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This thesis proposes a theoretical model of the cerebellum based on known anatomical and physiological data. The cerebellum is theorized to be functionally equivalent to a type of Perceptron pattern-recognition device. The mossy fiber → granule cell → Golgi cell input network performs a transformation on the incoming sensory data which enhances the learning and pattern-discrimination capacity of the Purkinje response cells. Data storage, or motor learning, is postulated to occur as a result of error correction signals conveyed to the Purkinje cells and interneurons via climbing fiber inputs. Parallel fiber synapses on the dendritic spines of Purkinje cells, basket cells, and stellate cells are theorized to be specifically variable in response to climbing fiber signals. It is shown that in order for this type of learning to be stable, data storage must be accomplished principly by weakening synaptic weights rather than by strengthening them.

Mossy fiber input from higher level motor centers is shown to be capable of modifying the transfer function of the granular layer so that the behavior elicited by the cerebellum can be controlled by higher centers. Thus, the cerebellum can be likened to a library of conditioned-reflex "subroutines," any one of which can be called-up on command by higher level motor centers. Patterns of nerve firings on mossy fibers from higher centers constitute "subroutine calls" which enable the cerebellum to execute selected elemental movements under feedback control.

This theoretical model of the cerebellum has been implemented in software and used to control a mechanical manipulator. Readings from position measuring potentiometers on the manipulator are converted into simulated peripheral mossy fiber input patterns. Somatotopic convergence and overlap of peripheral mossy fibers in the granular layer is modeled. A control keyboard is used to simulate mossy fiber input from higher level motor centers. Climbing fiber error-correction signals are generated by comparing the position of the computer-driven arm against the position of a master-arm worn by a human experimenter.

A series of experiments is described which demonstrate the model's ability to learn and generalize as well as its susceptibility to interference between learning different tasks. The experimental results demonstrate a remarkable similarity between the behavior of the mechanical arm in learning simple motor tasks and the performance of biological subjects under similar conditions. Suggestions are made concerning possible applications to prosthetics and robotics.

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