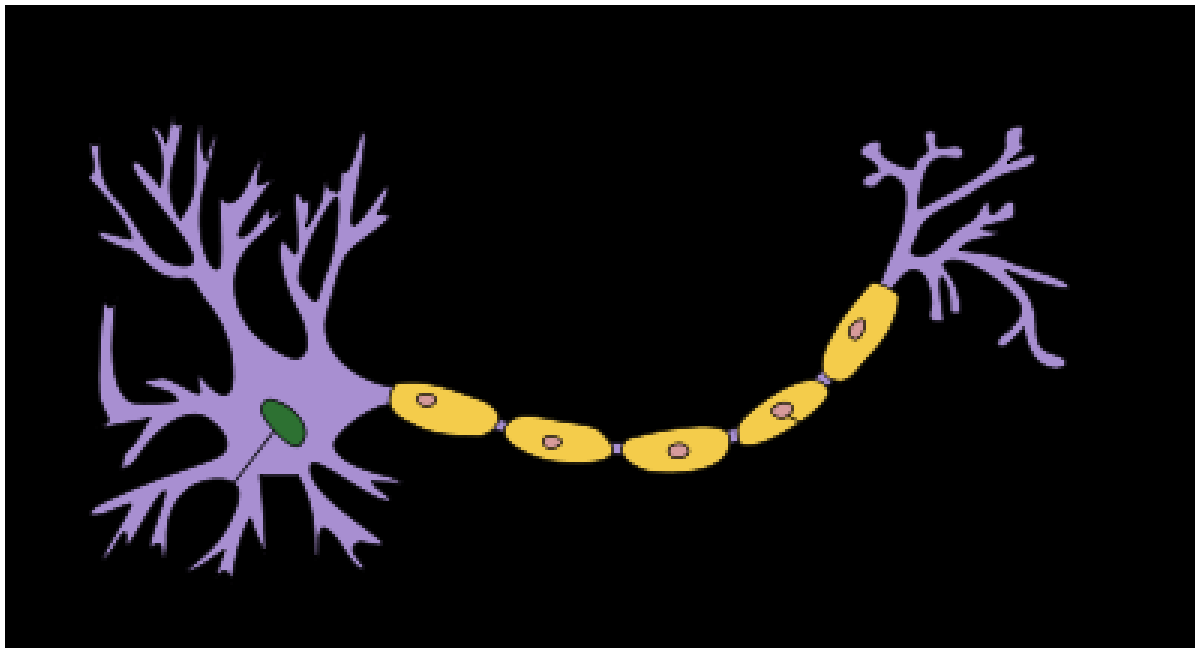# A theory of Cerebellar Function (1971)
James S.Albus

Background

- Cerebellum : part of the brain that controls coordination and balance
- Made up of different types of neurons.

The actors

- Mossy Fibers (the input layer): relays information from receptor organs such as muscles, skin. Excite up to 50 granule cells.

- Granule Cells (the associative cells): 100-250 granule cells per Mossy Fibers, excited by 4 mossy fibers.

- Golgi Cells (part of the recoder): excited by both Mossy Fibers and Granule Cells. Inhibit Granule Cells.

