Understanding Collaborative Cyberinfrastructure Need of Neuroscientists – Survey Results

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Introduction: We have been operating the Neuroscience Gateway (NSG), funded by the National Science Foundation, since early 2013. The NSG has close to 400 users and the users are utilizing High Performance Computing (HPC) core hours on Extreme Science and Engineering Discovery Environment (XSEDE) HPC resources at SDSC, TACC (and soon at PSC) at an increasing rate every year since NSG went into operation in 2013. NSG provides various computational neuroscience and brain image processing tools on XSEDE HPC resources for the neuroscience community. NSG lowers or eliminates the administrative and technical barriers that can make it difficult for researchers to use HPC resources.

To show how the NSG has been successfully serving the neuroscience community and to lay the background of the survey being discussed in this report, we show in Fig 1, Fig 2, and Fig 3 the growth in number of NSG users, yearly HPC core hours used, and size of the maximum core count job per month. As shown in Fig 2, we are noticing almost exponential need for HPC core hours via NSG from the neuroscience community. Although we try to estimate, albeit conservatively, the amount of core hours that the NSG users will need in the following year, due to increasing need of core hours by neuroscientist we are running out of XSEDE allocated core hours every year within about 7 or 8 months of the 12 month allocation period. So we are forced to request Supplemental allocation from the XSEDE allocation review committee and they have been supportive by providing additional core hours after they review our Supplemental allocation proposal. The main point is that given that the NSG has been around for about three years now, it is becoming more known among neuroscientists and need and usage of HPC resources, via NSG, are growing at a tremendous rate. This shows that the NSG is successfully serving the neuroscience community well to enable large scale simulations and processing of brain image data.

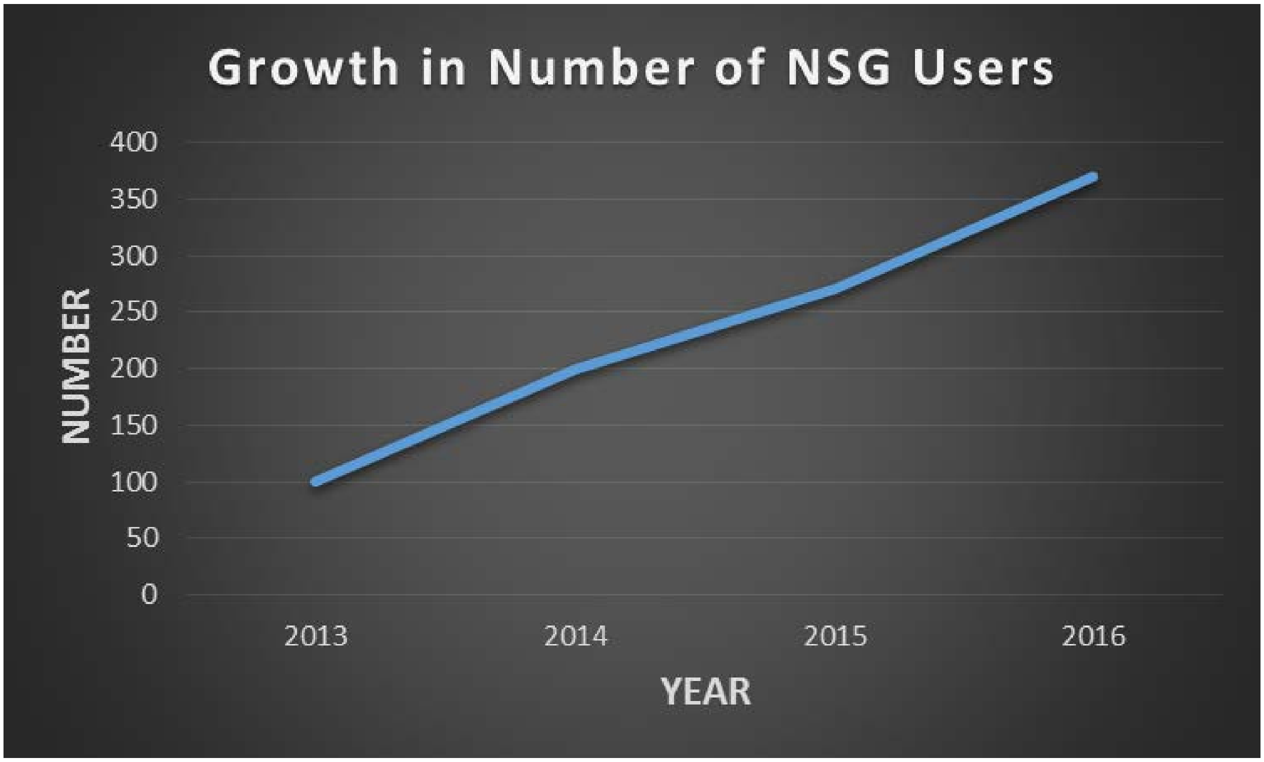

Figure 1. Number of NSG Users.

