Brain-computer interface predicts hand motion based on cortical signals

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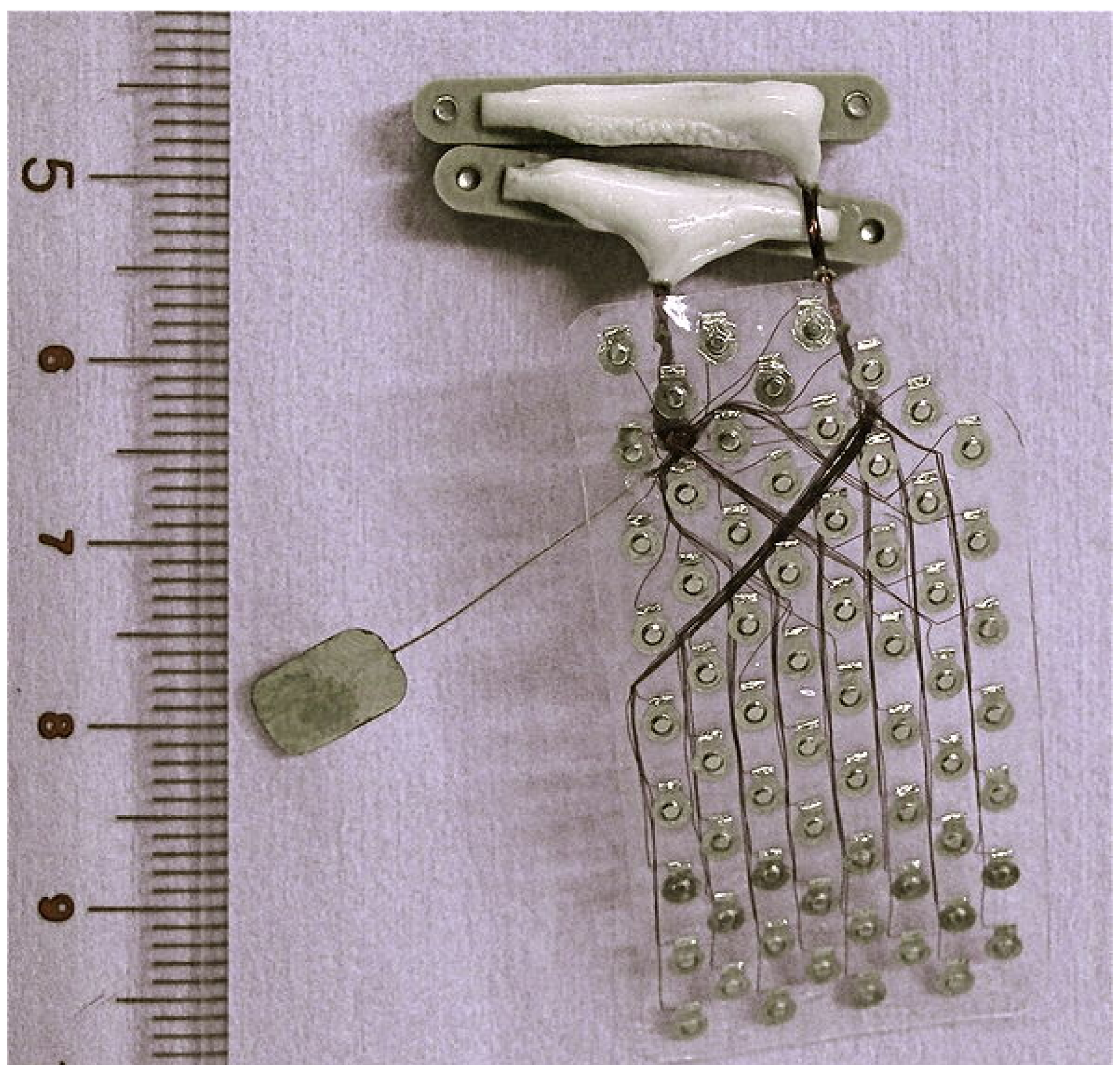
Model to predict hand movement trajectories based on cortical activity

The Brain-computer interface project aims to develop compensating systems that will help people with a severe motor control disability recover mobility. Signals are measured directly from a human brain. The predictions rely on linear models. This offloads the processor, since it requires less memory and fewer computations in comparison with neural networks. As a result, the processor can be combined with a sensor and implanted in the cranium. By simplifying the model without degrading the predictions, it becomes possible to respond to the changing brain signals. This technology could drive exoskeletons that would allow patients with impaired mobility to regain movement.