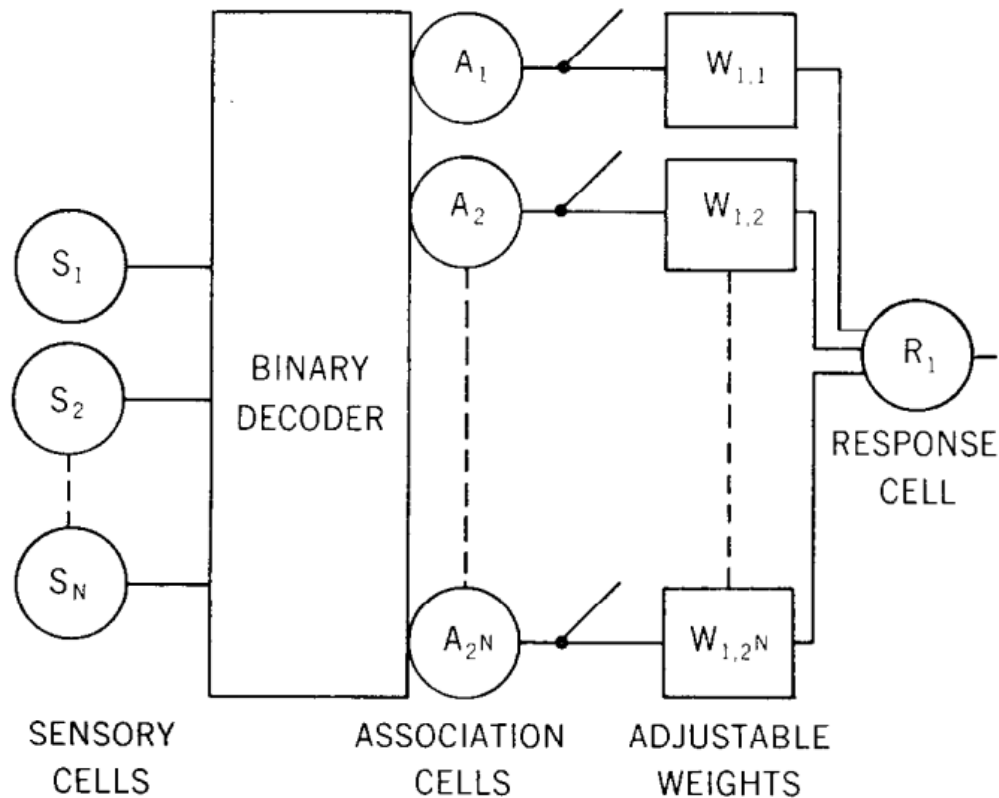- Purkinje Cells (response cells): Excited by every Granule Cells.

The Perceptron

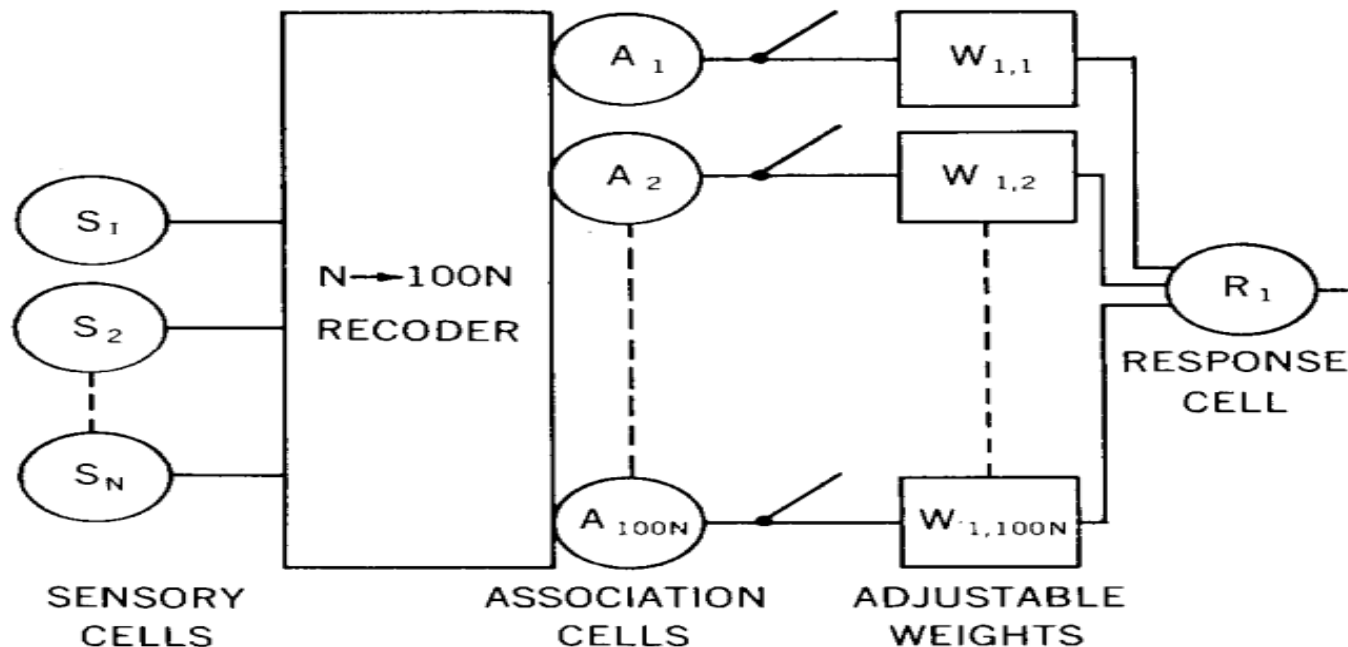- Used to model the Cerebellum.

