have fallen, without compromising their privacy and independence, is an important problem for improving the lives of the elderly.

## Our Initial Solution
One of the main objectives of our robot is to assist elderly people when they experience a fall. This will involve providing a level of effective support and a means to escalate the matter further by contacting an emergency contact that has been previously set up by the user.

Our ultimate goal is not to simply create a single purpose robot but an entity that that allows elderly people to live on their own and feel safe in case of emergencies. An important note is that while aiming to

achieve this, we want to explore on the depth of each deceptively simple human-robot interaction to give the user the best possible experience with our robot -- so they feel safe and independent.

With Bettybot, our goal is to help make seniors' lives better without forcing them to become dependant on a senior home or a personal aid worker. We aim to create a robotic entity that can fulfill specific needs of the elderly, and also one that elderly people can feel comfortable around.

Some nice to have (optional) features that the team is hoping to implement includes:

1. Pill carrying and medication reminder throughout the day (Breakfast, Lunch, Dinner). Reminders require acknowledgment from user, else another reminder will happen in another fifteen minutes.
2. Ability to set alarms/reminders
3. Ability to call others
4. Ability to show entertainment on the laptop (pictures, news, music, etc)
5. Ability to control smart home devices

## Updated Scope

The initial scope was to ensure the elderly person's safety while keeping their independence and privacy intact. This scope has now been expanded to also consider how to build trust and companionship with the elderly person, because this is important to the building of a long-term relationship and allowing the elderly person to believe the robot will be able to help them in their times of need. So the problem space, rather than just handling problem areas like falls and pill reminders, will also include general interactions like providing entertainment or a means of conversation. Furthermore, rather than just having audio conversation through the Google Home, also provide a way to use the physicality of the robot to create a meaningful interaction. We have looked at doing this by creating a memory game for the elderly person.

## Updated Limitations

The initial limitations, as in what wasn't being implemented, was as follows:

1. Mapping: the robot is unable to map the full environment it is placed in (i.e if a robot is placed in a home, it is only able to react according to its immediate surroundings, it cannot dynamically tell where each room of the house is)
2. Tracking: the robot will not actually be able to track and follow the movements of the elderly person in their home. This will be simulated by us in order to focus on the actual interaction.

Both of these things still hold. A further limitation has been added, given a better understanding of the robot's ability.

1. Visual: The robot will not respond to any visual cues (or through sonar), as that will introduce another vector of interaction that will complicate it a lot.
2. All dialogue by the elderly person will need to be prefaced with "OK Google" in order to trigger the Google Home, which builds in a sense of artificiality to the interaction.

## Current Strategy

The ARIA SDK is integrated with the Pioneer robot, and runs the robot navigation functionality which is controlled by one of us. A python script then runs that responds to the Google Home, which is set atop the Pioneer, and deals with the voice interaction. A phone accelerometer has been hooked up with IFTTT (If This Then That) in order to notify a Dropbox server that a fall has occurred, which activates that python script.

Physical movements that are programmed need to override the user-controlled movements.

## Design Evolution

*Initial Solution*
In Phase I, the team focused on active interactions between the robot and the elderly person where the robot would be able to provide straightforward aid to them. These interactions were handling an elderly person's fall, providing pill reminders (and the pills) to the elderly person at appropriate times, and providing entertainment to prevent loneliness during extended periods of idleness, and providing connections to loved ones. These interactions focused primarily on how the robot could provide the most use value for the elderly person.

