Abstracts

1. **A computational model of the amygdala revisits pavlovian learning**
Frederic Alexandre
Institut des Maladies Neurodegeneratives

Recent technical advances in neuroscience give a more precise view of the inner circuitry of the amygdala and of its links within the medial temporal lobe, and with the basal ganglia and prefrontal cortex. We will summarize corresponding data and present the computational model of the amygdala that we have designed accordingly. This model proposes how the main features of pavlovian conditioning are computed in the amygdalar nuclei and how emotional values of stimuli are computed and exploited in other brain regions, for episodic and semantic learning and for instrumental conditioning.

2. **Compressive Sensing in Sensory Systems**
Victor James Barranca
New York University Abu Dhabi

Considering that many natural stimuli are sparse, can a sensory system evolve to take advantage of this sparsity? We explore this question and show that significant downstream reductions in the numbers of neurons transmitting stimuli observed in early sensory pathways might be a consequence of this sparsity. First, we model an early sensory pathway using an idealized neuronal network comprised of receptors and downstream sensory neurons. Then, by revealing a linear structure intrinsic to neuronal network dynamics, our work points to a potential mechanism for transmitting sparse stimuli, related to compressed-sensing (CS) type data acquisition. Through simulation, we examine the characteristics of networks that are optimal in sparsity encoding, and the impact of localized receptive fields beyond conventional CS theory. The results of this work suggest a new network framework of signal sparsity, freeing the notion from any dependence on specific component-space representations. We expect our CS network mechanism to provide guidance for studying sparse stimulus transmission along realistic sensory pathways as well as engineering network designs that utilize sparsity encoding.

3. **Quantifying Release and Short-Term Synaptic Plasticity at Chemical Synapses: A Generative-Model Framework**
Alessandro Barri
Université Paris Descartes

Quantifying Short-Term Plasticity and Variability at Chemical Synapses: A Generative-Model Approach. The rapid, transient modification of post-synaptic responses as a result of repetitive pre-synaptic activation is a distinctive feature of chemical synaptic transmission. Similarly distinctive, especially at central synapses, is the large variability of the responses upon repetition of an identical pattern of presynaptic activation. However,

quantitative investigations of short-term plasticity (STP) almost exclusively focus on trial-averaged responses, thus disregarding variability. Likewise, the quantitative analysis of fluctuations in synaptic responses is routinely carried out in steady conditions, thus disregarding dynamics. Here, we present a new methodology to quantify responses variability and STP at the same synapse, and from the same set of recordings, in an integrated and statistically-principled way. We use a generative-model approach to build a parametric, probabilistic model of the synaptic responses to patterns of activation, thus taking into account the variability as well as the correlation between consecutive responses. Point-estimates of the model parameters are then obtained by maximum-likelihood estimation. We demonstrate two main advantages of our approach over conventional techniques. First, we simultaneously estimate both quantal and dynamical parameters from the same recordings, consisting of synaptic responses to spike trains of varying rates at Layer 5 pyramidal-to-pyramidal connections in the ferret medial pre-frontal cortex. The parameters estimates obtained with our method are consistent with those derived by standard procedures. Second, and most importantly, since the estimation procedure does not rely on trial-averaged quantities, the repetition of identical stimulations becomes unnecessary. Parameters can be estimated from single traces. It is thus possible to devise alternative stimulation protocols and analyze their impact on parameters estimation by the use of theoretical tools. Specifically, by using Fisher Information Matrix theory one can design 'optimal' stimulation protocols (e.g., protocols which minimize the variance of the parameters estimates) for any given synaptic model. As an example, we show that Poisson spike trains yield better parameters estimates than periodic spike trains with the same rate.

