Short Wave Infrared Neuromodulation Gadget (May 2023)

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***Abstract*— Direct stimulation of neurons in the brain can potentially treat many diseases, such as Parkinson's or Alzheimer's disease. Direct stimulation, whether it be through electric or photonic stimulation, provided a way to activate neurons in the brain and treat diseases and conditions. However, this kind of invasive stimulation can have risks that lead to worsening the condition or cause infection. The Short-Wave Infrared Neuromodulation Gadget (SWING) aimed to build and test a non-invasive optical method of stimulation with funding provided by the KIND Laboratory's Brain IMPACT project. SWING is part of the two semester long Electrical and Computer Engineering capstone sequence at The Ohio State University.**

Because the optical coefficients of biological tissue are not well known at 1550 nm, SWING used a cubic extrapolation to approximate these coefficients. Monte Carlo eXtreme (MCX) was then used to predict the expected photon distribution and intensity throughout a model of the human head. MCX was ran multiple times with different positions and wavelengths using The Ohio State Supercomputer. MCX showed that deep brain stimulation is possible at all the wavelengths tested. Based on the MCX results, 1550nm wavelength is the best choice for further testing. Solving the problems previously discussed has the potential to reduce the effects of brain disorders on the general population, mitigate the risks of surgery that patients would have to go through if done invasively, and to improve overall health.

***Index Terms*—**

I. Introduction

There are many physical issues in the brain, including Parkinson's disease and functional problems such as attention-deficit/hyperactivity disorder (ADHD) and depressive disorders. A solution to such problems that has been explored recently in the Neurotech community is one that involves a direct stimulation of neuronal connections in the brain [1]. Direct neuronal stimulation, whether it be through electric or photonic stimulation, provides a way to control mechanisms in the brain and treat diseases and conditions. These treatments result in an improvement of the effects caused by these diseases and conditions. However, most modern neuromodulation strategies are invasive in nature, and there are limited options for a non-invasive approach to neuromodulation for medical benefit. Many invasive techniques involve surgical implants and increase the risk of brain hemorrhage and worsening mental and emotional status for some patients, that often make the cons worse for life-threatening conditions [1]. As a result, SWING looks to investigate a non-invasive method for neuromodulation using a near-infrared photonic stimulation method.

TABLE I
Estimated Optical Coefficients

Tissue	Wavelength, nm	Absorption Coefficient μ_a, cm^{-1}	Reduced Scattering Coefficient μ_s', cm^{-1}
Scalp	810	0.505	2.35
	980	1.23	2.35
	1064	1.23	2.35
	1550	1.23	2.35
Skull	810	0.099	2.35
	980	1.23	2.35
	1064	1.23	2.35
	1550	1.23	2.35
Gray Matter	810	0.455	2.35
	980	1.23	2.35
	1064	1.23	2.35
	1550	1.23	2.35
White Matter	810	1.23	2.35
	980	1.23	2.35
	1064	1.23	2.35
	1550	1.23	2.35

II. Methods

III. Results

Using MCX and the interpolation-extrapolation estimation method, the fluence distribution of wavelengths 810 nm, 980 nm, 1064 nm, and 1550 nm were simulated and compared. The estimated coefficients can be found in Table I below.