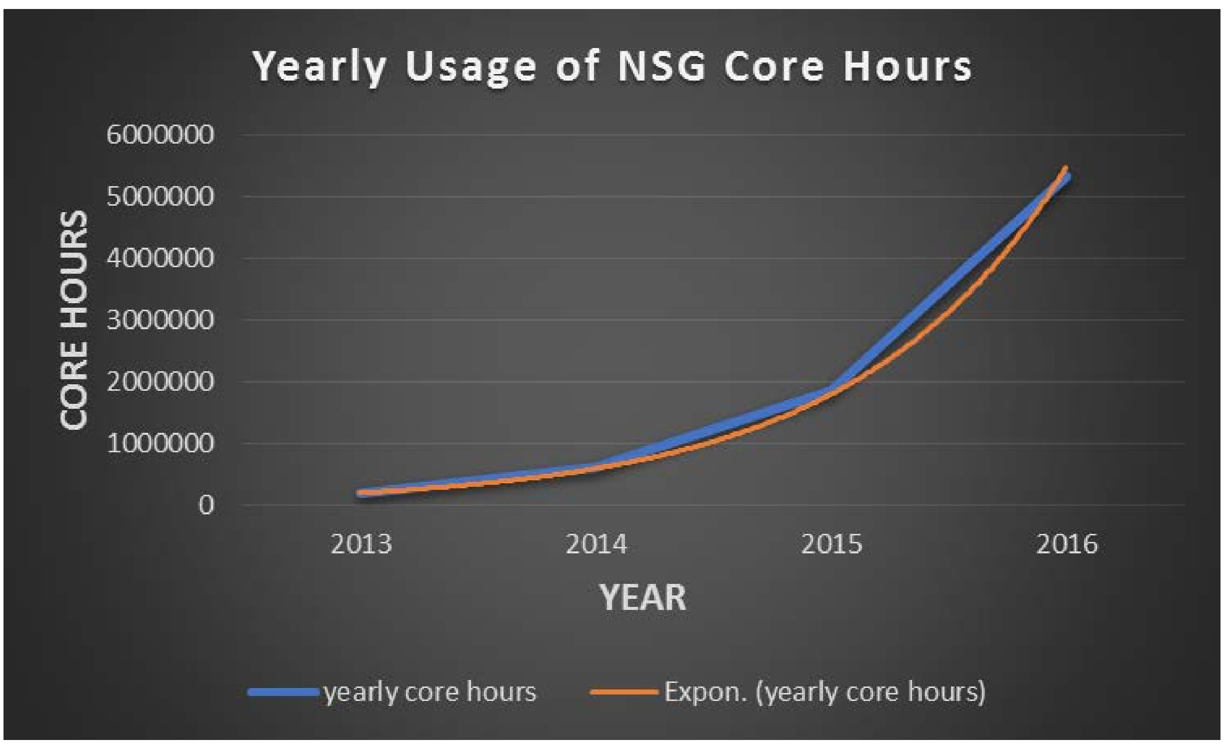

Figure 2. Yearly Use of HPC Core Hours (in Comet HPC machine equivalent core hours).

