

MAS 965 Week 1: Project Overview

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Overview

I want to build a voice controlled wheelchair. This vehicle would understand high level voice commands like “Go across the room.”, “Go around it”, or “Take the next right.” Ideally, the interface would be the same as the interface to a human servant pushing the rider’s chair.

I am building this system to explore an affordances-based architecture for understanding grounded spatial language. I chose a wheelchair as a vehicle to explore this problem because it seemed to be a natural platform for this research.

The Human-Horse Relationship

Overall the human-horse relationship does not seem to be well understood.

Police officers are often one rider to each horse. They trust their horse because they can predict what it will do in most situations. (Robinson, 1999) This predictability will be important for the chair; if it is unpredictable, users will not trust it and will not want to use it.

Riding has historically been a status symbol; riders incite envy of pedestrians. The wheelchair probably would not be able to do this because of the inherent stigma. It seems like the status might come from the horse’s size. Controlling such a large animal might incite respect from people watching. (Robinson, 1999) also cites studies showing that people who ride horses have high levels of assertiveness, and had more dominant personalities than dog owners. Respect for achieving control over the horse might lead to the high status. This aspect of riding is a mismatch for the wheelchair task because it

(McKinley and Sambrook, 2000) show that horses do not respond to pointing or eye gaze cues as well as dogs. They were presented with overturned buckets with food hidden underneath. Humans would signal the bucket with food in various ways. Two of the four subjects found food when the experimenter tapped the bucket but only one responded to pointing.

Understanding the Target Population

I am trying to understand the target population in three ways: by seeking feedback from potential users, by understanding the various mobility options currently available, and by studying able-bodied subjects giving commands to a human driver.

Overview of Mobility Options

(Fehr et al., 2000) did a survey of clinicians, asking them to give information about their patients and the usefulness of new powerchair technology. They found that 9 to 10 % of patients who receive powerchair training “find it extremely difficult or impossible to use the wheelchair for activities of daily living.” The authors are developing their own powerchair system that tries to solve some of these problems.

They also explored the types of control interfaces in current use. They found more than 95% of patients use one of the following interfaces:

- **Joystick**
- **Sip-and-puff** (Wechsler, 2004) describes a sip-and-puff interface. A strong puff makes it go forward and a strong sip makes it go back. Turning right or left is done by a soft puff or soft sip. The user of this interface said it was awkward sometimes, and the system got confused by a strong puff (forward) and a soft puff (turn right).
- **head or chin controls** (Wechsler, 2004) describes a user with a head control. Moving the head forwards, backwards, left or right turns directional switches on and off. This user recommended the device to others. (Schaaf, 2000) describes a chin-pad control for a child paralyzed from the neck down. The control had to be modified because of his size. He was unable to use a head control because he could not move his head back to midline, after he moved it laterally.

Other interfaces that (Fehr et al., 2000) found used by less than 5% of patients, over clinicians surveyed:

- **eye gaze**
- **tongue pad**
- **head, hand, foot switch controls** (Wechsler, 2004) describes one patient with head and foot controls. One sensor is on top of her left foot, and she uses a rocking motion to put the chair in forward or reverse. An additional sensor on top of her head allows her to steer by tilting her head left or right. Finally, there is a switch to turn the system on and off with her finger.

User Feedback

I talked to Spaulding Rehabilitation. In order to interview their patients I need to find someone there who is willing to supervise the work, and then get IRB approval. I am currently searching for a supervisor; I have contacted two people and I am waiting to hear back.

I also talked to some people in a forum for wheelchair users. This was more informal. It was impossible to know the degree of disability of most users, and the kinds of hardware that they used. Replies ranged from encouraging without much detail (eg, “sounds promising kkeep up the good work.”) to detailed feedback on the idea. Many users expressed safety concerns.