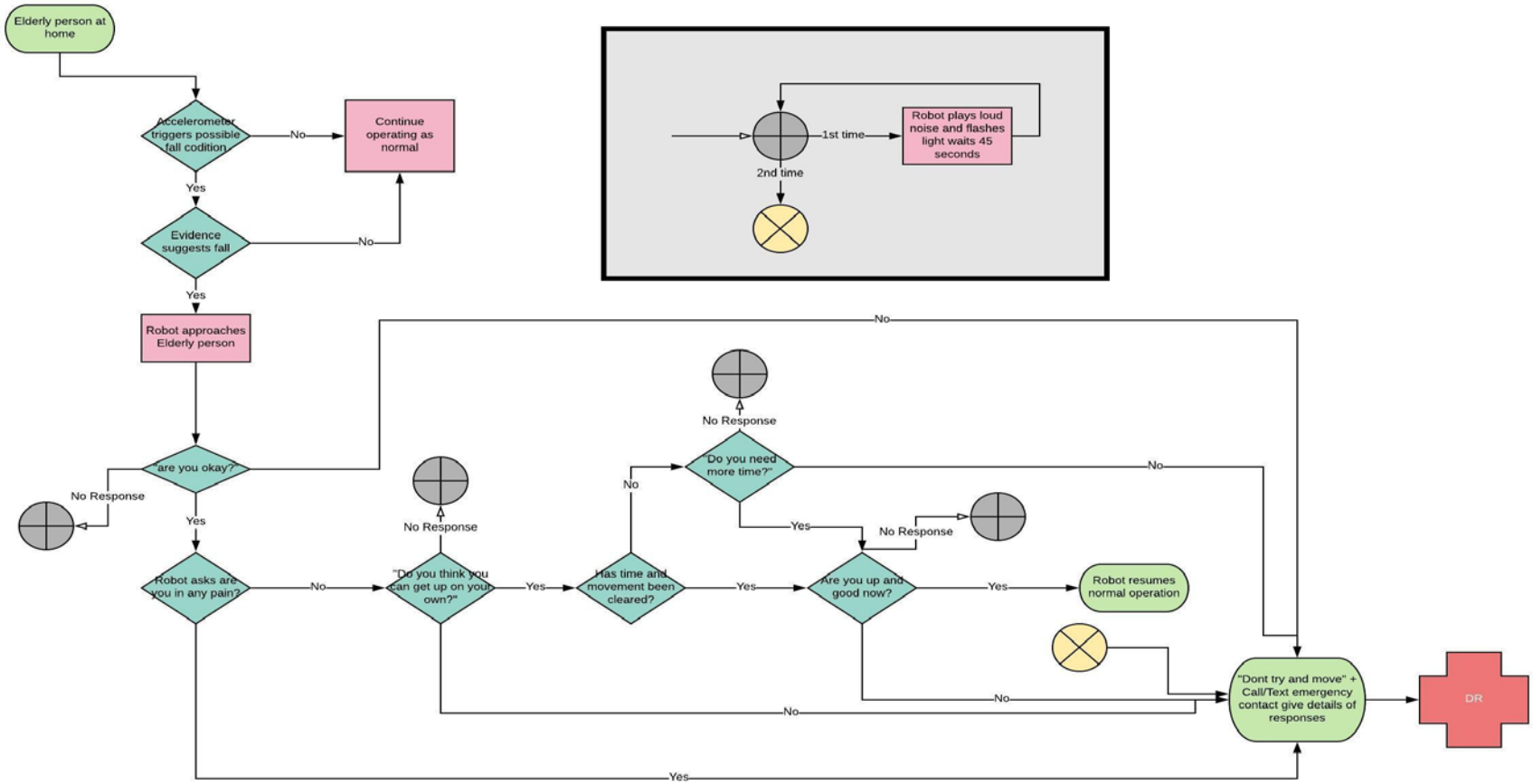
*Passive Interaction*
After receiving feedback on the design workflows for this, we realized that a lot of the interaction is occurring between Bettybot and the elderly person implicitly and was not related to having a conversation. For example, we wanted the interactions to be efficient so the elderly person could get help as soon as possible for the falling scenario, however, this made Bettybot seem more superior and controlling when it was meant to be more of an assistant. In Phase II, we made sure to put the interaction and whether the elderly person can build trust with the robot -- which takes priority for the majority of interactions -- at the forefront of these scenarios. We also realized we needed to focus more on passive interactions, such as the everyday interactions that occurred between the elderly person and Bettybot when no "event" (as the original scenarios were all event-based, i.e. a fall occurred, it was pill time, etc.) occurred. These interactions would be the interactions that would occur 80% of the time and needed to be considered, furthermore these interactions are vital to building trust *for* when an "event" occured. One of the questions we did not consider was: what does Bettybot do when it is not needed? The general outcome was that Bettybot follows the elderly person around at a distance in order to keep them aware of her presence and to encourage interaction, and unless an event occurs to cause her to speak, remains quiet.