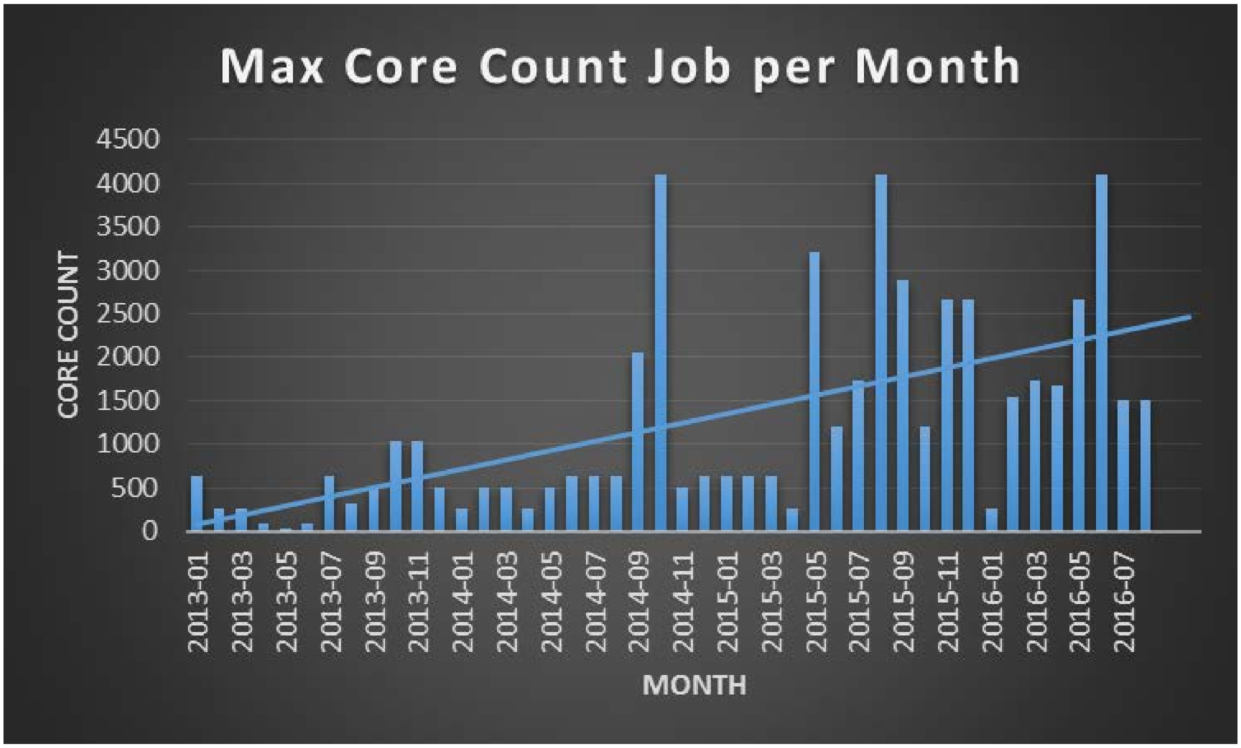

Figure 3. Maximum Core Count Job per Month.

Survey: Operating the NSG for the last almost four years has allowed us to interact with various kinds of neuroscientists. Hosing multiple NSG workshops regularly at the Society for Neuroscience annual meetings, Computational Neuroscience annual meetings, NEURON Summer Courses, NIH funded workshops, XSEDE conferences etc, and presenting posters at some of these conferences and workshops including Supercomputing 2015, has also allowed us to interact with large number of neuroscientists from various research areas of neuroscience.

Based on feedback and these interactions we realized that the neuroscience community is eagerly interested in utilizing a collaborative data/compute-enabled cyberinfrastructure environment to pursue collaborative neuroscience research. Many in the neuroscience community believe that collaborative research is the necessary next step to realize the mandate of the BRAIN Initiative. Collaborative research has played deciding role in other areas of science such as high energy physics, genomics etc.

As a result, and to further understand the collaborative cyberinfrastructure needs of the neuroscience community we ran a survey over the last few months. Over 100 neuroscientists from various fields of neuroscience filled in the survey. The actual web form of the survey can be found here:

https://docs.google.com/forms/d/e/1FAIpQLSe2vpxnvd4BPyYXimQPxGVbErBNrAC0tHXh2FFxs_hY-CwFSA/viewform

It should be noted that the answers to the first two questions of the survey involved personal information about the researchers who took the survey. Hence the questions are not shown in the current state of the survey anymore and the answers are also not shown in the published survey results (see below).

The first question was “Your name, institution, and email address please”

The second question was “Briefly describe your research”.

Although the second question did not in most cases include personal information, some of the respondents referred to personal websites or papers. Since the UCSD Institution Review Board does not allow us to share personal information, we have edited the answers in a few places and otherwise presented the respondents’ answer to that question in Appendix A.

Survey Results: As stated earlier the survey was filled in by over 100 neuroscientists from various areas of neuroscience. Many of these respondents are individual researchers such as postdocs or graduate students, and in addition many are senior researchers (professors or research lab group leads or directors) who oversee large number of neuroscientists and neuroscience research projects. Many of these neuroscientists are involved with large scale neuroscience community projects such as developing large scale network models, providing open source models, developing/serving EEG software, providing service for fMRI data processing, Human Brain Project in Europe, Blue Brain project in Europe etc. Hence, although just over 100 neuroscientists have filled in the survey, we believe that effectively they represent many 100s of neuroscientists’ collaborative cyberinfrastructure needs worldwide.

