The Neurally Controlled Animat: Biological Brains Acting with Simulated Bodies

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The Human Brain is one of the most powerful computational tools in existence. However, studying how the brain works is often difficult because access to it is limited by skin, skull, and sheer number of cells. Thus, a new technique, the Neurally Controlled Animat approach, has been developed.

An Animat is a computer simulated or robotic animal behaving in an environment. A Neurally Controlled Animat is the conjunction of (1) a neural network cultivated on a multiple electrode array and (2) a virtual body, the Animat, “living” in a virtual computer generated environment, connected to this array. Patterns of neural activity are used to control the virtual body, and the computer is used as a sensory device to provide electrical feedback to the neural network about the Animat’s movement in the virtual environment. The Neurally Controlled Animat approach allows correlations to be made between neural morphology, connectivity, and distributed activity, not presently feasible with in vivo neural interfaces.

Setup

Cortical tissue (from day 18 embryonic rats) is dissociated and cultured on a 60 channel multi-electrode array (Multichannel Systems). Each electrode can detect the extracellular activity (action potentials) of several nearby neurons and can stimulate activity by passing a voltage or current through the electrode and across nearby cell membranes (e.g. +/-600 mV 400 s, biphasic pulses). Dissociated neurons begin forming connections within a few hours in culture, and within a few days establish an elaborate and spontaneously active living neural network. After one month in culture, development of these networks becomes relatively stable and is characterized by spontaneous bursts of activity. This activity was measured in real-time and used to produce movements within a virtual environment. The computer is used as a sensory device to provide electrical feedback to the neural network about the Animat's movement in the virtual environment.

Scheme for the Neurally Controlled Animat. A network of hundreds or thousands of dissociated mammalian cortical cells (neurons and glia) are cultured on a transparent multi-electrode array. Activity is recorded extracellularly to control the behavior of an artificial animal (the Animat) within a simulated environment. Sensory input to the Animat is translated into patterns of electrical stimuli sent back into the network.

Summary and Conclusion

The goal of the Animat project is to create a neurally controlled artificial animal with which complex processes of brain will be better understood. This preliminary work has shown that it is possible to construct a system that can respond to and provide feedback in real-time to a living neural network. Increased understanding of how feedback changes network activity, connectivity and cell morphology, might enable the development of more robust biologically-based artificial animals and control systems, and shed light on the neural codes within these networks. It will be possible to create artificial animals as a control system to solve a wide variety of tasks, or map the neural processing power to perform calculations, pattern recognition, or process sensory input.

http://www.neuro.gatech.edu/groups/potter/animat.html