ECoG signal sources

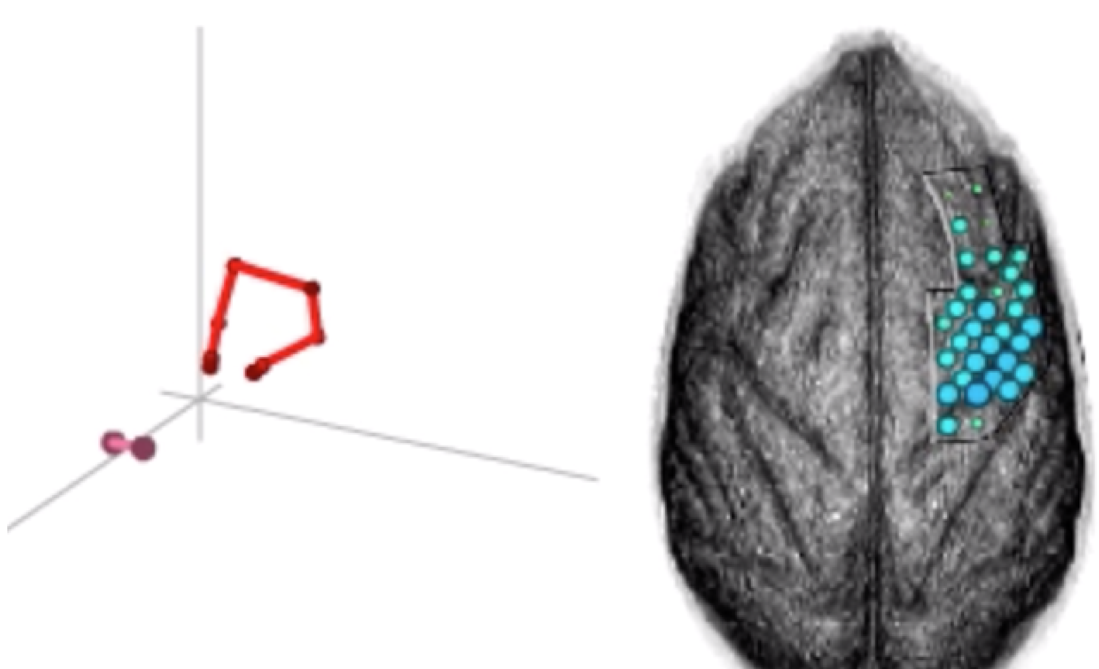
The implant to measure ECoG detects the electrical activity in the motor cortex with minimally-invasive implantation in the cranium and, over the long term, to measure signals thanks to an array of electrodes in contact with the dura mater [?].



Source: neurotycho.org

Experimental setup

The project Neurotycho aims to share reliable massive neural and behavioral data for understanding brain mechanism. The monkey was tracking food rewards with the hand contralateral to the implant side. ECoG data and motion data were recorded simultaneously during the task [?].

