NEURON-Based Nerve Bundle Model

1. Introduction

This project aims to develop a simplified nerve bundle model using the **NEURON** simulation environment to study the effect of **Electrode** to **Compound Action Potential (CAP)**.

The model will begin with a **single nerve fiber** and progressively advance to a more complex **nerve bundle**. The stimulation methodology transitions from **intracellular** electrode to extracellular electrode (only considering the **distance** between electrode and fiber) and ultimately to extracellular electrode (considering both distance and **membrane area**). Recording techniques will evolve from **intracellular** electrode to **extracellular** electrode.

2. Scope

For the nerve cell structure, the model will focus on **Axon**, omitting soma, dendritic structures, and neurotransmitter-mediated synaptic transmission. And this model will only consider the topology of the nerve, and ignore the anatomical shape.

This model will take into account a **general fiber bundle** without considering a specific part of the human body or an animal. And the stimulus is a **universal electrode** and does not correspond to a specific device.

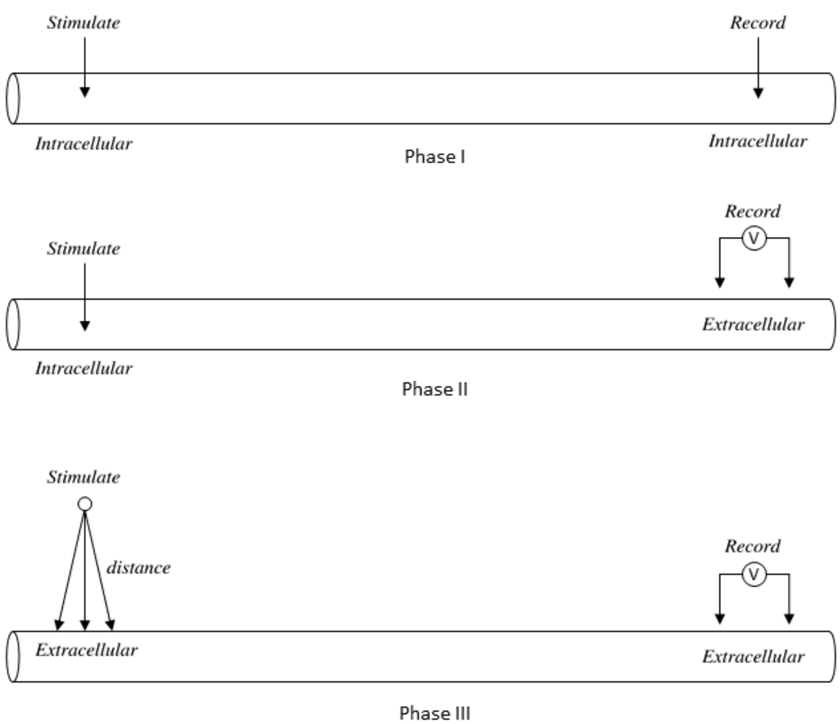
3. Procedure

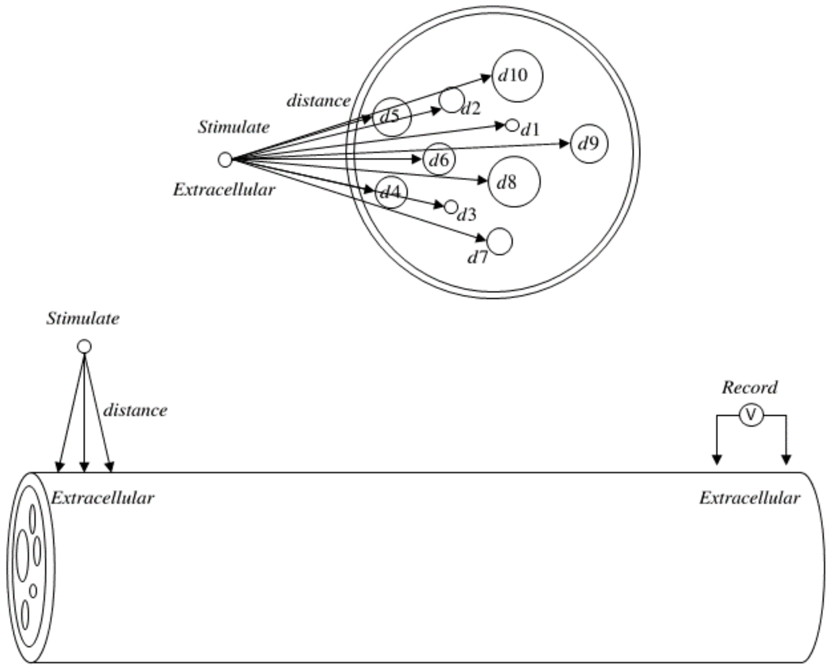
The project is divided into five distinct phases:
- **3.1 Phase I**: Single neuron fiber, stimulation and recording via intracellular electrode.
- **3.2 Phase II**: Single neuron fiber, stimulation via extracellular electrode (considering distance), recording via intracellular electrode.
- **3.3 Phase III**: Single neuron fiber, stimulation via extracellular electrode, recording via extracellular electrode.
- **3.4 Phase IV**: Nerve fiber bundle (considering fiber diameter variability), stimulation via extracellular electrode, recording via extracellular electrode.
- **3.5 Phase V**: Nerve fiber bundle, stimulation via extracellular electrode (considering charge