- One person was worried about what happens when the user talks to people - would the chair get confused? To get around this I suggested a push to talk button, or using a name to signal that the chair is being addressed. He responded saying that if someone could use a push-to-talk button, they could probably use a joystick or other control. From his reply I do not think he had direct experience with any of these interfaces.
- Another person had a friend who had head-movement control on his powerchair, and said the control could be better.
- Another person was hemiplegic: he said “carrying a cup of coffee (or anything else) across the kitchen is a big deal since my good hand is on the joystick.”

Preliminary Study Results

I am currently running a user study using able-bodied people to explore the interface to this system. In the study, pairs of subjects come in. One subject drives a vehicle around in a simulated environment. The second subject stands behind and gives verbal commands to the first subject. There are two tasks. In the first task, the subject searches through a maze (really a map of the fourth floor of the lab) to find as many statues as possible. In the second task, the user is given a map of the environment showing their current location and a target location. Their job is to navigate from the start to the finish.

In general, subjects were able to perform this task easily and naturally. They did not seem to be frustrated, and they were able to control the motion effectively by verbal instructions to another human. (I did not formally evaluate their reaction to the task.)

Example utterances from the data are:

- “Take the next right.”
- “so so we wanna turn to the right.”
- “Go further in”
- “ah, let’s explore the next one.”

- “turn right”
- “so you should go forward.”
- “go around the corner.”

Initial Specification

A large fraction of the utterances captured in the user study consist of directives to “go right”, “go left”, and “go straight”. The meaning of these depends on the immediate surroundings of the vehicle. “Go straight” means to follow the current passageway, even if it curves. “Go right” means head towards the passageway or doorway on the right. For my initial implementation I will focus on identifying and obeying these three commands reliably.

The simulator also needs a way to indicate confusion. Cory suggested beeping like R2D2 in Star Wars. I think this makes more sense than language because it will not raise the user’s expectations for the interface. It will have two kinds of confusion beeps: one when it did not understand the utterance, and a second when it thinks it understood the utterance but cannot map it to instructions. (eg, the user said “Go right” and there is no passage way to the right.

It might also make sense to have a “question” beep. In one of the runs, the subject said “right” when they meant left, and the driver silently went left, since that was the only possible interpretation. The system might not want to be so bold, but in those cases it could start to turn left, and emit a “question” beep to try to elicit confirmation from the user.

Demonstration

The demo will consist of a simulated vehicle that obeys voice commands. A user can give it instructions and it will obey them to the best of its ability.

Evaluation

First, I want to measure the effectiveness of the language understanding. This evaluation doesn’t directly measure the relational component directly, but it is important because one of the reasons I’m building this system is to understand spatial language. In addition, it will serve as a baseline for trust measures; it will be a way of quantifying how trustworthy the system is in fact, which can then be compared to how people perceive it.

To evaluate the relationship, I want to measure how much the human trusts the wheelchair. Although it would be most appropriate to measure this in a long term relationship, this is probably impractical given time and subject constraints. To properly establish a relationship, a physical chair would need to exist and be used for an extended period of time, while for this project I plan to implement it in a simulator. So probably the right thing is to evaluate the first impressions of the chair, after a tutorial session and completing some tasks together.

To do this, subjects will come in and interact with the simulated vehicle. They will complete the tutorial session, and then use it to navigate through the simulated world to solve problems. I am currently running a user study where the chair is replaced by a human driver in order to collect instances of spatial language use. I am using two tasks. First, a search task where the team is searching in a maze for treasure items. Second, a navigation task, where one member of the team is given a map of the maze and instructs the driver on where to go. I will use these same two tasks for the evaluation, replacing the human driver with the program.

After subjects complete the evaluation, they will complete a questionnaire to determine how much they trusted the chair. I would compare this data to data from human-human pairs, to see how the relationship compares. It might make sense to also compare it to human-human pairs where the human driver has been handicapped in some way (perhaps showing a more limited environment or putting them in separate rooms with a poor quality speech feed.) The program would be successful based on how similar the human-machine questionnaire data was to the human-human data.

References

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