- Most likely too simple for the task.
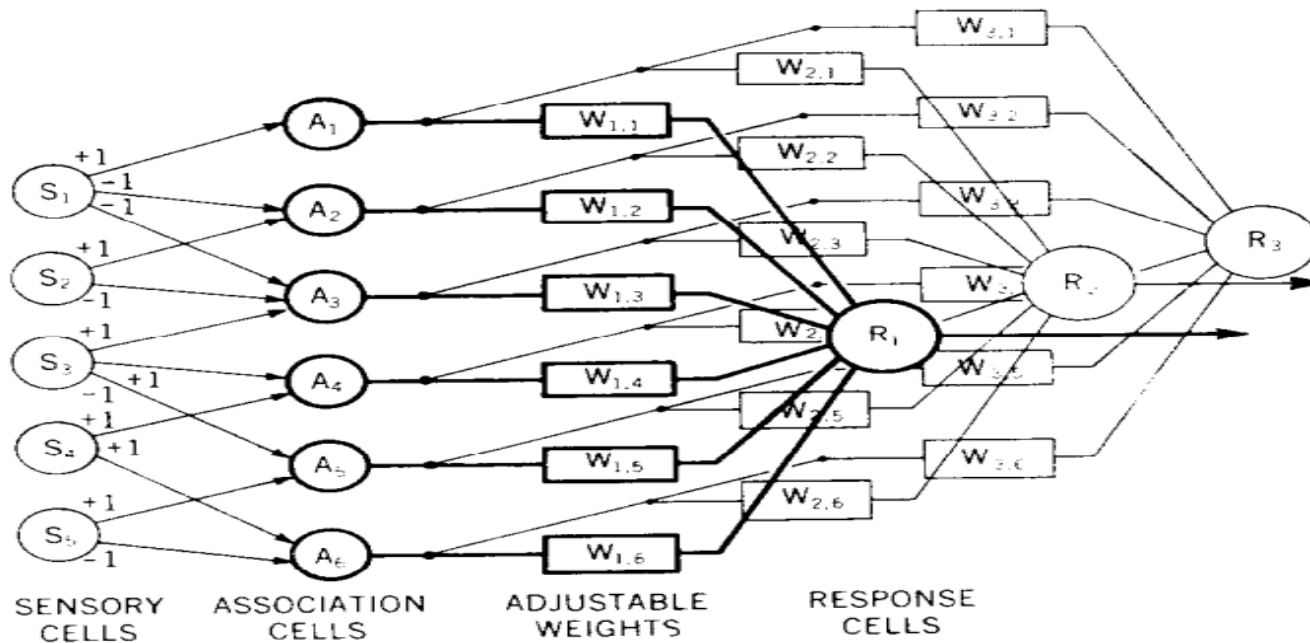
Binary Decoder

- Turn N bit signal into 2^N bit signal.
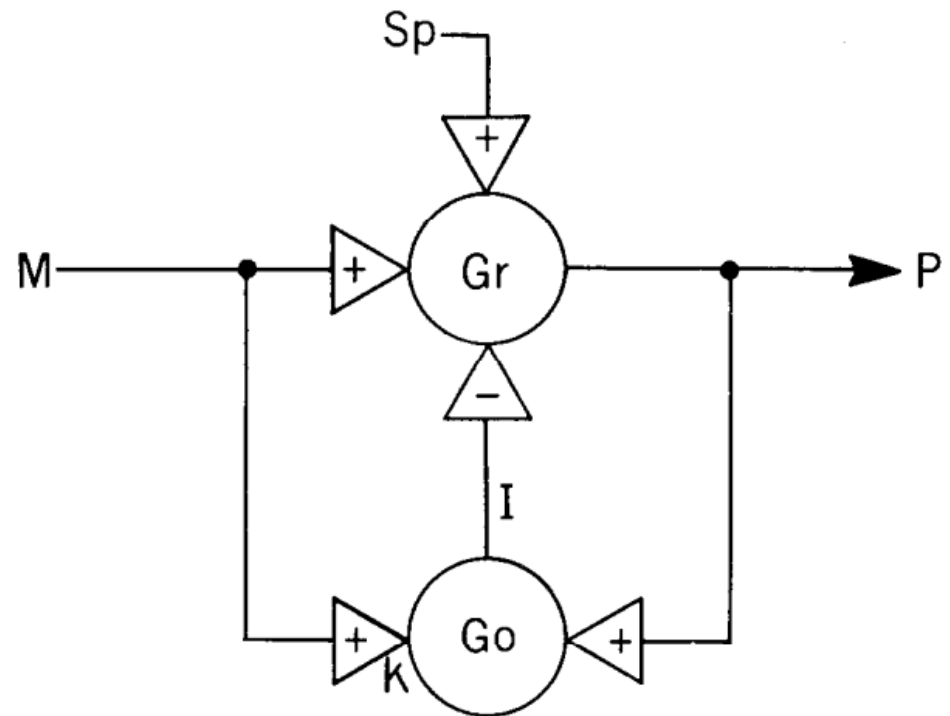- Not realistic for the cerebellum.

