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A shared-control framework for BCI control of various effectors: towards home-used BCIs

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Introduction: Despite promising progress in ongoing clinical research in BCI, very few systems allow daily use outside the laboratory. Several shortcomings, in terms of device reliability, safety, portability and ease of use, still need to be addressed to enable home-use. In this context, an implantable BCI technology was developed [1], aiming to enable a person with quadriplegia to control various effectors in a semi-assisted shared-control framework based on proximity sensors [2].

Materials, methods and Results: The shared-control framework consisted in a combination of an ECoG-based BCI system and an external Time-Of Flight (ToF - ST-VL53L1X) sensor-based solution located on the effectors (Fig. 1). ToF sensors and control module constantly monitor the local surroundings in order to localize near objects/obstacles and progressively take control over the BCI system to assist the user. Preliminary experiments have been conducted with one tetraplegic participant as part of "BCI and Tetraplegia" (NCT02550522) clinical trial. Reach-and-grasp with a robotic arm and wheelchair driving tasks have been performed within this shared-control framework, and compared to their BCI-only execution. BCI decoding and sensors processing module have been integrated on a power wheelchair allowing the participant to drive freely using a fixed BCI model. A Kinova JACO arm allowed performing the reach and grasp task.

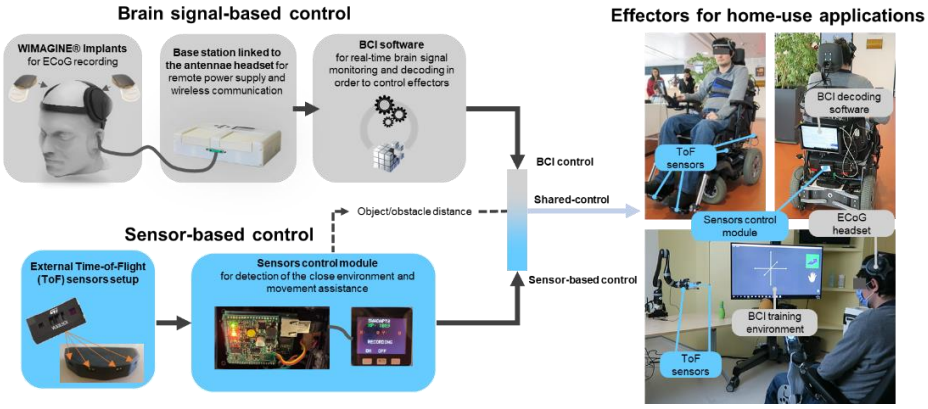

Figure 1. Schematic of the shared-control framework

A first proof of concept of 2D shared-control wheelchair driving was performed, showing the efficiency of the combination of BCI and sensor-based control compared to a BCI-only system, in terms of number of collisions and speed of execution. A significant reduction of the number of “mental commands” sent by the participant to perform the tasks was also observed, indicating a decrease of mental load using shared-control solution. 2D semi-assisted grasping was also demonstrated. The success rate was increased with shared-control compared to BCI-only.

Discussion and perspectives: In order to further evaluate the efficiency of the proposed solution, more experiments will be necessary in various use cases. Different strategies of fusion between both types of control are to be explored. Finally, hardware and software platforms will also need to be optimized to allow a better integration for home-use. The goal is to allow a faster and more accurate execution of tasks in a secure and robust way while leaving a “natural” control to the user.

References

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