IV. Next Steps

V. Conclusion

Acknowledgment

References

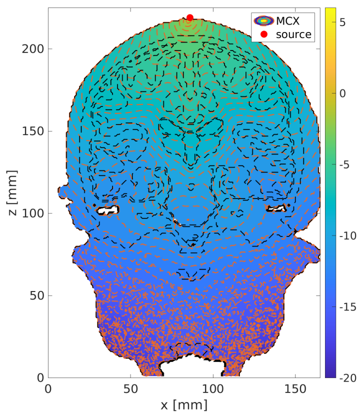

Fig. 1. 810 nm CZ Position

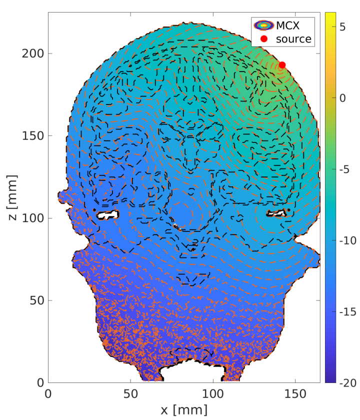

Fig. 2. 810 nm 45 Degree Position

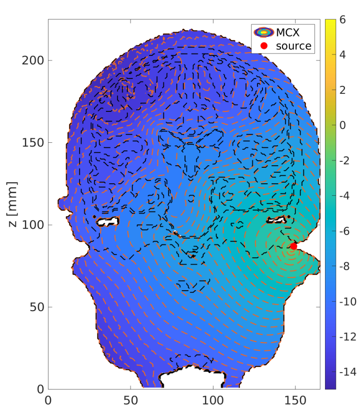

Fig. 3. 810 nm Cochlear Position

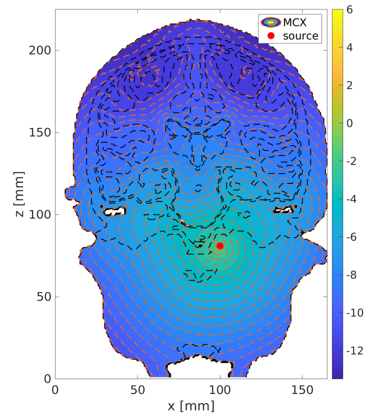

Fig. 4. 810 nm Intranasal Position

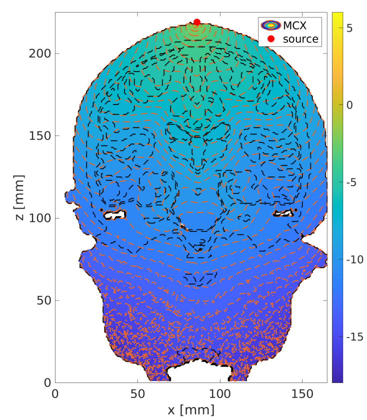

Fig. 5. 980 nm CZ Position

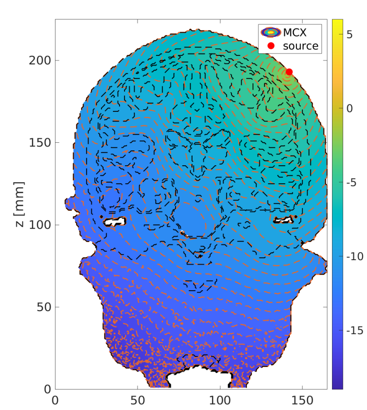

Fig. 6. 980 nm 45 Degree Position

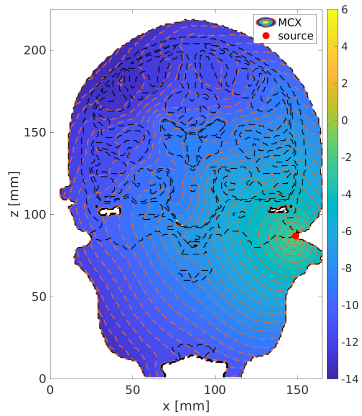

Fig. 7. 980 nm Cochlear Position

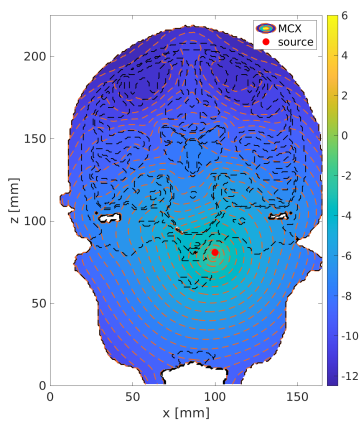

