

I-STEM Software Request - Guide Approval Form

User Details

- Name of Researcher: Mushahid Salmani
- User Type: ☒ Ph.D. Scholar ☐ Postdoctoral Researcher ☐ Bachelor's ☐ Masters
- Institution Name : Jawaharlal Nehru University
- Institutional Contact No: 9654463102 / 011-26739227
- Research Topic: Retinal Implant

Software Request Details

- Software Name: COMSOL Multiphysics
- Justification for Software Request: [Provide detailed explanation of how the software supports your research objectives]

Guide/Supervisor Approval

I, Sandeep Kumar (Guide/Supervisor Name),

- Confirm that the above-mentioned researcher is affiliated with our institution
- Have reviewed the software request and its relevance to the researcher's academic work
- Approve the software request for research purposes

Approval Confirmation

- I approve the software request
- The software aligns with the researcher's research objectives
- The request meets the institutional research guidelines

Guide/Supervisor Signature: _____

Date: 20-06-2025

Official Stamp/Seal: [Space for Institutional Stamp]



डॉ. संदीप कुमार / DR. SANDEEP KUMAR
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Important Notes

- This form must be signed and scanned
- The scanned copy must be uploaded with the software request
- Electronic signatures are acceptable if from an official institutional email

Subject: Request for Access to COMSOL Multiphysics for Retinal Electrode Simulation Research

Respected Sir/Madam,

I am currently conducting a research project focused on **retinal neurostimulation**, specifically targeting **Retinal Ganglion Cells (RGCs)** using advanced electrode designs such as **concave electrodes** and **Penetrating Electrode-In-Well (PEIW)** architectures. My objectives include:

1. **Designing and optimizing 3D electrode geometries** for selective stimulation of RGC somas while minimizing activation of axons, which is crucial for improving spatial resolution in visual prosthetics.
2. **Simulating electric field distributions** in the multi-layered retinal tissue to understand how variations in electrode shape, material, and positioning affect neural activation.
3. **Comparing electrode types (concave vs PEIW)** for their effectiveness in localized and selective neural stimulation.
4. **Integrating electric field outputs from COMSOL into NEURON simulation environment** to simulate biophysical responses of RGC populations.

To achieve these goals, **COMSOL Multiphysics is indispensable** for the following reasons:

1. Accurate 3D Modeling of Complex Retinal Tissue and Electrodes

COMSOL allows me to:

- Create detailed 3D models of **retinal layers** (NFL, GCL, IPL, etc.) with realistic anatomical thicknesses and electrical properties.
- Precisely construct **concave and PEIW electrode geometries**, including control over curvature, depth, and insulation pattern.
- Modify **electrode-retina distance (ERD)** and other geometric parameters to assess stimulation efficiency.

2. Electric Field Simulation Using the AC/DC Module

With the **Electric Currents (EC)** interface in COMSOL:

- I can simulate extracellular voltage distributions generated by **monopolar cathodic pulses** or other custom waveforms.
- COMSOL supports **quasi-static or time-domain simulations**, which is critical for modeling the transient nature of stimulation pulses (e.g., biphasic or triphasic).
- This enables direct assessment of how electric fields interact with specific retinal layers, especially the **Ganglion Cell Layer (GCL)** and **Nerve Fiber Layer (NFL)**.

3. Mesh Control and High Spatial Resolution

- I require **very fine spatial resolution ($\leq 1 \mu\text{m}$)** in the GCL to accurately capture the localized potential gradients influencing individual RGC somas.
- COMSOL's advanced meshing tools allow selective refinement in regions of interest while maintaining overall computational efficiency.

4. Post-Processing and Export for Multi-Scale Modeling

- Voltage distributions computed in COMSOL will be **exported as extracellular field maps**.
- These outputs are then integrated into the **NEURON simulation environment**, where multicompartment models of RGCs are used to simulate action potential generation.
- This **multi-tool approach** (COMSOL $\rightarrow$ NEURON) enables **comprehensive analysis of soma vs. axon activation**, a key aim of my project.

5. Parametric and Comparative Studies

- I will run **parametric sweeps** to evaluate the effect of design changes (e.g., curvature of concave electrodes, depth of PEIW) on electric field distribution.
- COMSOL's **parameterization and automation** features are ideal for such comparative design studies.

Conclusion

The use of COMSOL Multiphysics is critical to achieving the core objectives of my project:

- Design and simulation of novel electrode architectures,
- Evaluation of electric field targeting in layered biological tissue,
- Integration with neuronal modeling to predict stimulation outcomes.

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