

A minimal reaction-diffusion neural model generates *C. elegans* undulation

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Abstract

The small (1 mm) nematode *Caenorhabditis elegans* has become widely used as a model organism; in particular the *C. elegans* connectome has been completely mapped, and *C. elegans* locomotion has been widely studied (c.f. <http://www.wormbook.org> [Corsi]). We describe a minimal reaction-diffusion model for the *C. elegans* central pattern generator (CPG) [Xu *et al.*, Wen *et al.*]. We use simulation methods to show that a small network of FitzHugh-Nagumo *et al.* neurons (one of the simplest neuronal models) can generate key features of *C. elegans* undulation [see Mages *et al.*] and thus locomotion. Compare the neuromechanical model of Izquierdo and Beer. We also investigate dynamics and stability of the model.

INTRODUCTION

The small (1 mm) nematode *Caenorhabditis elegans* (*C. elegans*) has become widely used as a model organism [Corsi], and has been among the most widely studied biological models of neuronal development, locomotion and the central pattern generator [Katz]. The *C. elegans* connectome has been completely mapped [Jabr] and, as described below, its locomotion has been widely studied. “When crawling on a solid surface, the nematode *C. elegans* moves forward by propagating sinusoidal dorso-ventral retrograde contraction waves. A uniform propagating wave leads to motion that undulates about a straight line.” [Kim *et al.*]. A different type of locomotion, often called swimming, occurs when nematodes are submerged in a liquid medium. The nematodes “switch” between these two gaits, under the regulation of particular serotonergic and dopaminergic neurons.

The purpose of this paper is to describe a minimal reaction-diffusion model for the C. elegans central pattern generator (CPG) [Xu *et al.*, Wen *et al.*]. We use simulation methods to show that a small network of FitzHugh-Nagumo *et al.* neurons (one of the simplest neuronal models) based on a skeleton model of the C. elegans CPG can reproduce key features of C. elegans undulation [Magnes *et al.*] and thus locomotion.

THE MODEL CENTRAL PATTERN GENERATOR

The central pattern generator is a small neural circuit which regulates the movement of the nematode. This structure is present in different forms in many different animals, and it regulates many different types of regular movement.

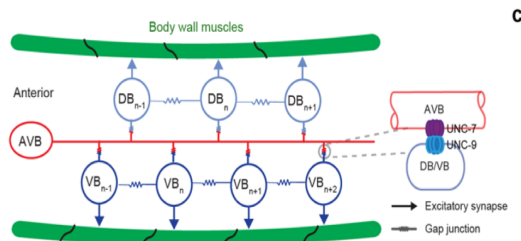


FIG. 1. Pirated from Xu

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