The Expansion Recoder

- 100 times more Granule Cells than Mossy Fibers.
- Restricts the activation rate of the association layer at 1%. More than 100^N possible patterns.

Maintaining constant activation in Associative Layer

- When many cells in the associative Layer are active, the Golgi Cells inhibit their activity.

- $P = (M - I + Sp)*Gr$
- $I = (KM + P)*Go$
- $Gr = 100$
- $Go = 100000/1000 = 100$
- $K = 1/10^5$
- $dP/dM = Gr(1-K*Go)/(1 + Gr*Go) = 0$

Advantages of using a recoder

- Can map the 2^N patterns to over 100^N patterns (ratio of 1 to 50).

- Allows pattern recognition for previously unrecognizable patterns.

- Helps the model to learn more quickly (more likely that the weights will be shifted in the right direction on the first example).

The response cell

- Purkinje cell serve as response cell for the cerebellum. The have a large fan-in whereas granule cells have large fan-out.

- The output of the cerebellum is the firing rate of the Purkinje cells (not binary).

- Problem with our model : Not possible for a neuron to be excitatory to one response cell but inhibitory to another.

The Actors(2)

- Basket Cells : receive excitatory contacts from granule cells. Inhibits about 50 Purkinje cells.

- Stellate Cells: Receive excitatory contacts from granule cells. A type inhibit Purkinje cells near them. B type similar to Basket Cells.

Inhibitory signals are summed by basket and stellate cell before being relayed to the response cell.
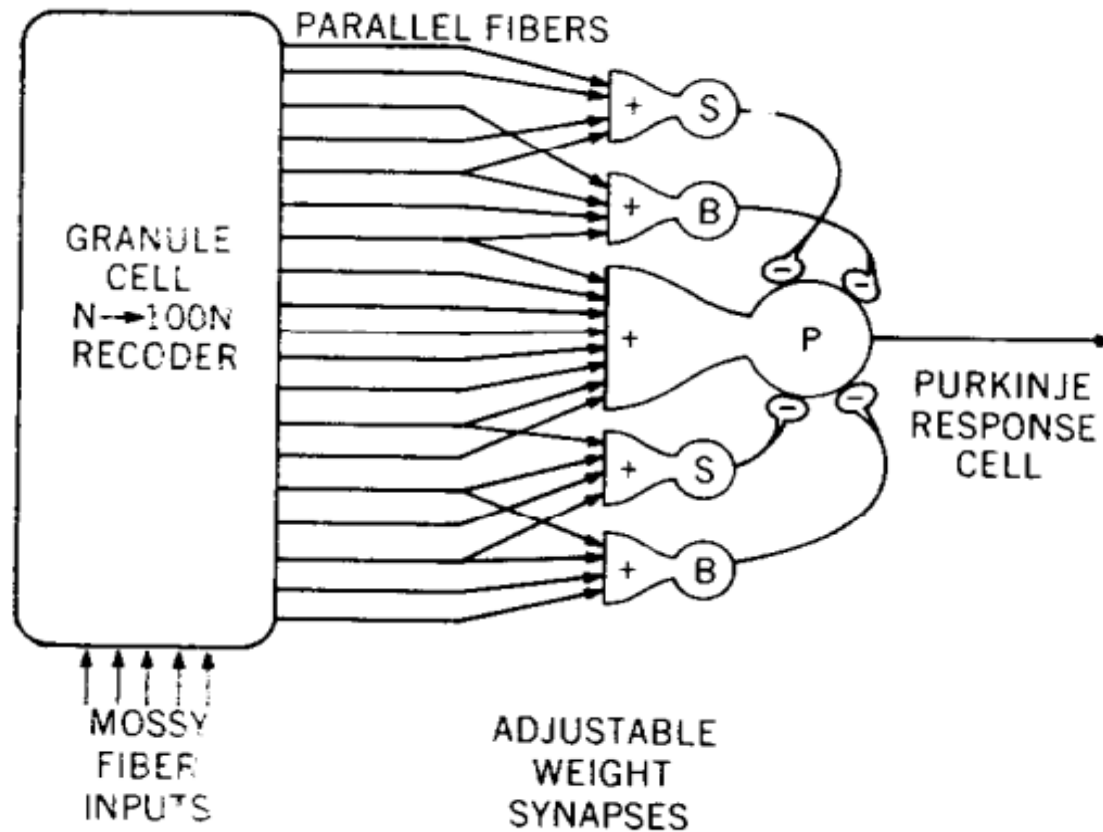
The Actors(3)