density to each fiber), recording via extracellular electrode.

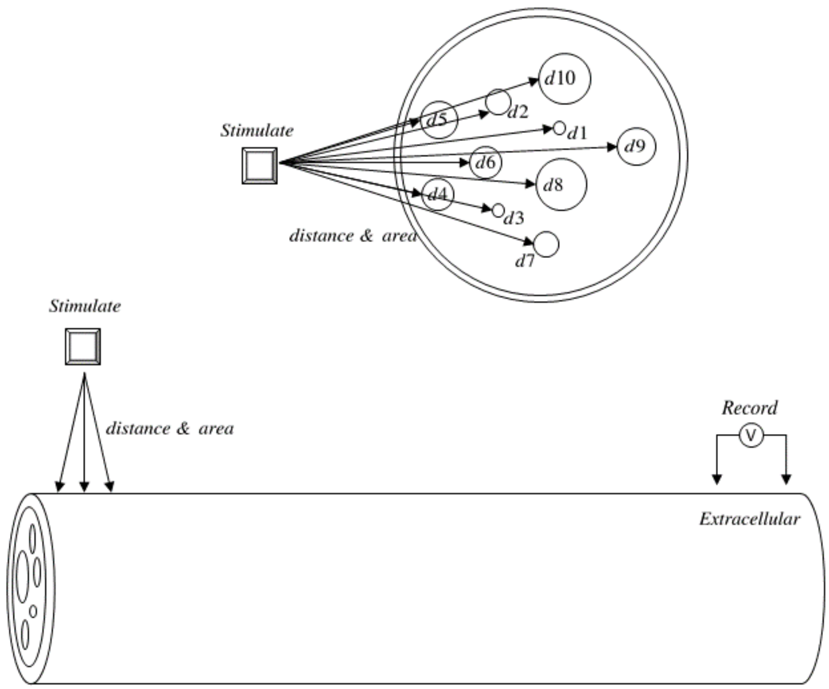
4. Schedule

Procedure	Nerve	Stimulation	Record	Date
Phase I	Single	Intracellular	Intracellular	2025.03.05
Phase II	Single	Extracellular (distance)	Intracellular	2025.03.07
Phase III	Single	Extracellular (distance)	Extracellular	2025.03.11
Phase IV	Multiple	Extracellular (distance)	Extracellular	2025.03.12
Phase V	Multiple	Extracellular (charge density)	Extracellular	2025.03.13




Stimulate
distance
Extracellular
d10
d5
d2
d1
d9
d6
d8
d4
d3
d7
Stimulate
distance
Record
V
Extracellular
Extracellular

Phase IV



Phase V

5. Implementation

5.1 Programming Language

The model will be implemented using the **hoc** and **python** programming language.

5.2 File Architecture

- **Topology**: Definition of the modeled nerve fiber and nerve bundle structures.
- **Stimulation**: Implementation of various stimulation methods across different phases.
- **Record**: Implementation of different recording methods and data acquisition approaches.

6. Stimulation

6.1 Waveform

The simulation will incorporate different types of waveforms, including: - **Single pulse stimulation**: A single short-duration stimulus. - **Biphasic pulse stimulation**: Two-phase waveform for reducing charge accumulation.

6.2 Parameters

Each stimulation will be configured with different parameters: - **Amplitude**: 0mA to 5mA - **Duration**: 0 us to 2, 000 us - **Waveform Type**: Square pulse, Biphasic pulse, Sinusoidal - **Electrode-fiber distance**: - **Fiber diameter**: - **Charge density**:

7. Recording

- **Intracellular electrode**: Measures intracellular potential changes.
- **Extracellular electrode**: Measures the extracellular potential changes.
- **Compound action potential**: Sum the action potentials of different nerve fibers.

8. Outcome

The expected results from this project include: - A nerve boundle model built with hoc file. - Some figures and animations which show the compound action potential. - A document show how to use the model.