Retinotectal Projection Simulation: Requirements Document

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April 2024

1 Foreword

This simulation program is designed to advance the understanding of axon guidance and topographic mapping, critical processes in neural development. It focuses primarily on retinotectal projections but is adaptable to other areas, offering a versatile tool for the scientific community to explore and experiment with these complex phenomena.

Equipped with customizable parameters and a user-friendly graphical interface, the program allows researchers to delve into the dynamics of axonal behavior, enhancing both the accessibility and depth of neuroscience simulations. Researchers can adjust simulation variables such as growth cone size, step distance, and substrate types, and visualize outcomes including growth cone trajectories and projection mappings. This document details the functional and non-functional requirements, setting the foundation for its effective use and ongoing development.

2 Target Definition

The primary goal of this simulation program is to serve as a research tool for axon guidance studies, specifically for experimenting with models developed for topographic mapping in retinotectal simulations and other contexts.

3 Functional Requirements

/FR-10/ Simulation

The program conducts simulations of the Retinotectal Projection based on user-defined configurations.

/FR-20/ Simulation Parameters

Users can customize the following simulation parameters:

1. Number of growth cones
2. Size of growth cones
3. Total number of steps
4. Distance covered in each step
5. Probabilities of steps taken in x and y directions individually
6. Fiber-fiber interaction factor by a sigmoid function
7. Sigma for Gaussian Distribution
8. Force along X axis enabling
9. Adaptation enabling
10. Mu for Adaptation
11. Lambda for Adaptation
12. Adaptation history length

/FR-30/ Substrate Parameters

Users can customize the following substrate parameters:

1. Dimensions of the Substrate
2. Type of Substrate
3. All necessary variables to customize settings for different types of substrate, i.e., wedge or stripe dimensions

/FR-31/ Substrate Types

Following substrate types are supported as default:

1. Continuous gradients
2. Wedges
3. Stripe Assay
4. Gap Assay and Inverted Gap Substrate

/FR-32/ GUI Substrate Configuration (optional)

Users can customize the substrate using the GUI by adjusting each cell.

/FR-40/ Graphical User Interface
The program offers a graphical interface for user interaction.

/FR-50/ Visualization
The program visualizes the following:

1. Substrate
2. Tectum end-points of growth cones on empty background or substrate
3. Projection Mapping on a two-dimensional plane, with axes representing the initial and final growth cone positions
4. Growth cone initial sensor values *(new)*
5. Growth cone trajectory
6. Growth cone history *(new)*

/FR-51/ Evaluation of Projection
The program calculates linear regression on projection mapping and presents its graphical representation, including correlation, intercept, and slope values.

/FR-52/ Evaluation of Projection: Smooth Interpolation
User can select smooth interpolation instead of linear regression. *(new)*

/FR-60/ Result Saving (optional)
Users can save simulation results both textually and visually.

/FR-70/ Estimated Time
During the simulation, the program provides an estimated time remaining indicator.

4 Non-Functional Requirements

/NR-10/ Scalability
The program should be designed to accommodate larger quantities of growth cones, steps, and field sizes.

/NR-20/ Performance
Considering NR-10, the program should optimize simulation time to efficiently handle larger inputs.

/NR-30/ Usability

The program should be intuitively usable by anyone and easily extendable by bioscientists.

5 Constraints

/CN-10/ Development Platform

The development platform is limited to MatLab or Python.

/CN-20/ Mathematical Model

All calculations in the simulation will adhere to predetermined mathematical models of this Paper.