Proposal Summary for: National Institute on Drug Abuse (NIDA) Challenge "$100,000 for start a SUD startup"

Neuralmodels.com: Software as a Service (SaaS) for modeling the neurobiology of substance use disorders

Principal Investigator: Antonio Ulloa, Ph.D., Founder and CEO of Neural Bytes LLC, 6136 New Hampshire Ave NE, Washington, DC.

PROPOSAL

Every human brain has about 100 billion neurons organized into vast complex networks. Neuroscience researchers work to understand how those networks produce cognition and behavior, as well as how the networks change over time and in the presence of substance use disorders (SUD). Many SUD researchers focus exclusively on empirical research, though scientists from a variety of disciplines consistently have identified the need to verify empirical results by integrating them with other empirical data through computational models.

To begin meeting this need, the Brain Imaging and Modeling Section of the National Institute on Deafness and Other Communication Disorders has developed large-scale neural modeling software ("LSNM"). Neuroscientists in this laboratory have refined LSNM over twenty years and today it allows researchers to make cohesive analyses of dispersed and dissimilar empirical data sets. LSNM merges functional magnetic resonance imaging (fMRI), diffusion tensor imaging (DTI), electroencephalography (EEG), magnetoencephalography (MEG), and other data and generates both neural models and simulated neuroimaging results. These simulated results support ongoing research into the neural mechanisms underlying cognition, behavior and brain disorders. LSNM has been used in a number of research projects, the latest of which was published as: Ulloa A and Horwitz B (2016) Embedding Task-Based Neural Models into a Connectome-Based Model of the Cerebral Cortex. Front. Neuroinform. 10:32. doi: 10.3389/fninf.2016.00032. Please use the following link to consult that article: http://dx.doi.org/10.3389/fninf.2016.00032. The source code of LSNM is also available from the following repository: https://nidcd.github.io/lsnm_in_python.

Though LSNM is available to its developers, and more recently in a public repository, it has not been prepared or deployed for wide-scale use in the neuroscience research community. LSNM requires users to have deep acquaintance with the underlying source code and to modify it appropriately before each use. In addition, any data to be merged and analyzed must be manually formatted before importing it into the software. As a result, scientists outside of the developers' laboratory are not able to use LSNM unless one of its developers is available to assist.

LSNM has the potential to advance significantly the analytical capabilities of the SUD

research community at a comparatively low cost to individual research teams. Neural Bytes LLC (neuralbytes.com) proposes to transform the LSNM simulator into Software as a Service (SaaS) to help SUD researchers further the understanding of the neurobiology of SUD. Neuralmodels.com will be the basis for a startup that will add computational neuroscience capability to every empirical SUD research team.

TECHNICAL COMPETENCE AS BIOMEDICAL SCIENTIST

Antonio Ulloa earned his Ph.D. in Cognitive and Neural Systems at Boston University and has extensive experience in computational neuroscience projects. He served as Postdoctoral Fellow at the Brain Imaging and Modeling Lab of the National Institutes of Health from 2001 to 2004, where he helped develop Large-Scale Neural Models Simulator (LSNM). He also founded Alpha Brain Technologies Ltd in the United Kingdom, a company that used brain science to develop mobile applications to interactively teach language skills. Dr. Ulloa also founded Neural Bytes LLC in the United States, a company that specializes in developing software to simulate the human brain. Through several federal contracts, Neural Bytes has completed an array of computational neuroscience solutions at the National Institutes of Health. Additionally, Dr. Ulloa has authored several scientific papers in the area of computational neuroscience and presented results of his research at several international conferences. Dr. Ulloa is currently the CEO of Neural Bytes LLC and a contract scientist at the Brain Imaging and Modeling Section of the National Institute on Deafness and Other Communication Disorders. Please refer to Antonio Ulloa's profile on Science Magazine at http://bit.ly/2czzNGx for more information about his personal and professional achievements.

DESCRIPTION OF PROTOTYPE

The proposed prototype will be developed in HTML markup language and javascript and will be available at the server neuralmodels.com, which is already owned by Neural Bytes LLC. The server will provide both free trial and subscription service to give registered users access to the following: **Intuitive user interface** that will allow researchers to generate easily neural models that integrate cognitive, behavioral and neuroimaging data. **Model building component** that will allow a user to build a circuit model of brain areas relevant to the research question at hand. **SUD modeling component** that will allow researchers to simulate changes in brain function related to substance addiction as part of research seeking to understand links among biological and behavioral components of substance use disorders. **Import component** that will allow researchers to incorporate their own structural neuroimaging data into the simulator. **Data analysis component** that will provide several methods to quantify the simulated neuroimaging data. **Visualization component** that will allow researchers to create graphical presentations of data inputs, neural models and simulated results.

A typical use of neuralmodels.com can be illustrated by the following example: Let us

assume a SUD researcher has two hypotheses in mind to explain her neuroimaging (e.g., fMRI, MEG, EEG) and behavioral experiments. Which of the two models explains the data better? The researchers would need to log into neuralmodels.com and build the competing models computationally by using an automated pipeline provided. neuralmodels.com will integrate functional neuroimaging and neurophysiological data from human subjects performing an experimental task similar the task used in the SUD researcher's experiments. The researcher would then fill knowledge gaps by training both competing models to match empirical task performance. Then, the researcher would run multi-subject simulations and evaluate, using the analytical tools provided by neuralmodels.com, which of the two competing models better explain her own neuroimaging experiments. Finally, the researcher would run analyses on simulated data to make predictive measures then compare outcomes with her own empirical measures.

PROPOSED METHODS

Neural Bytes LLC will conduct market research to determine whether the product is needed by the target customers and whether the customers would be willing to pay for the product. Specifically, we will do primary research by conducting online surveys among SUD researchers using surveymonkey.com and twitter.com. Neural Bytes LLC has previous experience in conducting online surveys using monkeysurvey.com and is an active user of twitter at @neuralbytes, with a large number of neuroscientist followers. We will also conduct in-person interviews at the following scientific conferences: Human Brain Mapping Conference, June 17-21, 2018, in Singapore; Neuroinformatics Congress, August 9-10, 2018 in Montreal, Canada; Interpreting BOLD conference, September 9-11, 2018 in Oxford, United Kingdom; and Society for Neuroscience Meeting, November 3-7, 2018, in San Diego, CA. We will also perform secondary market research by analyzing published data at Grantome (grantome.com) and the NIH Reporter (projectreporter.nih.gov), among others, to identify competitors and narrow the SUD scientific community target segment.

YOUTUBE VIDEO

Link to youtube video: https://youtu.be/sDxW32qTn0s