Object-Affordance Control of a Humanoid Robot with BMI

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***Abstract*— We describe the framework we envision to achieve brain-machine interface (BMI) whole-body control of humanoid robot serving as a robotic surrogate for the user. Our framework takes a novel approach with respect to the usual motor/brain decoding used in previous works in the field: we propose to rely on an object-task-affordance paradigm based on the integration of recent developments in both neuroscience and robotics task-space control capabilities.**

INTRODUCTION

Brain-Machine Interfaces (BMI) allow one to bypass the usual efferent pathways to control a wide range of systems, including humanoid robots. The general approach to BMI is divided into three processes: (1) *signal acquisition*: where brain waves activities is monitored using various technologies (e.g. EEG, fMRI or ECoG); (2) *signal processing and classification* of the acquired signals that will be mapped into machine commands; (3) *application*: where the commands are interpreted and achieved by a system, which can be anything, from a virtual keyboard to a robotic device.

In this paper, we introduce a novel approach to control a (humanoid) robot using BMI. Moving away from the classical way –menu/icons selection or understanding the motor intentions of the human to translate it to a device, we propose to move towards an object-centric methodology. This is motivated by current development in neuroscience and task-space control that will lead to such a possibility. We also assessed the viability of our approach in an EEG-based demonstrator.

OBJECT-CENTRIC CONTROL WITH BMI

In recent remarkable works, the motor activity of a subject's brain, acquired through ECoG or Intra-Cortical, was decoded into movement inputs for a robotic arm, allowing the subject to move the arm freely in its operating space, grasp a bottle and bring it to the subject's mouth. This is made by a quasi closed-loop fashion. Similar results can be obatined with EEG – with less degrees of freedom though.

These impressive works illustrate a dominant trend in current BMI-based control: decoding the motor activity in order to map it onto the controlled device. However, controlling the cartesian motion of a robotic arm by neurofeedback requires a long and sustained training for the subject and usually perform with less than perfect accuracy and slowly compared to the capacity of the controlled robotic systems they use as substitutes or surrogates. Why would one needs controlling an external device with such a degree of precision?

From Cartesian-Motion to Task-Space Control

The task-space function is a powerful control paradigm for robots. A task can be seen as motion primitives or constraints that can be defined directly or indirectly in the robot's sensory space. The desired motion can be defined implicitly as a state or a state error vector in the perception space, which is mapped into the robot's motor-sensors space.

Controlling robotic systems with BMI is tedious. However, selecting an object can be reliably achieved. This observation leads to considering tasks as affordances on the surrounding objects/environment. Thus, controlling a robot with a BMI becomes a problem of selecting an (object, task) pair, which is simpler to achieve than closed-loop brain-motor control.

Furthermore, recent developments in neuroscience have shown promising results that could lead to the ability to understand object concepts and perhaps task concepts directly from monitoring brain activity.

EXPERIMENTAL VALIDATION

In [1], we have illustrated this concept with currently available technologies. Using the well-known steady-state visually evoked potentials (SSVEP), we have used sensory information provided by the robot on its environment to display off-line learned objects that the user can interact with, as seen in Figure 1. After the user has selected an object, the robot autonomously grasps the object. In fact, the robot motion adapts to changes in position of the objects and monitoring ErrP allows to redo the action with another try.

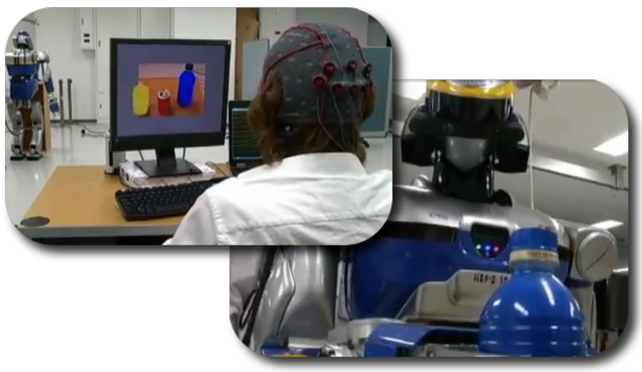

Fig. 1. Experiment illustrating the task-control approach with BCI

REFERENCES

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