4. **Functional and structural diversity of neuronal synapses**
Guoqiang Bi
University of Science and Technology of China, Hefei

Synapses are communication nodes in neuronal circuits. Robust rules of activity-induced synaptic plasticity are believed to play instructive roles in learning and memory. Experimental evidence indicates that these rules can take quantitatively and qualitatively different forms under different contexts of extrinsic and intrinsic modulation. I will present cases showing the diversity of synaptic function and plasticity in vitro and in vivo, and discuss how quantitative analysis of synaptic ultra-structures might lead to a better understanding of synaptic plasticity.

5. **Integration of a moving object by V1 population**
Frederic Chavane
Institut de Neurosciences de la Timone

In this talk I will present evidence that a moving object can be specifically processed and represented by V1 population. Motion processing along the visual system has been mostly studied using drifting stimuli presented within a fixed aperture. In contrast, not much is known about how motion is processed when induced by a stimulus whose position is changing, as

opposed to its phase. This bias probably exists because the standard single-unit recording technique generally circumscribe the analysis to a fixed aperture, the receptive field and it's immediate surround. However, recent techniques, such as voltage-sensitive dye imaging and/or multi-electrode arrays, offers the opportunity to record the activity of large retinotopically ordered neuronal population of visual cortices with high spatial and temporal resolutions. Using such techniques in the awake fixating monkey, I will compare results from two paradigms, two-stroke long-range apparent motion and continuous motion over a long trajectory. For this two paradigms, lateral interactions within and between visual cortices is rapidly pre-activating the visual cortex from the first apparition of the stimulus. This pre-activation shapes non-linearly the spatio-temporal profile of population activity to represent global motion over the V1 retinotopic map at the right speed and in real-time. I will discuss the relevance of such timely representation for the visual system.

6. **Chaotic Rate Dynamics in Large Neuronal Networks**
   David Hansel
   Université Paris Descartes

We investigate the dynamics of networks of excitatory-inhibitory (EI) spiking neurons with random sparse connectivity. Combining mean-field-theory with numerical simulations, we show that for sufficiently strong synapses chaotic, asynchronous firing rate fluctuations emerge. Two different mechanisms can lead to these chaotic fluctuations. One mechanism relies on slow I-I inhibition. The corresponding chaotic regime is characterized by slow subthreshold voltage and rate fluctuations. The decorrelation time is proportional to the time constant of the inhibition. The second mechanism relies on the recurrent E-I-E feedback loop. It requires slow excitation whereas the inhibition can be fast. In the corresponding regime neurons exhibit voltage and spike fluctuations on both time scales. We briefly discuss the neurophysiological significance of our results.

7. **Optimization, Adaptation, and Initiation of Biological Transport Network**
   Dan Hu
   Shanghai Jiao Tong University

Blood vessel systems and leaf venations are typical biological transport networks. The energy consumption for such a system to perform its biological functions is determined by the network structure. In the first part, I will talk about the optimized structure of the network, and show how the blood vessel system adapts itself to an optimized structure. Mathematical models are used to predict pruning vessels in the experiments of zebra fish. In the second part, I will discuss our recent discovery on modeling the initiation of transport networks. Simulation results are used to illustrate how a tree-like structure is obtained from a continuum adaptation equation set, and how loops can exist in our model. Possible further application of this model will also be discussed.

8. **Metabotropic glutamate receptors mGluR1 hold the key to the orphan GluRdelta (GluD) receptors**
   Carole Levenes
   Université Paris Descartes

Our research shows that the metabotropic glutamate receptors mGluR1s hold the key to the orphan glutamate receptors GluRdelta2 (GluD2s), solving the twenty-year mystery of how the GluD receptors open (ADY et al. EMBO Rep. 2014Jan;15(1):103-9;
http://onlinelibrary.wiley.com/doi/10.1002/embr.201337371/full).

