SENSOPAC
SENSOrimotor structuring of Perception and Action for emerging Cognition

Robotic applications of LSAM: Large-Scale Analog Model of the Cerebellum Based on Reverse-engineering

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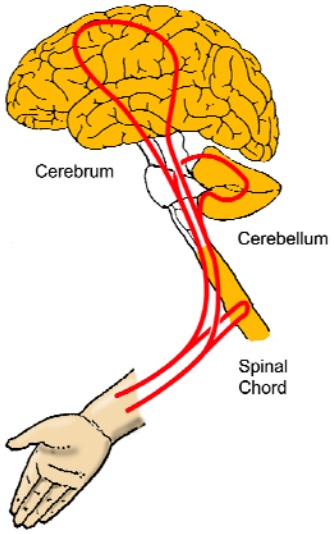
What is LSAM?

LSAM is a bottom-up executable mathematical model of the cerebellum, developed at the Swedish Institute of Computer Science in Stockholm. LSAM is primarily a biomimetic model, based on detailed cerebellar measurements and neuronal connectivity data collected at Lund University, Sweden, and the University of Pavia, Italy. However, as we uncover algorithms evolved by nature, we find that they may also be useful in human-designed, artificial systems. For testing LSAM in practice, we combine the model with a biologically inspired robot hand, developed at DLR's Institute of Robotics and Mechatronics in Oberpfaffenhofen, Germany.

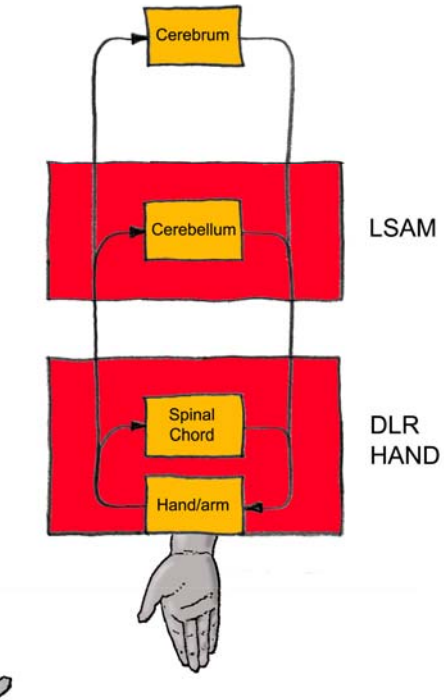


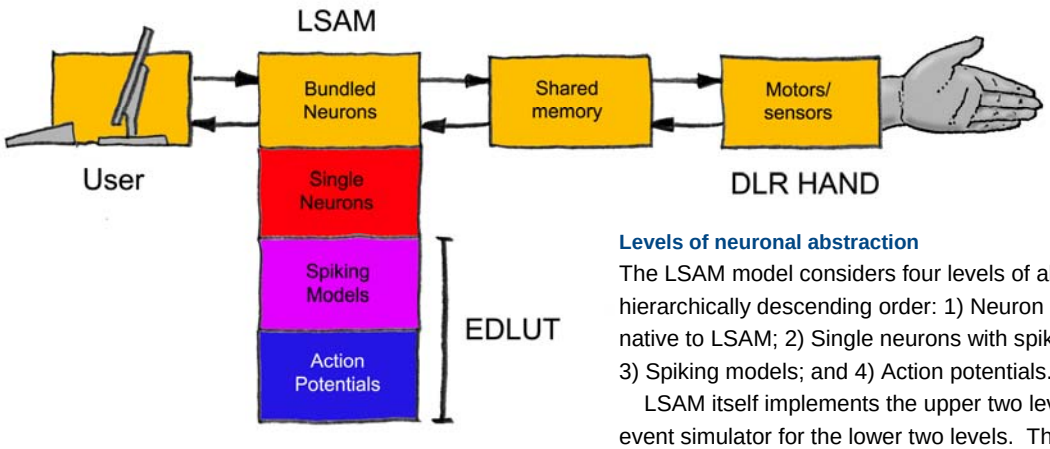
The Hand-arm cascaded control system

The motor control system of a mammal is a cascaded control system, where the innermost control loop is the reflex path. This simple but fast loop serves to calibrate and linearize the underlying mechanical system. In our test application, this function is provided by the DLR robot hand's impedance controller.

The cerebellar loop implemented by LSAM is the second innermost loop. It is responsible for precision tuning and coordination of motion along multiple degrees of freedom via the primary motor cortex and red nucleus. Each degree of freedom corresponds to what is known as a cerebellar microcomplex.

The third and higher level loops, involving slower but more complex control, pass through the higher order motor areas of the cerebral cortex and more lateral parts of the cerebellum.





Levels of neuronal abstraction

The LSAM model considers four levels of abstract neuronal representation, in hierarchically descending order: 1) Neuron bundles, the abstraction level native to LSAM; 2) Single neurons with spike interval probability distributions; 3) Spiking models; and 4) Action potentials.

LSAM itself implements the upper two levels directly, and calls a discrete-event simulator for the lower two levels. The simulator, EDLUT, is based on table lookup, and has been developed at the University of Granada, Spain.

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