The survey results are published from the webpage:

https://docs.google.com/forms/d/1vY7xXaeXFDb63EbgmgvQ7ZbUNpIopvh6UuTpwYeDmzs/viewanalytics

Summary: In this report we present the survey results for the reader. Based on the survey developing a comprehensive cyberinfrastructure architecture and solution that will serve the collaborative data/compute needs of the broader neuroscience community requires thorough understanding of data management (storage, access, sharing, privacy/security, publication etc.), data transfer, compute/HPC, user interface etc. and is outside the scope of this short report. It should be noted that this survey result does set the ground for developing such comprehensive cyberinfrastructure solution for the broader neuroscience community similar to what the NSG is providing regarding HPC resource for the neuroscience community.

APPENDIX A: Answers to question 2 (“Briefly describe your research”.)

	Multi-compartment modelling of interneuron specific 3 (IS3) interneurons in hippocampus. Research involves collaborations with experimental researchers with the goal of predicting IS3 intrinsic properties, inputs, and roles within the hippocampal microcircuit.
	Single Particle Simulation using software STEPS, Mcell, Neuron.
	Our goal is to promote the understand, diagnosis, and treatment of concussion (human). We use neuroimaging, neuropsychological evaluation and clinical evaluation to develop as complete a picture as possible of each volunteer/patient. Based on those findings, we provide targeted interventions with 6 months of interactive follow-up at multiple time points with a full re-evaluation at the end of the 6 months.
	Computational models (of different types: from small populations of neurons to interactions between areas or just "abstract" functional models) + behavioral experiments.
	computational neuroscience applied to neurological and psychiatric diseases
	Simulating theta rhythm in CA1 region of the hippocampus and studying the balance for the input to generate this rhythmic activity.
	Using novel diffusion magnetic resonance imaging to quantify normal brain tissue damage after radiotherapy
	I study oscillations in the LFP signal in the amygdala
	Biophysically detailed network models of mouse V1 cortex.
	Large scale spiking neuron network models of the cortex using NEURON.
	Computational biology related to the creation of a virtual C. elegans nematode.
	Modeling of axonal responses to extracellular stimulation
	Data analysis and modeling related to a) electrical biomarkers of epilepsy and seizures, and b) diagnosis, treatment, and research of sleep disorders.
	Open collaboration in computational neuroscience
	Advanced EEG source imaging, with applications to basic and clinical research in human cognitive neuroscience and neurotechnology development. Multimodal mobile brain/body imaging (MoBI) including EEG.
	Neuromorphic systems engineering, computational neuroscience, learning and intelligent systems, biomedical circuits and systems.

	I work on neural circuits and use electrophysiogy and imaging to collect information about small circuits and use computational models to simulate them.
	My research involves the development and clinical translation of new imaging methods. This work relies on CI to provide compute resources for high-throughput and/or real-time analysis of data acquired at shared instrumentation centers, as well to provide access to structured repositories of imaging data sets.
	My research focuses on theoretical, computational, and modeling of learning in neural systems that exploit the features of brain-inspired computing hardware.
	language processing and cognitive functions using ERPs and behavioral measures
	Using electrophysiology and modeling approaches to examine the cellular and synaptic mechanisms of homeostatic plasticity in the crab *Cancer borealis*.
	Computational modeling of proprioceptive circuitry in the macaque spinal cord, with the goal of developing neural prosthetics.
	Observing changing associated gene clusters over neural development.
	Fly motoneuron modeling
	investigating the generation and propagation of dendritic spikes in the Purkinje cell.
	computational neuroscience, large scale biophysical models of neurons and networks
	Biophysical modeling of network and cellular mechanisms of neuronal feature selectivity
	Computer modeling of intracellular dynamics, single neurons, and neuronal networks. Using NSG for parallel evolutionary algorithms/optimization.
	Cellular electrophysiology and computational neuroscience.
	Ion channel biophysics Calcium Dynamics Neuromodulation Compartmental modeling
	Neocortical and hippocampal circuit analysis, in vitro and in vivo; compartmental modeling of cortical neurons; neocortical network modeling
	multiple patch clamp recording in mouse visual cortex to measure synaptic connection probability and connection strength between different type cell class
	Computational testing chloride homeostasis irregularity hypotheses