- Climbing Fibers: make strong excitatory contacts with Purkinje cells. Triggers a pause in Purkinje axon spike activity of 15 msec. Signal comes from higher motor center.

- Sends collaterals to branch on synapse between nearby basket and stellate b cells.

Hypothesis of variable synapses

- When the climbing fiber triggers a pause in the firing rate of Purjinke cells, it also weakens the synapses between the Purjinke cell and any granule cell attempting to excite it. The weakening is proportional to the excitation signal.

- On the other hand, it reinforces the synapse between granule cells and the basket and stellate b cells that inhibit the Purjinke cell.

- Single event triggers update in the weights. Not clear how it is performed in practice.

CMAC (origin of tile coding)

- The S to A* mapping is similar to finding the N tiles out of the 100N in which S landed.
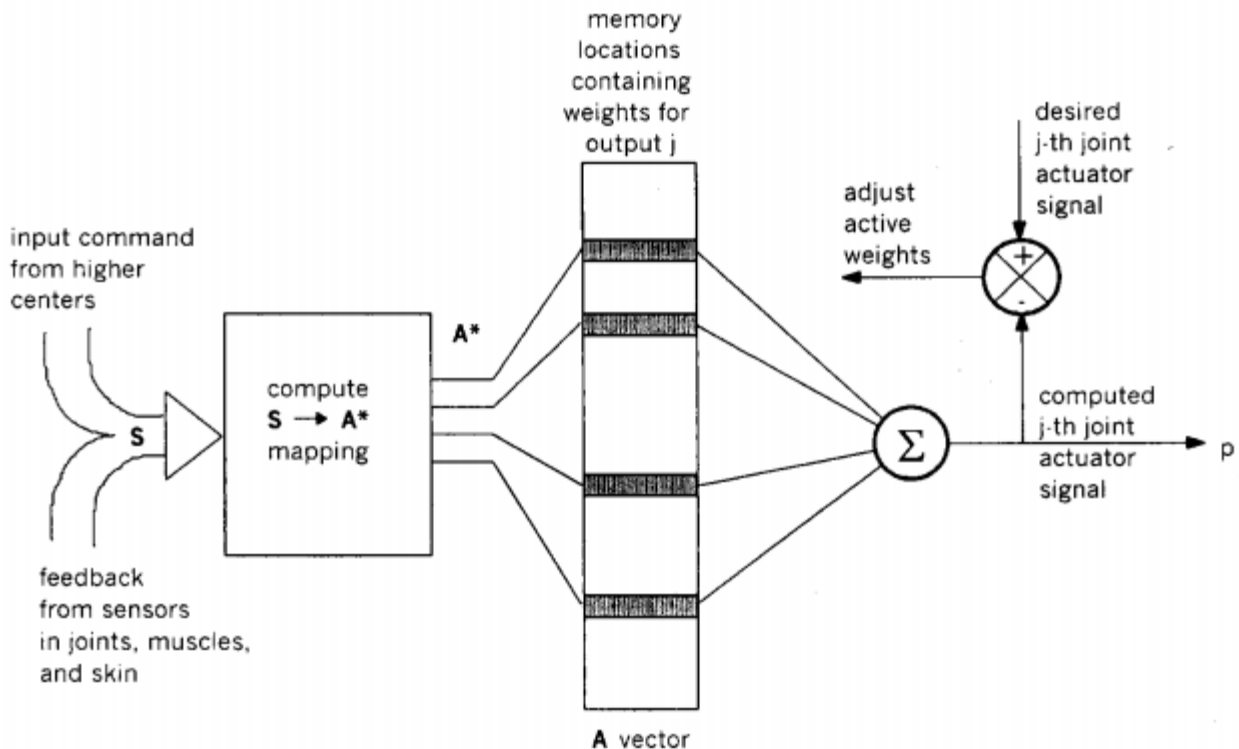
A new approach to Manipulator Control: The CMAC (1975)

Questions ?