Their sequence homology with the AMPA, Kainate and NMDA receptors, make the GluRdelta receptors (GluD1 and GluD2) members of the ionotropic glutamate receptors family. However, contrary to their famous brothers, they do not bind glutamate and ligand-gated currents through wildtype GluDs channels had never been evidenced so far. Whether GluDs operate as ion channels has been a long-standing question, that we just answered by showing that that the opening of the GluD2 channels is triggered by the activation of the mGluR1 metabotropic glutamate receptors. This occurs both in expression system (HEK cells) and in native condition, the cerebellar Purkinje cells. This study, publish in January 2014 in EMBO reports is the first example of such a gating mode for iGluRs. It sheds light on the GluDs receptors that are widely represented in neurons all over the brain.

In addition to its importance for basic research, this study is also of interest for biomedical research given that the GluD receptors might be implicated in schizophrenia and autism spectrum disorders (Yadav R et al. PLoS One. 2012).

I will review our knowledge about the GluDs receptors and describe our results on the GluD2 gating mode.

9. **Dynamics and Physiology of Motoneurons**
   Claude Meunier
   Université Paris Descartes

The discharge of spinal motoneurons, first studied in anesthetized cats, seemed for a long time pretty simple and matching logically the contractile properties of the muscle fibers they innervate. Subsequent studies on various decerebrate preparations and on mice in vivo have progressively revealed much more complexity : active properties of dendrites, bistability, mixed mode oscillations. I will present our research on this topic, grounded on a mix of in vivo electrophysiology, biophysical modeling and bifurcation theory, and discuss the physiological relevance of the dynamical states of motoneurons.

10. **Mechanisms underlying receptive field malleability in the primary visual cortex**
    Lionel Nowak
    Université Paul Sabatier, Toulouse

Stimulus size influences the response of V1 neurons in a nonlinear fashion: when the size of the stimulus increases, the response first increases up to a peak that corresponds to the dimension of the receptive center, then decreases below this peak due to the presence of surround inhibition. The response of neurons as a function of stimulus size (or "size tuning") can be explained by the presence of two components, a narrow excitatory center and a broader inhibitory surround.

One important feature of the response as a function of stimulus size is that it depends on stimulus contrast: counter-intuitively, the apparent center size seems to increase when contrast decreases. Two hypotheses have been proposed to explain this phenomenon: the first is that the center size truly increases when contrast decreases, while the second proposes that the gain of the surround decreases when the contrast decreases.

One of our aims in a recent study (Durand et al. 2012) was to test for these hypotheses. For this purpose, we designed an experiment in which stimuli (flashing light and dark bars) would stimulate the center in isolation. The bars were presented at three different contrasts and in 16 different spatial positions, so as to obtain maps of the RF. With this kind of stimuli, we found that the receptive extent decreased when contrast decreased. This is the exact opposite to the results obtained with drifting gratings of various diameters in size tuning experiments. This indicates that the dimension of the receptive field depends on the stimuli that are used to probe it.

In another study (Nowak et al. 2010), we examined the relationship between the subthreshold (synaptic) and suprathreshold (spiking) receptive field in area 17 of the cat. The stimuli used in this study were flashing light and dark bars as well, but presented at high contrast only. Among other results, we concluded that the subthreshold RF extent, as revealed with flashing bars, can be accounted for by thalamocortical and "vertical" intrinsic connections. On the other hand, the subthreshold RF appears to be too small in comparison to that expected if intrinsic horizontal connections or corticocortical feedback connections were involved as well.

In the different studies mentioned above, flashing light and dark bars were presented at high temporal frequency (10-50 Hz). In another study (Nowak et al. 2011, ECVP), we examined whether the temporal frequency of the flashing bars could modify the receptive field extent, and in particular whether using low temporal frequency (2-5 Hz) would disclose the participation of horizontal connections. Our results showed that RF extent is independent of stimulus temporal frequency. This suggests that the discrepancy between flashing bars and gratings derived estimates of the RF dimension can be attributed to differences of stimulus energy.

