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Shyam Diwakar

**Professor and Director,
Amrita Mind Brain Center,
Amrita University, India**

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Multi-Scale Modeling of the Cerebellum: Computational Neuroscience of single Neuron Models, Circuit reconstructions and Emergent Responses

Abstract: Computational neuroscience is trending multiple directions including bottom-up and top-down reconstructions of brain cells and circuits to better understand function and dysfunction. Modeling entire brain circuits has been progressing outcomes that may lead to digital twins and virtual patients. Degeneration of the granular layer of the cerebellum is also an autosomal recessive disorder exhibiting clinical features such as delayed motor development, non progressive ataxia, delayed language development with dysarthria and mental retardation (Pascual-Castroviejo, 1994). Information transmission at the Mossy Fiber (MF) - Granule cell (GrC) synaptic relay is crucial to understand mechanisms of signal coding in the cerebellum (Albus,1971) (Marr, 1969). The cerebellum input stage has been known to perform combinatorial operations on input signals. Using models (Medini, 2012, Vijayan, 2022), this talk will focus on information transmission and signal recording in the cerebellum. Understanding population activities of underlying neurons reveal emergent behavior as patterns of information flow in neural circuits. Local field potentials (LFPs) (Parasuram, 2016, 2017) and BOLD signals (Nutakki, 2020) were reconstructed to test and parameterize the molecular mechanisms of cellular function with network properties. Using methods in computational neuroscience, we reconstructed synaptic spike-time dependent plasticity and explored the role of single neurons in neural ensembles. The abstraction of a cerebellum-inspired model (Vijayan, 2022) to robotic tasks including pattern recognition and recording of inverse kinematics for trajectory tracking as emergent circuit behaviors will be discussed.

Brief Bio: *Shyam Diwakar is the Director of the Amrita Mind Brain Center, a Faculty fellow at the Center for International Programs at Amrita University. He is the Institute Integration Coordinator and Lab Development Coordinator of the major virtual labs initiative supported by Sakshat mission of Ministry of Education, Government of India, Indian cordinator of the Multi-Scale Brain Function India-Italy Network of Excellence and the Principal Investigator of few other projects. He currently continues his research on computational neuroscience, neurophysiology, EEG and building devices and tools for neurology and neuroscience.*