plan4act

Predictive Neural Information for Proactive Actions: Form Monkey Brain to Smart House Control

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CONSORTIUM

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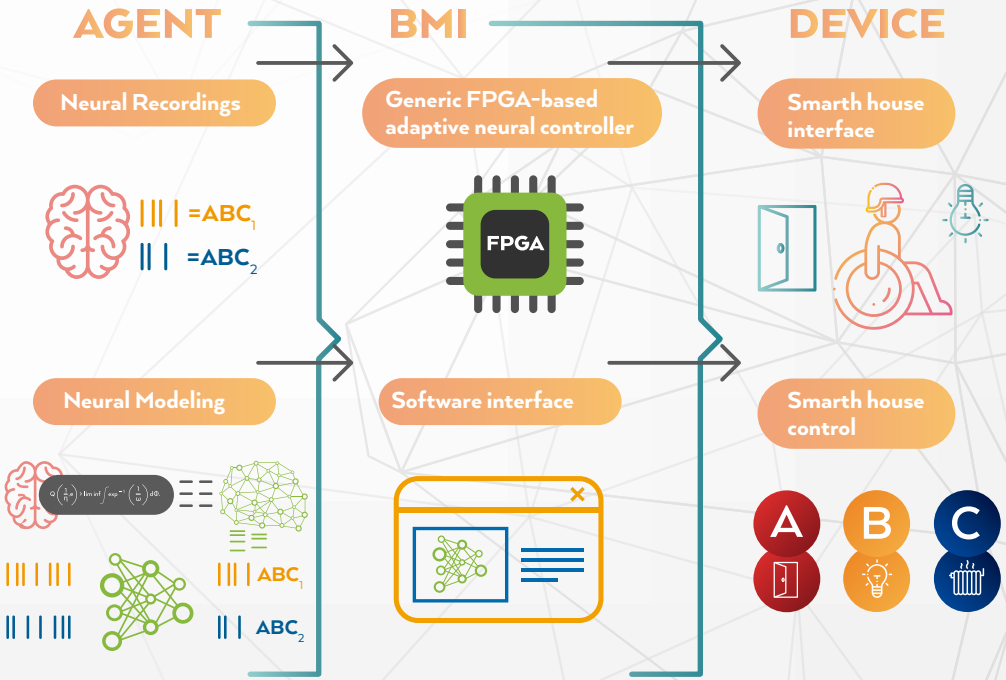
DESCRIPTION

The Plan4Act project will provide new emerging technologies that address "How neural activity, representing high-level cognitive processes of planning and mental simulation of action sequences, can be extracted and used to proactively control smart home environments".

The basis for this is recent experimental results that show that complex planning and sequencing information is represented by predictive neural activity in the (monkey) brain. These investigations shall here be extended and transferred to a BMI (brain-machine- interfaces) -setup for controlling devices with more foresight than present in the currently existing systems. The here planned research and innovation action will, thus, open up a future path for people with disabilities to interact with their (smart) environment in a more robust way by – for the first time – including predictive neural information towards improving the quality of their life.

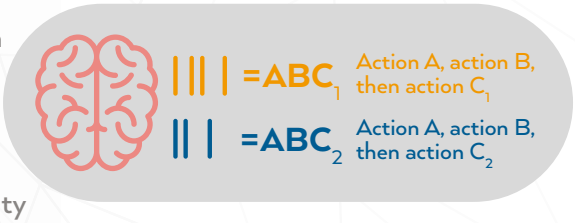
OBJECTIVES

1. Identify sequence-predicting neural activity in the monkey brain in a non-restricted environment, i.e., a smart cage.
2. Develop mathematical models based on the interaction of activity and plasticity mechanisms to understand this sequence-predicting neural activity and to provide the algorithmic basis of adaptive neural control (Objective 3).
3. Develop a generic FPGA (field-programmable gate array) - based adaptive neural controller that uses the models from Objective 2 to process the recorded sequence-predicting neural activity and generate complex action sequences to manipulate devices in a Smart House.
4. Employ the results from Objectives 1-3 to develop an advanced brain-machine-interface (BMI) system that can robustly extract sequence-predicting neural activity for proactive Smart House control.