These results support the proposal that the RF is composed of three components with different sensitivity to stimulus energy. The first component corresponds to the "classical" RF revealed with (low energy) flashing bars and reflects thalamocortical and "vertical" intrinsic inputs; the second component is revealed by low contrast gratings (intermediate energy) and likely involves

horizontal connections; the third component corresponds to the inhibitory surround, whose recruitment, especially with high contrast gratings (high energy), results in a shrinkage of the RF generated by the second component.

Another mechanism that could be involved in the contrast-dependency of size tuning with gratings corresponds to the feedback inputs to area V1. We attempted to determine whether the feedback input from area MT could contribute either to the expansion of the RF at low contrast, or to the recruitment of the surround at higher contrast (Nowak et al. 2014, SFN). Neurons in area MT were inactivated either by GABA injection or by cooling. Unfortunately, neither phenomenon appeared to depend significantly on MT feedback. However, we disclosed a peculiar feature of surround suppression, that is, the mechanism responsible for surround suppression seems to adapt over a time course of several minutes.

11. **Turn on and off intrinsic persistent activity in human neocortical interneuron**
Yousheng Shu
Beijing Normal University

Neuronal types such as pyramidal cells and non-pyramidal interneurons in the neocortex are highly conservative during evolution. It remains unclear whether human neurons have physiologically distinct features from those of other species. In this study, we performed whole-cell recording from acute human cortical slices and found a novel type of neuron with intrinsic persistent activity that could be evoked by weak but terminated by strong stimulation. Further investigation showed that this persistent activity was attributable to a depolarizing plateau potential induced by persistent Na^+ currents. Single-cell RT-PCR results indicate that these neurons are inhibitory interneurons mainly containing somatostatin, calretinin or cholecystokinin. Among cortical interneurons, the estimated percentage of these neurons was approximately 9%. Whether these neurons are unique to human neocortex remains to be further examined.

12. **A genetic and computational approach to structurally classify neuronal types**
Sen Song
Tsinghua University

The importance of cell types in understanding brain function is widely appreciated but only a tiny fraction of neuronal diversity has been catalogued. Here we exploit recent progress in genetic definition of cell types in an objective structural approach to neuronal classification. The approach is based on highly accurate quantification of dendritic arbor position relative to neurites of other cells. We test the method on a population of 363 mouse retinal ganglion cells. For each cell, we determine the spatial distribution of the dendritic arbors, or arbor density, with reference to arbors of an abundant, well-defined interneuronal type. The arbor densities are sorted into a number of clusters that is set by comparison with several molecularly defined cell

types. The algorithm reproduces the genetic classes that are pure types, and detects six newly clustered cell types that await genetic definition. I will also discuss plans to extend this approach to other brain areas.

13. **Capacity of synaptic transmission at a central synapse**
Jianyuan Sun
Institute of Biophysics, CAS

The brain contains billions of nerve cells(neurons) which are well organized into a very complicated neural network. Neurons communicate with each other through synaptic transmission, during which the presynaptic vesicle in the nerve terminal release chemical neurotransmitters that diffuse across the synaptic cleft to react with postsynaptic receptors and thus conveys neuronal signals. Synaptic transmission and its regulation plays essential roles in neuronal information procession and any related deficiency will cause mental diseases. We use an interdisciplinary approach to explore the mechanism determined the spatial and temporal capacity of presynaptic secretory machinery that achieves the precise neurotransmitter release.

Based on theoretical analysis and experimental justification, we successfully established an approach to simultaneously record presynaptic membrane capacitance and postsynaptic EPSC at the Calyx of Held synapse with time resolution of a millisecond. We measured presynaptic membrane capacitance as biophysical detection of presynaptic vesicle fusion and electrophysiologically recorded postsynaptic current to biologically sense neurotransmitter release. Taking this advantage, we obtained the basic parameters of synaptic transmission at this synapse and provided the quantitative knowledge of single and multiple vesicle exocytosis and endocytosis with high resolution and accuracy. Furthermore, we also estimated the kinetics of synaptic vesicle recycling during sustained presynaptic activities in combination of biophysical and electron microscopy approaches**.**

14. **Bidirectional connectivity increases the correlation length of in a balanced network model of cortex**
Carl van Vreeswijk
Université Paris Descartes

Over the last few years, evidence has accumulated theta fine structure in the connectivity of cortical networks, In particular, bidirectional connections are much more prevalent than would be expected from purely random connectivity.