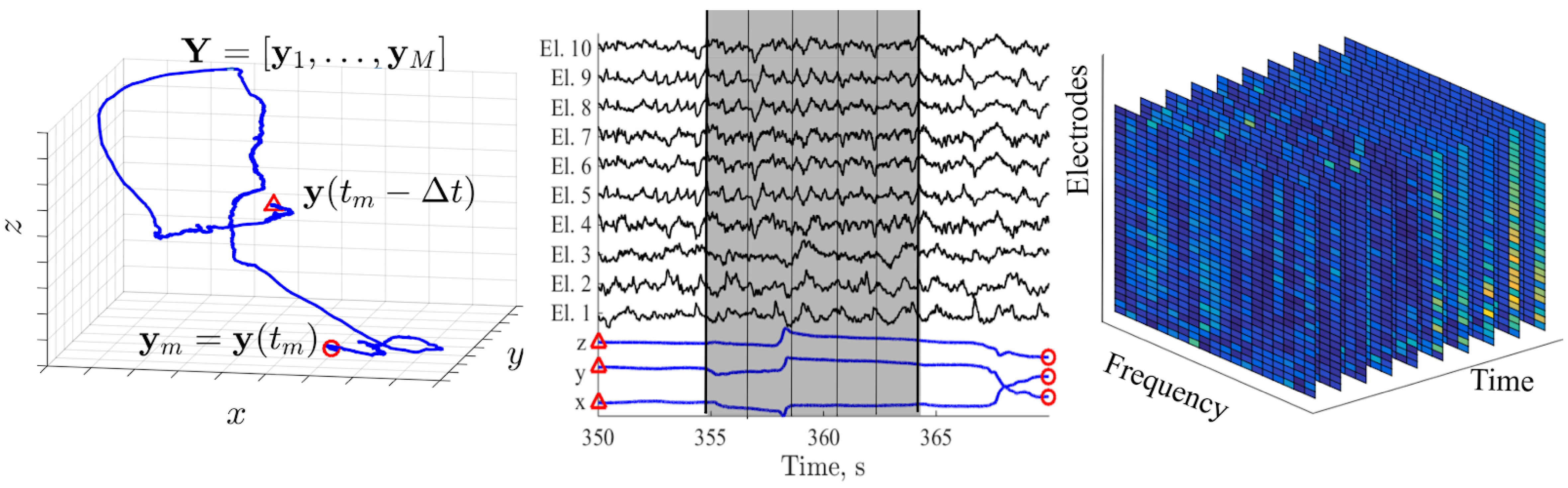


Source: neurotycho.org

ECoG and motion data were sampled at 1KHz and 120Hz, respectively, with time stamps synchronized.

Physical motion, corresponding ECoG signals, and feature representation

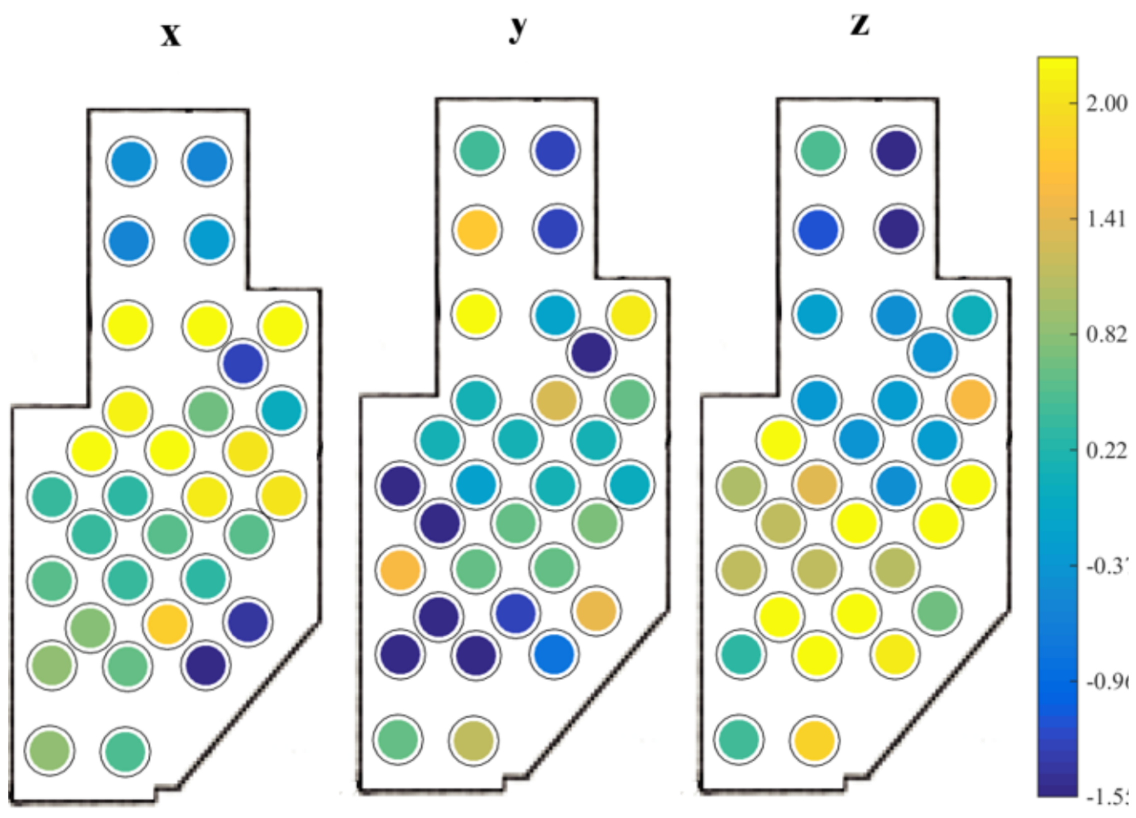
To restore motion, brain cortex signals are measured, and decoded to be transmitted to an exoskeleton. Decoding means interpreting the signals as a prediction of the desired limb motion. To pick up high-quality signals, the sensor needs to be implanted directly in the braincase. To use this data to control artificial limbs, movement trajectories need to be reconstructed from the electrocorticogram.



