Emulating the Functionality of Rodents’ Neurobiological Navigation and Spatial Cognition Cells in a Mobile Robot

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Abstract

A unique roving robot navigational system is presented here, which is inspired by rats’ navigational and spatial awareness brain cells. Rodents, as well as all mammals, are capable of exploring their surroundings when foraging or avoiding predators, and remembering their way home or to the closest known shelter through path integration. This is true for other creatures, but the neural cells involved in accomplishing these tasks have been most notably studied in rats, as they share certain similarities with a human’s brain. The robot built in this study, named ratbot, uses characteristics and interpreted functionalities of the specialized navigational and spatial cognition brain cells, which are primarily found in the hippocampus and entorhinal cortex. These cells are the: place cells, head direction cells, boundary cells, and grid cells, as well as memory used for the storage and access of salient distal cues. Similar to a rat, the ratbot uses path integration to navigate from one waypoint to another. This is accomplished through use of vectors and vector mathematics. Additionally, the ratbot uses a field programmable gate array to emulate grid cell inspired functionality for environment mapping and spatial cognition.

Keywords

Neuron, Spatial Cognition, Proprioceptive Stimuli, Vestibular Stimuli, Salient Distal Cues.

Introduction

This poster brings together a culmination of observations and findings from researchers in the fields of neuroscience and biology/zoology. The focus of such research falls into the following two areas: (1) the study of specific brain cells in rats found to be involved in navigation and spatial cognition[1-12], and (2) observations made of insects, mammals, and other animals in their travel patterns, along with the conjecture that their brains are continuously performing vector summation for calculating (path integration) from various points of travel to a straight vector “home” [13, 14].

Additionally, through the use of a field programmable gate array (FPGA), the ratbot’s environment is logically mapped into a two dimensional array of parallel processing units. Each unit is an instantiated grid cell’s firing region, which naturally maps over the local area in a hexagonal formation, as it does for a rodent. In a rodent or any mammal, a single grid cell fires whenever the animal has crossed (or stopped on) a spot that the animal has visited before.

References


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Received a B.A. in Mathematics/Computer Science in 1986 from the Western Connecticut State University, a B.S. in Electrical Engineering in 1989 from the University of Bridgeport (Cum Laude), an M.S. in Electrical Engineering in 1996 from the Johns Hopkins University, and is currently working towards his PhD in Computer Science and Engineering from the University of Bridgeport. He has worked the past 25 years in industry as an electrical engineer for companies such as: Raytheon, Lockheed Martin, the Department of the Navy – DOD, MIT Lincoln Labs, Synopsys, Inc. and the University of California – Davis. His interests/expertise are in the areas of parallel processing (FPGAs and GPGPUs), robotics, embedded systems, and neuroscience.