Higher order connection motifs also tend to occur more often. The origin and functional implications of the over-expression of these motifs is currently not clear. For example, it is possible that they are the result of the formation of the 'cell assemblies' that are necessary for the cortex to function properly.

Here I investigate another possibility, namely that they are not functionally relevant, but rather the natural outcome of cortical development. But even if

this is the case, the question remains, what is the effect of these motifs on the cortical dynamics. To investigate this issue I study model networks with sparse connectivity that operate in the balanced state. In these models the probability of bidirectional connections is systematically varied, and I show that increasing the probability of bidirectional connections between inhibitory neurons dramatically increases the correlation length of the auto-correlation of both excitatory and inhibitory cells, while the cross-correlations re, on average, not effected. The same phenomenon is observed for increased bidirectional connections between excitatory cells, albeit that in this case the effect is much smaller. The analysis of a much simplified model shows that the increase of the correlation length is explained by the fact that increased bidirectional connectivity leads to an effective excitatory self-coupling.

15. **From "cognitive-type" Microcircuits to Large-scale Brain System**
Xiaojing Wang
New York University at Shanghai

TBA

16. **Dynamic encoding of perception, memory and movement in a C. elegans chemotaxis circuit**
Quan Wen
University of Science and Technology of China, Hefei

Brain circuits endow behavioral flexibility. Here, we study circuits encoding flexible chemotaxis in C. elegans, where the animal navigates up or down NaCl gradients (positive or negative chemotaxis) to reach the salt concentration of previous growth (the setpoint). The ASER sensory neuron mediates positive and negative chemotaxis by regulating the frequency and direction of reorientation movements in response to salt gradients. Both salt gradients and setpoint memory are encoded in ASER temporal activity patterns. Distinct temporal activity patterns in interneurons immediately downstream of ASER encode chemotactic movement decisions. Different interneuron combinations regulate positive vs. negative chemotaxis. We conclude that sensorimotor pathways are segregated immediately after the primary sensory neuron in the chemotaxis circuit, and sensory representation is rapidly transformed to motor representation at the first interneuron layer. Our study reveals compact encoding of perception, memory, and locomotion in an experience- dependent navigational behavior in C. elegans.

17. **A decentralized view of neural information integration**
Si Wu
Beijing Normal University

Organisms live in a constantly changing world and the interpretation of noisy sensory inputs is a challenge for the brain that it has to solve. Higher organisms use multiple modalities to gather as much information about a

common source as possible, and the brain is indeed effortlessly able to combine this information to form a coherent concept. How the brain optimally integrates information from different cues remains a mystery. Here, we show that optimal information integration can be an emergent and robust property of communicating brain areas without the need of a centralintegration area. Using biologically realistic neural networks, we build a decentralized neural information integration system that replicates many biologically observed neural response properties. Our decentralized information integration system not only delivers a natural explanation of the widely observed reciprocal connectivity between regions of the brain, it also provides a novel framework of how optimal information integration might be achieved in neural circuitry.