RESEARCH TOPICS

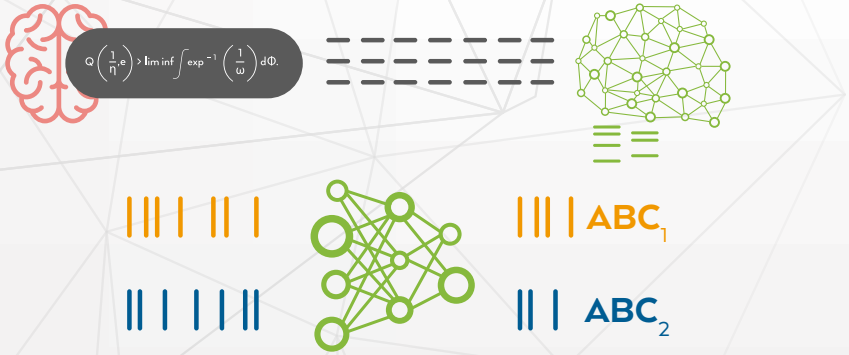
Neural Recordings



Different areas of the brain are involved in planning future movements. We register detailed neural planning or predictive activity while monkeys perform instructed sequences of actions in a Smart Cage environment. As the animal moves around freely, we wirelessly transmit neural signals corresponding to the animal's plans and actions. We extract animal's plans and actions. We extract signatures of proactive action planning from behaviour and brain activity.

Neural Modeling

The analysis of the data from neural recordings as well as the development of the adaptive neural controller are supported by a new theoretical model. This theoretical model links the formation and execution of complex action sequences with the underlying neuronal and synaptic dynamics enabling the extrapolation of new, synthetic data given various simulated scenarios.



Generic FPGA-based adaptive neural controller

The developed controller will directly interface to the neural recording system and the smart house system. It will process recorded sequence-predicting neural activity, predict the upcoming sequence of actions, and generate the corresponding complex action sequences to manipulate the smart house.

Smart house interface & control

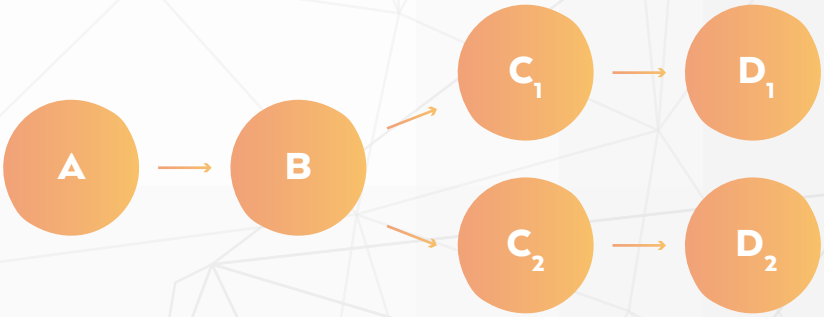
Smart home devices are orchestrated by IoT platform enabling users to control actuators such as doors, lights, air conditioning and even subscribed smart devices by simple commands. These commands are implemented through a Gateway which will authenticate and interpret orders from the neural controller, in order to provide simple and machine-understandable instructions.

DEMONSTRATORS AND QUANTIFIERS

The central demonstration of Plan4Act follows the general, well-established path for demonstrating BMI systems. We will use predictive neural signals from a monkey that performs a sequence of tasks, process them with the embedded FPGA-controller, and interface this with the smart house to control the required sequence of actuators in the smart house environment in a proactive manner. To emphasize the advantage of proactive control from predictive signals, we will contrast reactive conventional BMI control with our new proactive methods. To make this clearly visible we will quantify the "proactive gain" with several quantifiers as defined below. To make all this feasible, the demonstration will be performed in 2 steps:

DEMO1: We will show a system that can use neural data to proactively control smart house devices using an adaptive controller under simple sequences (actions A->B->C->D).

DEMO2: We will show a system that can use neural data to proactively control smart house devices using an FPGA-based adaptive hardware controller under complex branching sequences (actions A->B-> and C1->D1 or C2->D2).



For quantification of the demonstration, we will address two aspects: Prediction and Control and quantify at least four variables: 1) Successful prediction fraction and 2) its temporal persistence, 3) temporal speed-up in control and 4) control robustness against disturbance.

CONTACT

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