Strategies to Minimize Unwanted Axon Activation for Retinal BMIs

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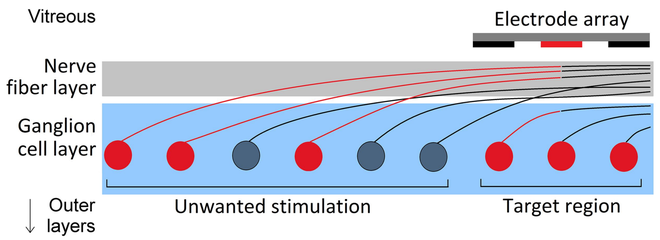
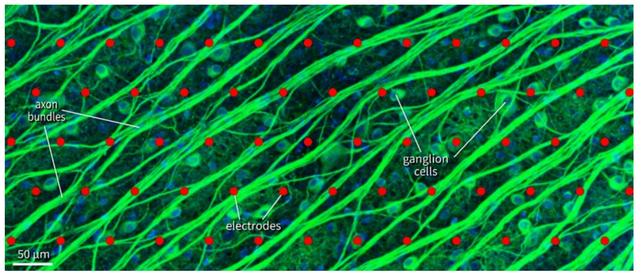
Introduction

- Unwanted axon activation is a major problem for modern epiretinal prosthetics.





[1-2]

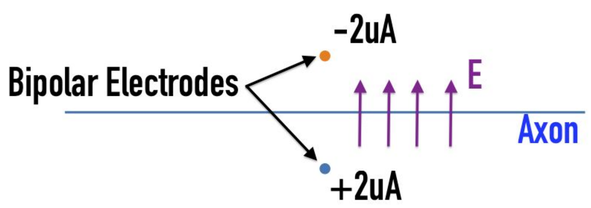
Methods

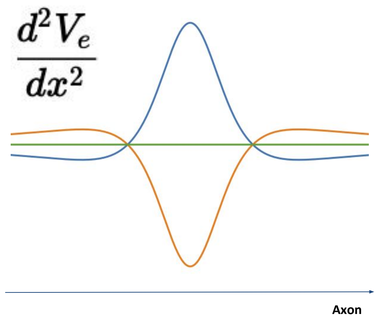
- We evaluate a bi-electrode, bipolar electrical stimulation strategy, as proposed in [3] -- which focuses on minimizing change in E-field across axon.

$$\text{Minimize } \max\left(\frac{d^2V_e}{dx^2}\right)$$
$$\text{Subject to: } p_e \in P_r,\ I_e \in [-4\mu A, 4\mu A]$$
$$\text{Given: } p_{e,fixed},\ r,\ \text{and } I_{e,fixed}$$

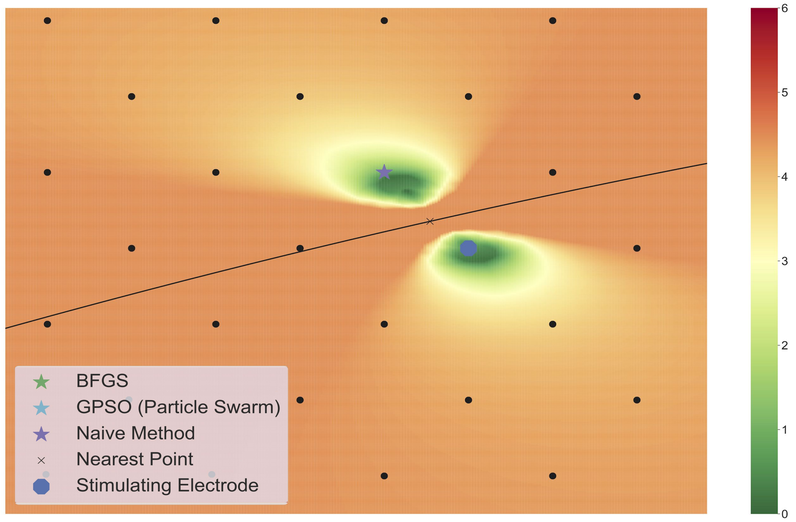
- We tested the following optimization methods:
  - Naive Method (Brute Force)
  - Global Particle Swarm Optimization (GPSO)
  - L-BFGS-B Gradient Search
  - Nelder-Mead
  - Conjugate Gradient

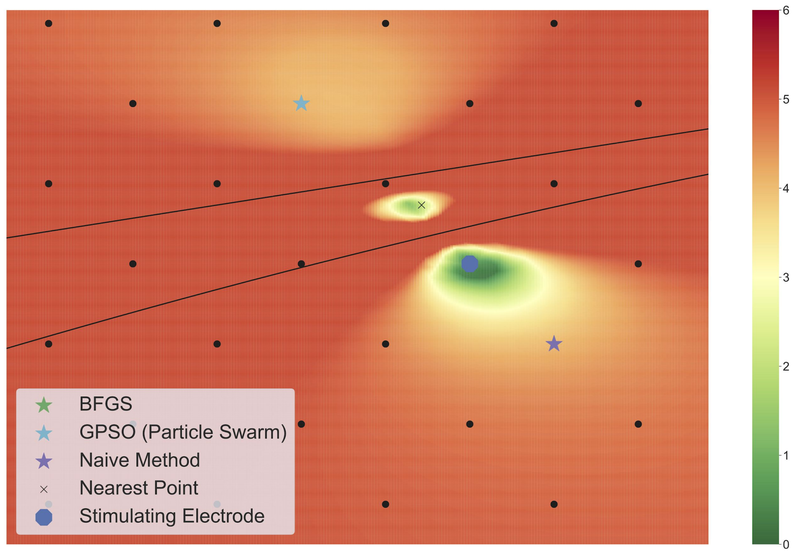
Theory





Results





Results Cont.

Optimization Method	# of Best Performances	Average Cost Improvement	Run-time
Naive Method	23	10.521	1
GPSO	16.67	11.2057	4.5423
BFGS	12.33	6.821	3.942

Optimization Method	# of Best Performances	Average Win Difference	Average Time
Naive Method	2.33	0.6279	0.001
GPSO	17.33	0.649	2.045
BFGS	18.33	2.065	1.98

Conclusions

- Overall, **L-BFGS** performed the best for the single axon scenario and the **Naive Method** worked best for the two axon scenario.

Future Research

- Re-design particle swarm optimizer, tailored to the lab-specific data structure
- Implement a deep learning model
- Evaluate impact on soma activation to fully understand the impact of this strategy on cellular selectivity

Acknowledgements

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References

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