	Modeling large-scale detailed cerebellar circuits with multicompartmental models. Interfacing such circuits for studying information processing, local field potential reconstructions, implications of STDP in such circuits. We are also looking into large scale models with simpler spiking models for modeling roles of cerebellar inputs into basal ganglia and thalamo-cortical relays. Recently we have started EEG recordings to study user behavior and simultaneously looking into mass models and sink-source reconstructions for such signals.
	Neuromorphic computing & bio-inspired machine learning; Structure-activity relationships for odorant receptors; Analysis of 2D-imaging data and single/multi-unit recordings; Analysis of electronic nose data.
	My research mainly focuses on building multicompartmental models of single neurons and or microcircuits of the cerebellum and the hippocampal CA1 subregion based on in vitro patch-clamp electrophysiological recordings.
	Computational neuroscience and experimental neurophysiology (fluorescence brain imaging).
	Study of synaptic integration in the rod bipolar cell using NEURON.
	Numerical simulation and mathematical analysis of different aspects of neural excitability. Centered on stochastic influences, chaotic phenomena. Applied to sensory systems and network dynamics
	Neural coding
	Quantitative Big Image data analysis: ~gigapixel images, with ~petavoxels, of connectomes.
	I design computational models of epilepsy and high-frequency oscillations.
	Right now, small circuit modeling of entorhinal cortex, but also continuing to do some large scale, parallel modeling of entorhinal and hippocampal networks, using NEURON software.
	We focus on complex brain activity. By combining advanced multimodal neuroimaging and computational modeling we aim to identify generative mechanisms of ongoing neuronal dynamics.
	We use do recordings of larger neuronal populations in sensory cortex, mainly devoted over their population dynamics across different experimental conditions.
	I develop computational models of brain systems like the olfactory bulb, the retina, the hippocampus and the cortex. In my models, I use detailed (compartmental, Hodgkin-Huxley-

	like) or simplified (Izhikevich, AdEx) neuron models, and the simulations are constructed using neural simulators (NEURON, GENESIS) or directly from scratch (in C++ or Python).
	Statistical modeling of membrane potential responses for conductance-based integrate and fire neurons
	Neuromodulation, Neural Engineering, Deep Brain Stimulation
	Peripheral nerve stimulation of the lower urinary tract. This includes experimentation and modeling.
	Computational Neuroscience focusing on dendritic computations
	(i) Neuroinformatics: analysing electrophysiological datasets, plus helping sharing of data and analysis techniques (ii) Modelling early auditory processing
	I work on cellular level computational models using NEURON software.
	Computational modelling to simulate electroencephalography and local field potentials
	I analyze ephys data (LFP, spike times), usually from rodents, collected from different brain regions in a variety of tasks and also under anesthesia. The goal is to perform "neuronal decoding" to try to understand how the brain works.
	I investigate the dynamics and computations in single cells and networks of the hippocampus using theoretical tools and computer simulations, often in close collaboration with experimental neuroscientists.
	Research in human judgment and decision making, numeracy and quantitative reasoning, risk and uncertainty, medical decision making, social judgment, and memory. Our group develops and uses fuzzy-trace theory, a model of the relation between memory and higher reasoning that has been widely applied in law and medicine. Group’s current research program is focused on: Risky decision making in adolescents Risk communication in cancer and AIDS prevention Spontaneous false memories in children and adults Aging and cognitive neuroscience

Cognitive neuroscience (learning and decision-making(Computational neuroimaging (fMRI, MEG, SEEG) Function connectivity analysis
Simulating cognitive processing in circuits of model neurons.
Computational models of rat navigation
We study the neurophysiology of learning and memory using a combination of modelling and experimentation.
I build large-scale computational models of the brain to study a wide variety of topics, ranging from inter-areal neural dynamics to cognition.
Currently my research develops simulations of biological neural networks and biophysics of the brain.
Visual mechanisms of collision avoidance
Biophysically realistic modeling of single neurons and functional circuits. The former is a solid record, the latter is a future aspiration.
Research focuses on the computational modeling of epilepsy. We use modeling methods to understand the time and spatial evolutionary properties of seizures. Using computer modeling tools, we explore how fast seizures spread, the spatial extent of spread, the spread of interictal spikes, and the effect of various therapies such as electrical stimulation.We also study mechanism of adaptation and synaptic plasticity in auditory system by modeling these mechanism in a biologically realistic model of auditory cortex.
Simulations of biophysical network models of the hippocampus.
My research integrates human MEG/EEG and computational neural model. We build biophysically principled models of neocortical circuits to connect MEG/EEG measures of human information processing to the underlying cellular and network generators. A particular focus of my work is on understanding the mechanisms and functions of brain rhythms.
Building a computational model of spike-and-wave discharges (SWDs) - an EEG signature of typical absence seizures. The model aims to explain past and recent experimental results and make predictions regarding the mechanism of SWDs. The aim is to describe a comprehensive theory of absence seizures that would inform experimental research.
I do electroencephalography research, computational analysis of electroencephalography data including bootstrap analysis and independent component analysis.

