Closing the feedback loop: the relationship between input and output modalities in human-robot interactions

agricultural biological & social robotics

Industrial Engineering & Management
Human Factors Engineering (Ergonomics)

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Introduction

- The **"Feedback loop":** the user provides input to the system in order to achieve a goal, gets output (feedback) from the system and interprets it. This interpretation affects the user's next actions, beginning the cycle again (Dubberly et al., 2009).
- Different communication modalities have been investigated for robot feedback or human control (Perrin et al., 2008; Redden et al., 2010), ignoring the relationship between control and feedback modalities.
- **Stimulus-Response compatibility:** when the relation between displays and controls is direct and natural, it is described as being compatible. Extending this principle, Greenwald (1970) suggested that there are stimuli modalities that most compatibly mapped to certain response modalities.

Hypotheses

- **There is a compatibility effect between control modalities and feedback modalities:**
  1. Voice control would be most compatibly mapped to feedback in the same modality
  2. Gestural control will be most compatibly mapped to motion feedback.
- **The efficacy of different combinations of control-feedback would be dependent on task type:** gestural control and motion feedback would produce a more efficient interaction when performing a spatial task like navigation.

Method

- **Navigation task**: participants will be asked to help a Turtlebot 3 robot (Figure 1) to get out of a maze (Figure 2) by giving it navigation commands. They will get feedback from the robot after giving each command. The possible commands and feedbacks are shown in the Table 1.

Figure 1| Turtlebot3 burger

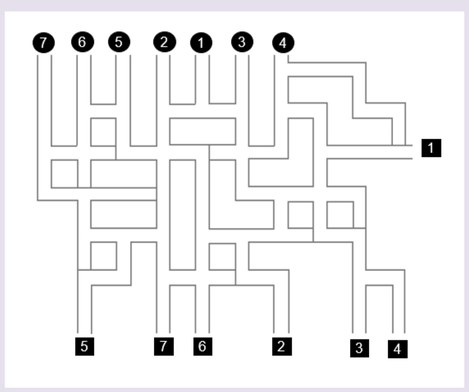

Figure 2| Maze Design

- WoZ experiment , within-subjects factorial design.
- Independent variables :
  - **Control modality** : vocal control, gestural control.
  - **Feedback modality**: motion feedback, vocal feedback, no feedback.
- Dependent variables:
  - **Efficiency:** evaluated by the total interaction time and participants' reaction time.
  - **User experience:** evaluated by a questionnaire about participants subjective feelings during the interaction.

Table 1 | Possible commands and feedbacks in the main experiment

Command	feedback
Turn right	The command was understood
Turn left	The command was not understood
Go forward	The command cannot be executed
Start moving	Starting to move

Preliminary experiment

Goal

To identify intuitive control gestures and robot feedback that could be used to later evaluate compatibility effects between control modalities and feedback modalities.

Method

First part:

- Designed to create two vocabularies, one for navigation commands and one for robot motion feedbacks.
- Fifty participants completed an online-questionnaire where they were asked to propose:
  - Gestures that would make the robot perform a certain action
  - Ideas for how the robot can move in order to communicate a certain message to the user (motion feedback)

Second part:

- Designed to validate the intuitiveness of the most common motion feedbacks and gestural commands.
- The same fifty participants that completed the first questionnaire also participated in the second one:
  - Saw videos of selected gestures and were asked to choose from a given list the command that they thought was most suitable for the gesture.
  - Saw videos of selected motion feedbacks and were asked to choose the robot message that they thought the given motion feedback is conveying.

Results

- **Gestural commands and motion feedback vocabularies** were built by taking the two most common gestures/motions suggested by participants in the first part, and gestures/motions that were suggested by participants and seemed to us as appropriate for expressing the desired command/message.
- By validating the intuitiveness of the gestures and motions present in the vocabularies (second questionnaire), **we mapped one gesture to each command and one motion to each feedback message** (Figure 3).

Command	Gesture
Turn right	Pointing with thumb to the right
Turn left	Pointing with thumb to the left
Go forward	A tense arm rises from the bottom up
Start moving	Hands clinging

Feedback Message	Motion
The command was understood	The robot moves one step forward and returns backward
The command was not understood	The robot turns to one side, then to the other side and returns
The command cannot be executed	The robot turns a little to left and returns
Start moving	The robot moves a little forward

Figure 3 | □ • ⌜□⌟ • ● ✓ ◠□■⌜ ? ▲ ▼ ✕⌜□⌜ ⁄● ▲ ✕ ⁄◠ □ ✓ ● ⌟□ ◡ ⁄▲ • ⁄●□⌟⌜⌜⌟✓ ✓⌜ ◡□⌟⌜ ? • ■ ● ?

Discussion

First part:

- Adaptation of gestures from humans interaction to human-robot interaction.
- Participants may expect the robot to communicate to them like a social, human partner.

Second part:

- Greater understanding of gestures compared to motion feedback.
- Possible explanation: we use gestures to communicate with others in our daily lives, whereas motion feedback is not so common.

References

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