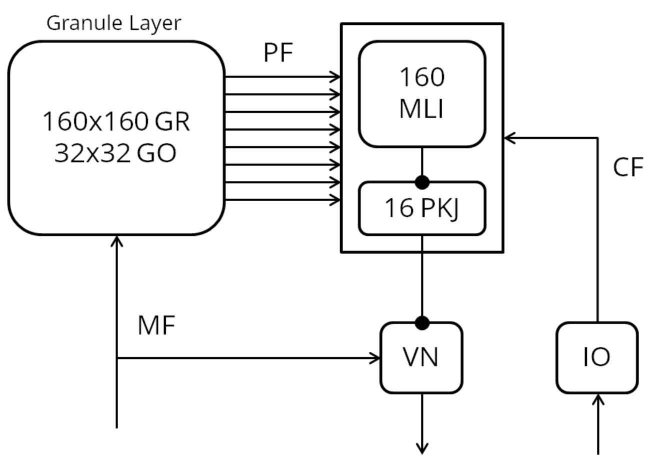
A Computational Model of the Cerebellum with Plasticity at the Parallel Fiber – Molecular Layer Interneuron Synapses

William Lennon[1], Robert Hecht-Nielsen[1] and Tadashi Yamazaki[2]

[1]Department of Electrical and Computer Engineering, University of California at San Diego.
[2]Department of Communication Engineering and Informatics, University of Electro-Communications

The functional role of the molecular layer interneurons (MLIs) (basket and stellate cells) in the cerebellar cortex is not understood. Experimental evidence from genetically modified mice lacking MLI feedforward inhibition onto Purkinje cells (PKJs) show significant impairments in their ability to consolidate VOR gain down learning over 24 hours and their ability to learn VOR phase reversals [1]. These deficits suggest a significant role for MLIs in cerebellar function. To investigate the role of MLIs, we extend a spiking neural network model of the cerebellum [2] to account for MLI physiology, anatomy and plasticity at the parallel fiber (PF) - MLI synapses. We model MLIs as conductance-based leaky integrate-and-fire neurons with a spontaneous depolarizing current and physiological parameters derived from the literature. We show that the spontaneous current is capable of reproducing complex neuron dynamics observed *in vitro*. We model plasticity at the PF-MLI synapse as a complementary and synergistic form of learning to plasticity at the PF-PKJ synapse, as supported by some experimental evidence [1]. The network successfully learns an appropriate opto-kinetic response (OKR) given simulated mossy fiber (MF) and climbing fiber (CF) input. The network also exhibits additional physiological phenomena observed *in vivo:* blocking GABA shifts PKJ firing rate from out-of-phase with MF input to in-phase, as observed in the VOR [3].



References:

Gao, Z, van Beugen, B & De Zeeuw, C, (2012). Distributed synergistic plasticity and cerebellar learning. *Nature reviews. Neuroscience,* 13(9), pp. 619-635.

Yamazaki, T. & Nagao, S., 2012. A computational mechanism for unified gain and timing control in the cerebellum. *PloS one,* 7(3).

Miyashita and Nagao (1984) Contribution of cerebellar cortical inhibition to Purkinje cell responses during vestibulo-ocular reflex of alert rabbits. J. Physio, 251, pp. 251-262