*Proxemics and Aesthetics*
Phase II also resulted in discussion over proxemics (e.g. how the robot's distance to the elderly affects their interaction). This allowed the difference between passive and active interactions to be considered: a passive interaction would involve more distance (but enough proximity to create a sense of familiarity) and an active interaction would be closer in order to convey care.

The sense of proximity also brings into question the aesthetics. We chose to change the robot's appearance and incorporated a personality to Bettybot as well. Since most of the active interactions necessitate closeness, Bettybot needs to look friendly and trustworthy. For example, we will be placing fur around Bettybot's body to make it more animal-like and approachable. However, Bettybot also needs to look reliable, i.e. it will be holding the pills for pill time and needs to look stable and capable of carrying them safely.

*Dialogue*
One of the main components of the interaction between the elderly person and Bettybot is dialogue. This interaction developed and changed a lot as we iteratively tried to improve the interactions.

One of the major points we had to consider was in the falling interaction: given that the intended users are relatively mobile and healthy seniors and in order to balance that with their safety, how does Bettybot ask the elderly person if they can get up on their own?



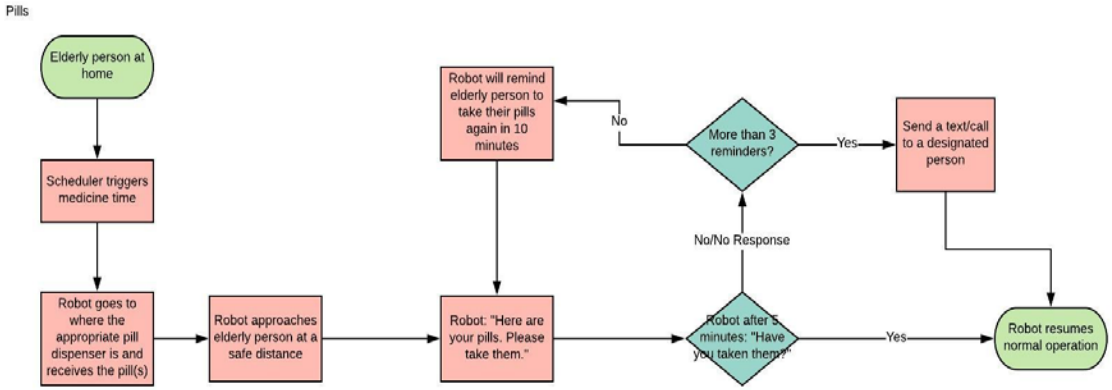

## The Fall Interaction Workflow

To get to that point of the interaction, the following has happened:

> *Senior falls. Bettybot approaches.*
> Bettybot: Are you OK?
> Senior: Yes <etc>.
> Bettybot: Do you feel any pain?
> Senior: No <etc>.
> Bettybot: Do you think you can get up on your own?

That last question opens up a can of worms. The senior should not in any way feel pressured by the robot to get up if they do not feel safe. This is why the question is not “Can you get up on your own?” which comes off more as a suggestion of an action, whereas prefacing it with “Do you think” first puts the elderly person in control, and is more of a question of ascertaining their feelings on the matter -- not inciting action. However, because Bettybot is the one to bring it up, no matter how restrained the question may seem, by broaching the topic Bettybot has applied some amount of pressure on the elderly person to consider this action and also incites a kind of urgency since the robot will wait without a response. We want the senior to get up on their own -- especially because as a healthy mobile