Fig. 8. 980 nm Intranasal Position

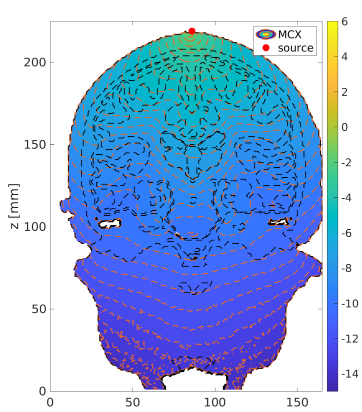

Fig. 9. 1064 nm CZ Position

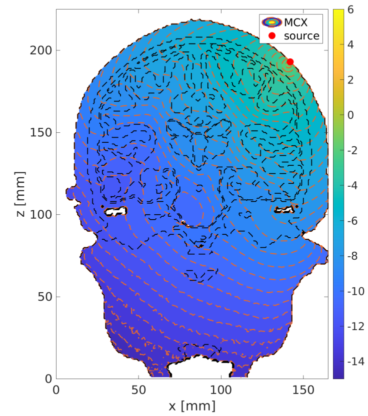

Fig. 10. 1064 nm 45 Degree Position

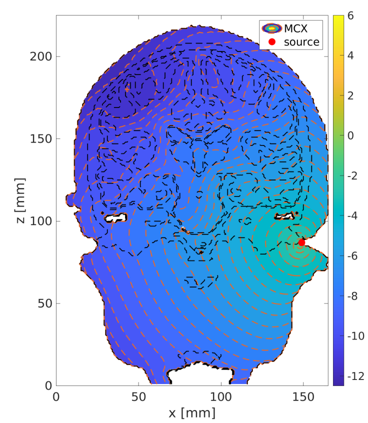

Fig. 11. 1064 nm Cochlear Position

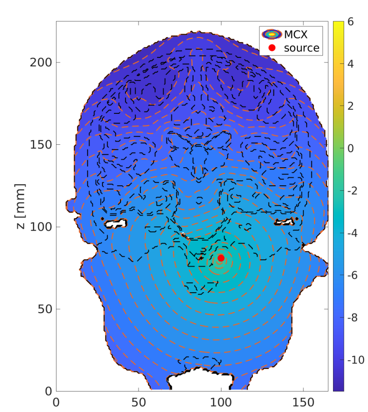

Fig. 12. 1064 nm Intranasal Position

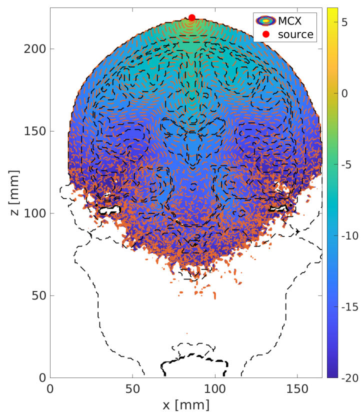

Fig. 13. 1550 nm CZ Position

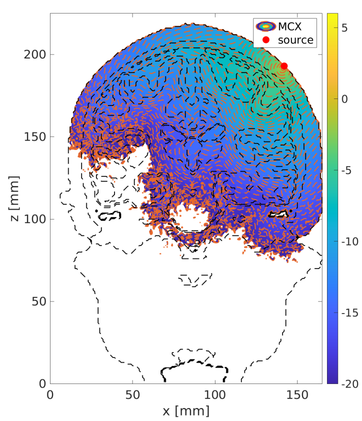

Fig. 14. 1550 nm 45 Degree Position

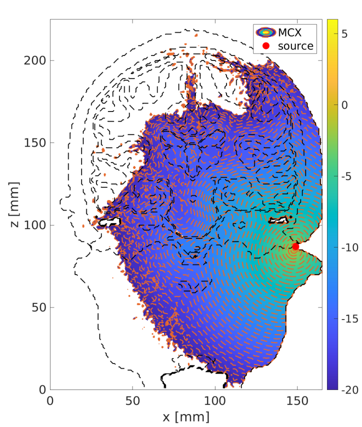

Fig. 15. 1550 nm Cochlear Position

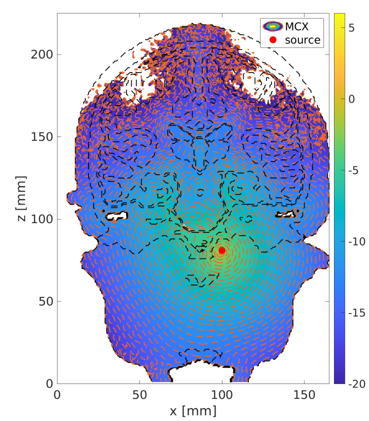

Fig. 16. 1550 nm Intranasal Position