For each electrode, one-second signal intervals undergo modifications and are assigned a feature description in amplitude-frequency space. It is color-coded. The blue curve on the left is a trajectory of limb motion. Each black curve in the middle corresponds to a signal on one electrode [?].

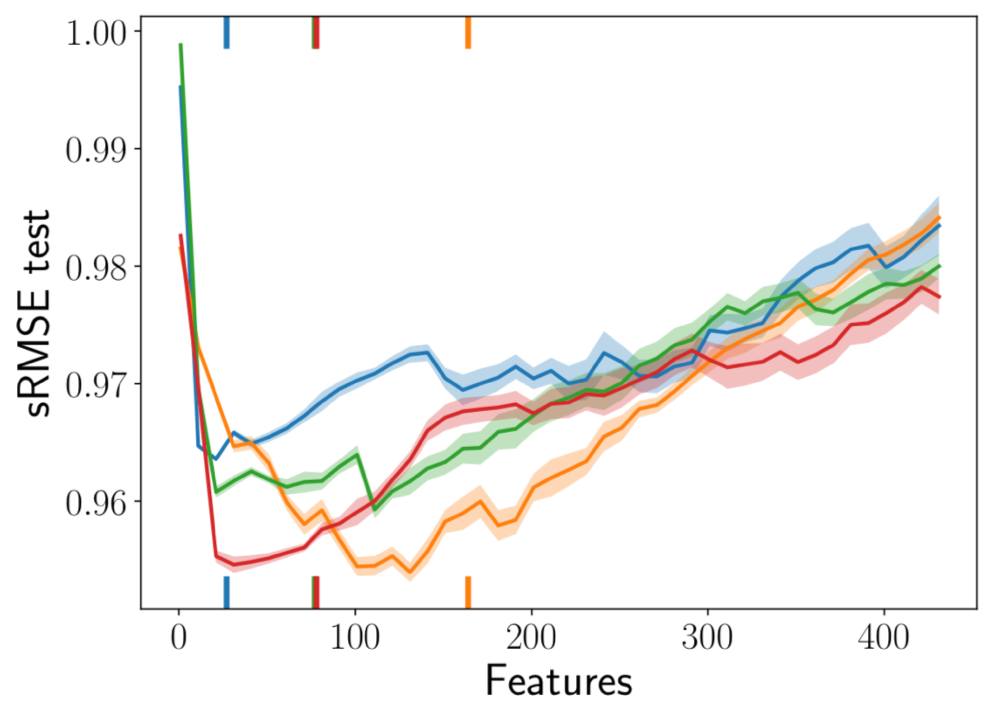
Electrodes correlate movements

Each dot represents an electrode. The color of the dots varies between yellow and blue, indicating the similarity between the signal of the electrode and the limb motion trajectory. The trajectory is given by the three projections on the coordinate axes in the physical experiment. For each axis, there is evidently a set of electrodes suitable for reconstructing the trajectory.



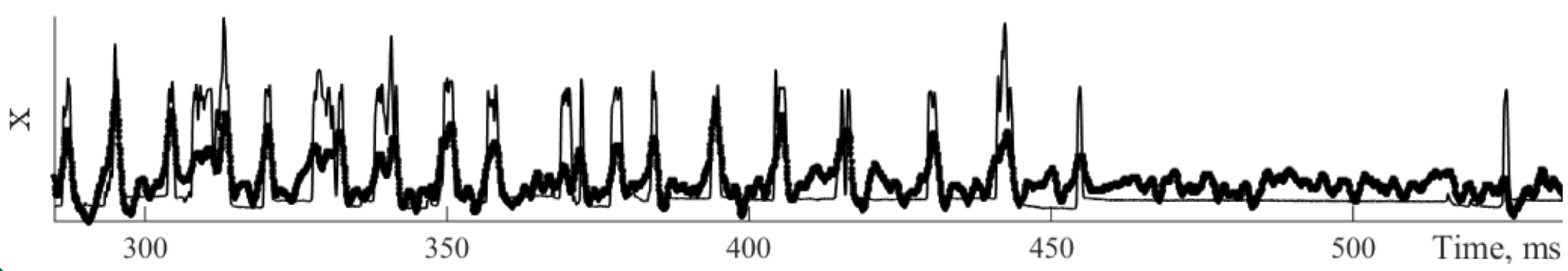
Decoding model quality

The tensor model was selected to predict limb motion trajectories. The advantage of the linear models over neural networks is that the optimization of model parameters requires much fewer operations. This means they are well-suited for a slow processor with limited memory.



The resulting model is optimized to be simple, robust, and precise with limited number of features [?].

The wrist motion trajectory prediction with ECoG



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