*The Pill Interaction Workflow*



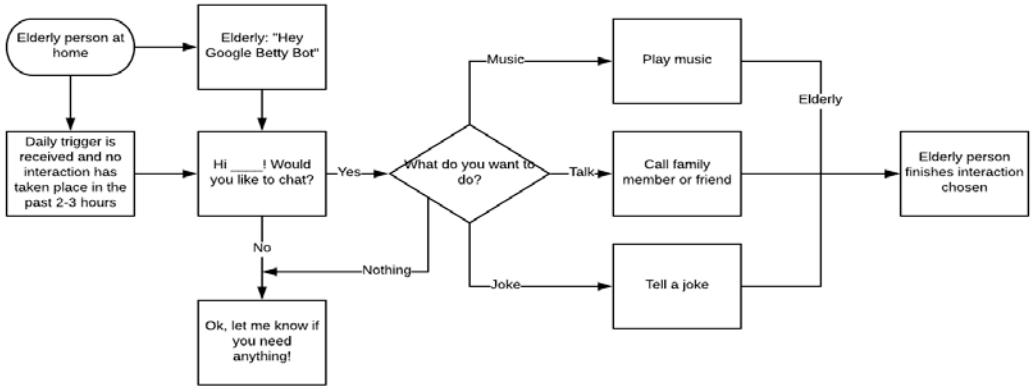

elderly person they should generally be able to -- but only if they feel safe. After much deliberation, we added some more factors. Bettybot would respond depending on the elderly person's history of previous falls. And no time sensitive response time, so if the elderly person doesn't respond, we go to the case where they have fallen and it makes sense to connect them with a loved one.

## The Pill Interaction Workflow

This workflow is very simple: when it's time for the elderly person to take their pills, Bettybot (who already has them) goes up to them with water (provided by a dispenser) and reminds them to take it and confirms that it is taken. But considering the difference between being a nag that constantly reminds the elderly person to take their pills versus being an assistant that is there to help the elderly person focus on other things while it manages their medication depends on how the interaction is organized. In order to be an non-intrusive as possible, Bettybot starts simply, "It's time to take your pills. Please take them." Being declaratives and not questions emphasizes the importance, but by being succinct and impersonal, it removes the sense of having a nurse. This design did not undergo many changes.

## The "One Less Lonely Senior" Interaction Workflow

This interaction workflow has undergone a lot of changes that have not been completely fleshed out. This is the workflow that is meant to trigger when an elderly person has been idle for an extended period of time and is not sleeping. Bettybot approaches them with suggestions of things to do: hear a joke? call a friend? listen to music? This interaction is being repurposed to the passive interaction workflow, meant to cover how Bettybot will generally keep the elderly person company. We added something that we think may be more practical: a game component. Bettybot



will suggest: do you want to play a game? And Bettybot will do a series of moves that the elderly person has to remember and then indicate in words later, a kind of memory game that uses the physicality of the robot -- to make it seem like it is dancing -- to help promote the elderly person's recall, and also to provide some companionship in a more personal and meaningful way rather than serving as walking Google Home. This part of the project is still under design changes and we are working on finalizing it.

## Strengths

The strengths of our current interactions are:

1. The robots prioritize safety of the elderly person in each of the interactions, but it is balanced with the goal to build trust with the person.
2. We now consider different aspects of interaction rather than functional: proxemics, aesthetics, dialogue, emotional effects.
3. The robot maintains a presence in the home to provide a sense of companionship, especially so it is considered as more of a companion than a machine, to build trust. But it remains non-intrusive, maintaining a distance until invoked.
4. Dialogue has been more fine-tuned to make the limited interaction as suitable as possible for a robot as an elderly companion.

## Weaknesses

The weaknesses of our current interactions are:

1. The dialogue interaction is more or less limited to yes or no answers, so there is a lot of nuance and richness lacking in Bettybot's ability to be a companion. This will significantly affect the trust relationship.
2. Bettybot doesn't have any kind of vision-like ability that would provide value in an interaction (apart from collision avoidance), so most interaction happens through dialogue, which slows down the interaction and makes it a lot less intuitive and natural.
3. The team chose not to provide Bettybot the ability to physically check whether the pills have been taken by the elderly. We are assuming that the elderly person is conscious of their well-being and will not purposefully deceive the robot.
4. Pill reminder interaction is very robotic and doesn't seem to have any richness in developing trust between the elderly person and Bettybot. (However, having a reliable source to remind you is a source of limited trust as well.)

## Current Implementation Progress

We have finished implementing the fall interaction, and creating the shelf and setup for the pill interaction. A phone's accelerometer app has been hooked up to IFTTT in order to let the program know that a fall has been detected. This starts up Bettybot's program which starts the workflow. The game for the passive interaction has been created, but not completely tied to the passive interaction. The aesthetic changes have not been made yet.

## Taxonomy (Evaluation Methods)

The taxonomy principles below is inspired from Yanco and Drury's *Classifying Human-Robot Interaction: An Updated Taxonomy* [2].

### *Task type*

The task type classification is companion for the elderly.