Development of neuronal network simulation software
We are designing a new class of artificial intelligence modeled closely after the brain.
My main research interests involve the study of neural information processing, neural coding and information representation in biological systems. In particular I am interested in understanding information processing functions of neural ensemble activity and the biological mechanisms through which these functions are implemented. Quantitative tools that I apply to achieve my research goals come mostly from branches of applied probability (information theory, signal processing theory, multivariate statistics, stochastic differential equations), dynamical systems theory and group theory. Many other branches of mathematics and statistics – optimization, operations research, and differential geometry being the ones I used most recently – are applicable in particular stages throughout my research.
computational neuroscience, high performance computing
3Drodent: A parallel algorithm for distance dependent wiring of arbitrarily detailed neuron morphologies. Outputs from the algorithm facilitate the study of network activity in 3D networks, making it possible to observe contributions from neurite atrophy and growth in 3D neural networks. This model has been implemented as an extension of the Allen Brain SDK Utils class. The advantages to this wiring algorithm is that all the distance dependant calculations occur inside the Python-HOC frame work. No additional programs are run, and only one configuration file needs to be set. The network size (the number of neurons) and the number of CPUs used to execute code is flexible.
Biophysically detailed simulations using single cell models for modelling visual cortex and generating ground truth datasets for spike sorting algorithm development
Computational Neuroscience
The aim of my research is to developing Mathematical and computational models that explains properties of neurons in the primary visual cortex.
Implementation for a middleware for HPC systems. My thesis is to join different HPC system for computation, specifically for Neuron, to permit an simplified interface with Python and RESTFul, for data sharing and elaboration.
MRI image acquisition and analyses development with applications to neurological disorders

Computational models of the basal gsnglia/cortex/cerebellum interaction for the understanding of tic productikn in Tourette syndrome and tremor in Parkinson desease
Our research is focused on developing new data and metadata representation and analysis techniques for biomedical and healthcare research. Our current research focuses on integrative analysis of brain connectivity data for characterizing spatio-temporal characteristics of epilepsy seizure networks using computational neuroscience approaches. To address the challenges of data quality and scientific reproducibility in data-driven biomedical research we are also developing a provenance metadata framework using provenance ontology and text mining of published articles. Our interdisciplinary research involves close collaboration with clinical, biostatistics, and high performance networking researchers.
Multiscale modeling from subcellular to network and behavior. Using evolutionary algorithms to optimize detailed/simplified models of pyramidal neurons.
I spend half my time curating and developing Opensource neuronal models and the other half collaborating with experimentalists mathematically modeling their electrical and sometimes optical recordings from Neurons.
large scale simulation of brain regions (olfactory bulb and hippocampus)
Calcium imaging of dendrites and spines in an awake behaving mice.
I am studying how adaptable the Izhikevich model is to matching empirical data from the prefrontal cortex of Rhesus Monkeys. I use Latin Hypercube Sampling and differential evolution to optimize the model, which is what I use the gateway for.
I study neural circuits in the olfactory bulb and cortex using in vivo electrophysiology and calcium imaging as well as simple Neuron models. I am particularly interested in how principal neuron process distal apical tuft inputs to generate major neural system outputs.
Simulation of learning processes in populations of neurons and system-level (multiple brain areas) neural architectures. Bayesian models of learning processes. Behavioral experiments with human participants.
We develop biologically-based simulations of neural systems. Our main focus is central pattern generators (CPGs) which are used for functions such as respiration and locomotion.
cognitive neuroscience research using neuroimaging to study brain systems for decision making and executive function

	I mainly do experimental work using patch clamp recordings from single inhibitory cells. This experimental work provides some insights to some experimentally untestable potentials, which I aim to test using single cell multicompartmental modeling using Neuron environment.
	I am a phd student, I work with MRI, fMRI and MEG on autism population.
	Computational modelling of active perception in the whisker system.
	I am working on a small, biologically realistic NEURON model of place cells and interneurons in the CA1 region of the hippocampus. Specifically, we are looking at spatial navigation and replay.
	Working on a large scale, biophysically realistic model of the olfactory bulb that investigates synaptic plasticity and role of dopamine modulation.