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# A BCI-driven telepresence robot

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***Abstract.*** This paper discusses and evaluates the role of shared control approach in a BCI-based telepresence framework. By means of a bidirectional audio/video connection to a robot, the BCI user is able to interact actively with relatives and friends located in different rooms. However, the control of robots through an uncertain channel as a BCI may be complicated and exhaustive. Shared control can facilitate the operation of brain-controlled telepresence robots, as demonstrated by the experimental results reported here.

*Keywords: Brain-Computer Interface (BCI), EEG, Shared control, Telepresence, Mobile robot.*

## 1. Introduction

In this work we want to explore a BCI-controlled mobile device for telepresence, where the user mentally drives a mobile robot to join relatives and friends to participate in their activities. In this framework, the main question is how the subject might drive a mobile device by means of an uncertain channel such as a BCI. An answer to this fundamental issue is the well-known shared control approach [1, 2]. The cooperation between a human and an intelligent device allows the subject to focus the attention on his final destination and ignore low level problems related to the navigation task (i.e., obstacle avoidance). In the next sections we will describe the BCI system, our shared control implementation, the methodology and the results achieved.

## 2. BCI system

To drive our telepresence robot, subjects use an asynchronous spontaneous BCI where mental commands are delivered at any moment without the need for any external stimulation and/or cue. To do so the users executes two motor imagery tasks. Each of these mental tasks is associated to a steering command, either right or left. For our experiments, EEG was recorded at 512 Hz and band-pass filtered between 0.1 Hz and 100 Hz. A spatial Laplacian derivation was applied on the signals and the PSD was computed in the band 4-48 Hz. We used a statistical Gaussian classifier in order to compute the probabilities distribution over the two mental tasks [3].

## 3. Results

Our implementation of shared control focuses on low-level obstacle detection and avoidance. This way the subject keeps full control of the driving of the robot. The default behavior of the robot is to move forward at a constant speed. Then, upon the reception of a command it turns left or right by 30 degrees. To avoid obstacle collision, the robot uses its three frontal infrared sensors. Without shared control, the robot stops in front of the detected obstacle and wait for the next mental command. If shared control is enabled, the obstacle avoidance module will make the robot turns towards the opposite direction where the obstacle is detected until the path is free.

## 4. Methodology

Our telepresence robot is Robotino by FESTO, a small circular mobile platform. It is equipped with nine infrared sensors capable to detect obstacles up to ~15 cm. For telepresence purposes, we have added a notebook with an integrated camera: the BCI user can see the environment through the notebook camera and can be seen by others in the notebook screen.

Four healthy volunteers participated in our experiments (males, age 27 ± 0.8). Unfortunately, subject 4 could not finish all the experiments. The experimental environment was a natural working space with different rooms and corridors. The subject's task was to drive the robot along one of three possible paths (in Fig. 1), each consisting of two targets and driving back to the start position. The experimental space contains natural obstacles in the middle of the paths. Subjects were asked to perform the task as fast as possible. Since the goal of this work was to evaluate the contribution of shared control for a BCI telepresence robot, the experiment was run under four conditions: with or without shared control in combination with BCI or manual control. In the case of manual control the subject drove the robot by delivering manual commands through a keyboard and travelled each path once. In the case of BCI control the subjects drove the robot along each path twice.

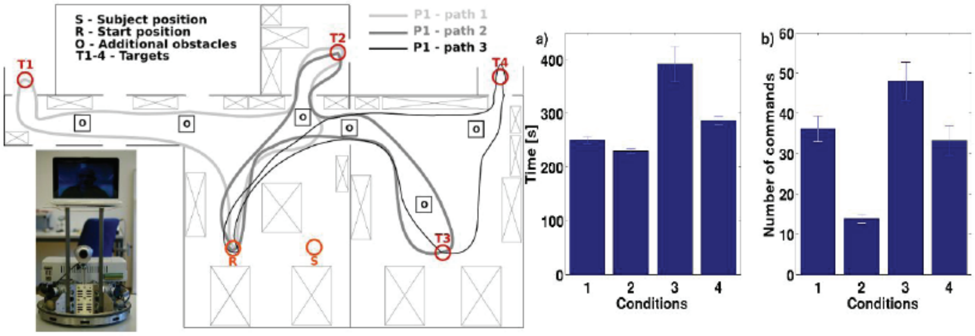

***Figure 1**.On the left, the telepresence robot and the experimental environment. On the right, the results (grand average and standard error) for time and number of commands needed to complete the task.*

## 5. Discussion

For each trial we recorded the total time and the number of commands sent by the user (manual or mental). The first striking result of our experiments is that all subjects succeeded in all the trials for all conditions. In addition the incorporation of shared control boosted the performance for both manual and BCI control in all trials for all subjects. Figure 1 shows the time and number of commands (averaged across paths and subjects) needed to complete the tasks. Even in the case of manual control (first two bars in the graphs), shared control reduced the amount of time and the number of commands. The benefit of shared control becomes more evident when subjects drove the robot mentally (last two bars in the graphs). But the most important result of our experiments is that, by enabling shared control the subjects driving mentally the telepresence robot reach almost the same performance as when they did the task delivering manual control without shared control. The ratio for each subject for all paths of BCI (with shared control) vs. manual control (without shared control) is 1.07, 1.11, 1.22 for time and 0.55, 0.82, 1.18 for number of commands, respectively.

The experimental results reported in this paper demonstrate the benefits of shared control for brain-controlled telepresence robots. Despite that our shared control implementation only deals with low-level obstacle detection and avoidance, it allows all subjects to complete a rather complex task in shorter times and with less number of mental commands. Thus, we argue that shared control reduces subjects' cognitive workload as it: (i) assists them in coping with low-level navigation issues (such as obstacle avoidance) and (ii) helps BCI users to keep attention for longer periods of time, resulting in delivering fast commands.

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### References

[1]O. Flemisch et al., "The H-Metaphor as a guideline for vehicle automation and interaction," NASA, Tech. Rep. NASA/TM–2003-212672, 2003

[2] D. Vanhooydonck et al., "Shared control for intelligent wheelchairs: An implicit estimation of the user intention," in Proc. 1st Int. Workshop Advances in Service Robot., 2003, pp. 176–182.

[3] F. Galán et al., "A brain-actuated wheelchair: Asynchronous and non-invasive brain-computer interfaces for continuous of robots,"Clin. Neurophysiol., vol. 119, pp. 2159–2169, 2008.