Bettybot will be primarily used to support elderly people who are capable of living on their own at home. The type of elderly persons Bettybot is designed to accompany are ones not diagnosed with any condition that requires them to be heavily taken care of and supervised, so independence is key.

***Criticality***
The main features Bettybot has in its interaction with the elderly person are:

1. Providing the elderly person with various opportunities to prevent their loneliness and social isolation
2. Detecting a fall and determining whether it is severe or not
3. Reminding elderly to take pills, and bringing these pills to the elderly

The first task is of low criticality because any failure in this task will not endanger human life. The second task is of high criticality because if the robot fails to detect a fall, it may endanger the person's life. Severe injury caused by the fall will be time-sensitive; any delay in this task will have an impact on the person. Finally, the third task will have a medium to high criticality depending on the type of medication. In the event that the robot fails to remind the person to take their pills, this failure might affect the person's health dramatically.

***Morphology***
In Phase I, our initial assessment of the BettyBot's physical features is that it looks more functional than anthropomorphic or zoomorphic. We decided to change the morphology of the robot a bit simply because of its frequent interaction with the elderly. The robot's role requires the elderly's trust and familiarity to help further interactions. During Phase II, Bettybot looks more like a pet to promote trust, and so the elderly does not feel subordinate to the robot. hence now its morphology is zoomorphic. Independence is key for the elderly person

We will do so by surrounding the Pioneer with white fur, which will cover up a lot of its lights and ports. We will also add a tail to give it more of a pet-like feeling. We will also add a shelf so it is functional and can hold pills. Overall, it will look functional and also zoomorphic, like a horse and a carriage.

***Human-Robot Ratio***
The human-robot ratio is many to one. Each pioneer is assigned to an elderly person. The pioneer is able to interact with other humans such as the elderly person's emergency contact, relatives, and friends.

***Robot team composition***
The robot team is homogenous, and is composed of exactly 1 robot. The components of the robot are comprised of the laptop, the Google home, and the Pioneer 3. The laptop is the brain of the robot, the Google home is the mouth and the ears, and the pioneer 3 represents the motor organs of the body.

***Level and character of shared interaction***
We have one robot, one human.

***Interaction-role***
Not applicable with existing values of taxonomy. An elderly person found in the interaction will be served by the Bettybot, and the corresponding interaction-role does not fit in existing values of supervisory, operator, teammate, mechanic, and bystander.

***Physical-proximity***
The mode of physical proximity between the elderly person and Bettybot with the most depth is *approaching*. This is also the most common mode of physical-proximity between the two parties. In particular, this mode occurs when Bettybot:

1. Approaches the elderly person to respond to their fall
2. Approaches the elderly person as it carries medicine and reminds them to take it
3. Approaches the elderly person to provide them with opportunities to be more socially engaged

***Decision support***
AVAILABLE SENSORS = SONAR, voice detection.

PROVIDED-SENSORS = none, no teleoperator will be present during interactions.

SENSOR-FUSION = {{voice} -> robot command}

PRE-PROCESSING = {{voice} -> pre-programmed voice responses based on input}

***Time/space***
TIME: synchronous; SPACE: collocated

All of the interactions require Bettybot to be in the same space as the elderly person, and all interactions are synchronous.

***Autonomy level***
AUTONOMY = 100%;INTERVENTION = 0%

Bettybot will be autonomous for all the interactions, and there is no factor of human intervention.

## Conclusion
Based on these evaluation methods of taxonomy, Bettybot fits in many of the pre-existing values. Most of the interactions that Bettybot does ranges from non-critical to critical, and its main task is to help the elderly in their homes. Using the evaluation methods is helpful to develop more meaningful interactions by using existing technologies and explore the different categories of taxonomies that could help make the interaction richer and nuanced.

Hence, we realize that the interactions between Bettybot and the senior are a lot more complex and nuanced, and actually contain many more elements of interaction than we had initially anticipated. Exploring the realm of these limited interactions and how to improve them has been really interesting. Changing distance, or physical aspects, and especially nuances in dialogue, really shape the interaction in a way that -- even with just yes or no questions -- without changing the mechanics really modifies the level of trust and safety that is established between the robot and the elderly person.

## Acknowledgements
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