Indian Institute of Science

Centre for BioSystems Science and Engineering

Annual Work Presentation

At 4:00 PM on 22nd October 2018 (Monday)

MRDG Seminar Hall, 1st Floor, Biological Sciences Building

A CONTROL SYSTEMS FRAMEWORK TO UNDERSTAND THE PRINCIPLES OF VOLUNTARY MOVEMENTS

Ms. Varsha Vasudevan

Advisers: Prof. Aditya Murthy and Prof. Radhakant Padhi

Abstract

Movements are the building blocks of goal-directed behavior and represent an evolutionary solution that enable organisms to seek food, avoid predators and find mates in an unpredictable and unstructured environment. Although the biological structure and function of motor systems has been understood in detail, many fundamental principles underlying motor control remain elusive. For example, why are some movements always carried out in a specific pattern, say a straight line, although there are multiple possible ways? One reason for this lacuna perhaps is that these questions need not necessarily be answered by deeper descriptions of the biology and are better posed at a more abstract level.

Control theorists have tried to understand motor control by essentially modelling it as a feedback control system. But these studies have largely been restricted to investigating the central tendencies of movements like the mean trajectories. However, given that the motor system is inherently noisy, movements are typically variable in nature and this is observed when people make repeated movements towards the same end goal. Hence, it is imperative to study, and more importantly include variability as an aspect of motor control. One approach that incorporates behavioral measures of variability in understanding principles of motor control is the stochastic optimal control framework. These models hypothesize that the motor system could have evolved to produce optimal motor commands that minimize a biologically relevant cost of movement generation even in the presence of noise.

In this thesis, I have studied eye movements with emphasis on mean trajectories as well as inter-trial variability. Using the natural variability in a kind of eye movement called saccades, I have tried to gain more insights into principles based on which a noisy motor system could be functioning, that enables it to be efficient. Some questions I have addressed via this approach are:

1. Does the saccadic system plan for a trajectory control or an endpoint control?
2. What type of internal feedback information is used for saccade control?

Using a stochastic optimal control framework, I provide evidence that the saccadic system may use trajectory planning that includes the desired saccade velocity. This is an important finding given that the dominant view in the field is that saccades are planned based on target displacement only. I have also shown using a stochastic saccade generation model of the brainstem circuit that saccades may use multiplexed velocity and displacement internal feedback information to improve accuracy.