Multimodal communication for guiding a person following robot

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Introduction

Robots designed to support people in different tasks at home and in public areas need to be able to recognize user intentions and operate accordingly. To date, research has focused on developing the technological capabilities of the robot and the mechanism of recognition. Several studies have attempted to identify user-friendly gestural and speech controls of robots in a variety of settings (Otero et al., 2008; Kuno et al., 2007; Gleeson et al., 2013; Wongphati et al., 2012), yet the intuitiveness of navigational commands for robots has remained largely unstudied.

Study aims

1. To investigate how people intuitively guide the motion of a robot.
2. To evaluate whether an existing navigational gesture vocabulary used for human-human communication was intuitive enough to be applied to human-robot interactions with novice users.

Method

First part

- WoZ technique
- Participants were asked to guide the robot to perform ten different navigational commands (commands were not explicitly stated, for each command both initial and final states were described).
- Trials were filmed by video for future analysis

Second part

- Eight video demonstrations of predefined commands were presented.
- Participants were asked to associate between the commands that were demonstrated in the videos to one of 8 predefined possible suggested commands.

Analysis

Each command was categorized on a two dimensional axis: **modality** (voice, gesture or a combination of both) and **mode** (discrete, continuous, or breaking the command into sub-commands).

An agreement score based on Wobbrock et al. (2005) and Cauchard et al. (2015) was calculated for each command. Each gesture was categorized according to its direction of movement on the x-y-z axes, and similarity of two or more gestures was determined in case movements on all three axes were in the same direction.

Results

1. Level of agreement among participants

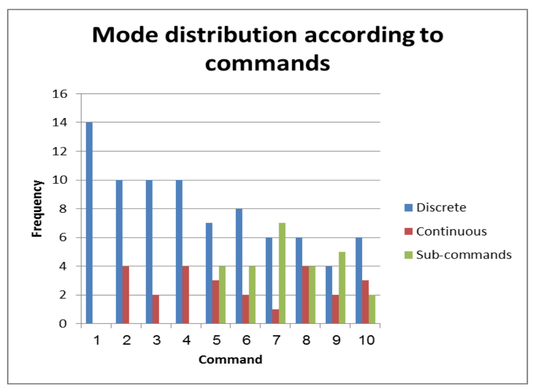
Command		Agreement score	
		Voice (N)	Gestures (N)
1	Stop	1 (11)	0.31 (7)
2	Follow me	0.63 (9)	0.34 (8)
3	Slow down	0.82 (10)	0.68 (5)
4	Increase speed	0.66 (10)	0.55 (7)
5	Move right	0.28 (9)	0.60 (12)
6	Move left	0.20 (10)	0.62 (13)
7	Move forward	0.31 (8)	0.36 (11)
8	Move backward	0.36 (11)	0.24 (11)
9	Walk closer	0.28 (9)	0.68 (5)
10	Walk further	0.19 (8)	0.39 (6)

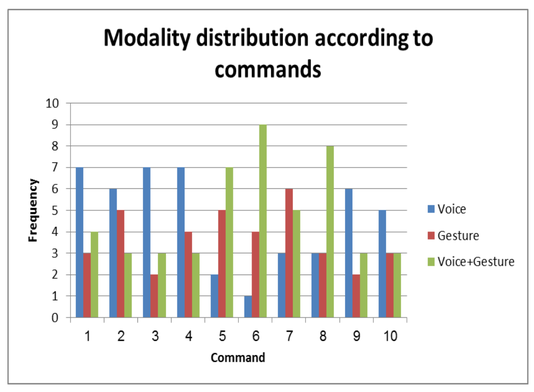
Agreement score of the commands for each one of the modalities. The number of commands that were observed for each of the modalities appears in parentheses. In blue - scores higher than 0.5

2. Modality and mode - moderate strength but significant associations between participants and modality and between participants and mode were found. Lower strength associations were found when analyzing the relation of both parameters with commands.

Modality: Voice commands were more dominant among participants in the case of commands 1-4 and 9-10. However, commands 5, 6 and 8 yielded a different pattern, in which the mixed modality (speech and gesture) was used more, while the voice modality was relatively reduced.

Mode - providing a discrete command was usually the preferred mode (commands 1-6, 8 and 10). Moreover, discrete was the only observed mode for the Stop command.





3. Commands identification - most of the participants (9/14) found the commands well understood, except for 2-3 commands that were not intuitive and therefore participants were not sure about their meaning.

Conclusions

- Simple commands had higher agreement scores and were more frequently communicated as voice commands.
- Commands that were more "direction-oriented" received higher agreement being communicated via gestures.
- These patterns should be further evaluated using a wider set of commands in order to create classification criteria and conclude regarding the appropriate command required for each of them.

References

agricultural biological & cognitive robotics

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