18. **Functional differences of laminae in Macaque V1**

Dajun Xing
Beijing Normal University

Neuroanatomy indicates that there are distinct intra- and inter-laminar connection patterns within each area of the cerebral cortex. This changes our view of each cortical area from a single uniform network to a stack of loosely interconnected but distinct neuronal networks. Each lamina has different specific inputs, projection targets, and feedback connections. Understanding the laminar pattern of neural activity is crucial for understanding the processing of neural signals in the cerebral cortex. We chose Macaque primary visual cortex (V1), an important stage of the visual system, as a test bed to understand how these intra- and inter-laminar networks interact. We made measurements of the activity of single V1 neurons (single-unit spike) and V1 population activity (multi-unit spike activity and local field potential) in response to different visual stimuli. These data reveal a variety of laminar response patterns including receptive field size, surround suppression, black-dominant responses, response nonlinearity, and g band (20-60 Hz) activity. The dramatic laminar differences imply that neural activity in V1 is generated by laminar-specific mechanisms. In particular, visual responses in cortico-cortical output layers 2&3 and 4B appear to be strongly influenced by laminar-specific recurrent circuitry and feedback. A general V1 network model including feedforward, recurrent, and feedback connections is proposed to account for the laminar response differences. Both experimental and theoretical work has pointed out the important role of recurrence and feedback for understanding the cerebral cortex.

19. **Processing of natural stimuli in the early visual pathway**

Haishan Yao
Institute of Neuroscience, Chinese Academy of Sciences

Both theoretical and experimental studies suggest that response properties in the visual system are shaped by the statistics of signals in natural environment. We used extracellular recordings in the lateral geniculate nucleus (LGN) and primary visual cortex (V1) to examine how receptive field (RF) property is adapted to natural scenes stimuli. In the study in LGN, we characterized the

spatiotemporal frequency tuning of LGN RFs and found that the preferred frequency of ensemble LGN neurons matches the range of frequencies in which the power spectrum of natural scenes varies most. We further showed that the match between LGN tuning and natural spectra variation enhances neural discrimination for natural stimuli. In the study in V1, we used ON and OFF stimuli at various contrast levels to measure RFs and found that neurons exhibit stronger OFF-dominance at higher contrast. Analysis of the distribution of negative and positive contrasts in natural images revealed that optimal coding of the natural contrast signals would lead to contrast-dependent OFF-dominant response. By modeling RFs exhibiting OFF- and ON-dominance, we showed that contrast-dependent OFF-dominance facilitated the discrimination of stimuli with natural contrast distribution. We also used in vivo whole-cell recordings to examine how cortical RF property is dynamically modified by natural visual stimulation. We found that repetitive stimulation of natural scenes movies could increase the similarity between V1 RF structure and the subset of movie images that depolarized the cell. Such dynamic RF modification may play an important role in dynamic coding of natural scenes. Finally, I will talk about our recent work on how the activity of specific type of inhibitory neurons contributes to the reliable representation of natural stimuli.

20. **Multiple Factors Facilitate Brain Enlargement During Evolution**

Yuguo Yu
Fudan University

Brain signaling is extremely demanding of energy. Because brain enlargement is constrained by limited energy, the trigger of the dramatic increase in brain size among mammals and birds has become an intriguing question. We examined the intrinsic relationships among metabolism, body-brain size ratios and neuronal densities of both endothermic and ectothermic animals and formulated a general model to elucidate the causes of brain enlargement and the origin of allometric body-brain size scaling. This framework identified temperature as a critical factor in brain enlargement via temperature-regulated metabolism. It also suggests that a rapid increase in the number of less energy-demanding glial cells that support long-distance neuronal communication may be another key factor contributing to the ten-fold increase in the brain sizes of endotherms compared with ectotherms. Our framework predicts that ectothermic animals living in tropical climates should have brain sizes that are several times larger than those of animals living in cold climates; this was confirmed by data from experiments in fish brains.

This study thus provides a quantitative theory that predicts the brain sizes of all the major types of animals and quantifies the contributions of temperature-dependent metabolism, body size and neuronal density.

21. **BCI-Based Active Motor Functional Rehabilitation and Neurofeedback**

Liqing Zhang
Shanghai Jiao Tong University

Brain-computer interfaces are emerging technology of establishing direct link between human intentions and devices, allowing people to communicate and control devices in their environment without using the peripheral neural system but instead through the use of signals from the brain.

The talk introduces general framework of BCI platform developed in SJTU, including the electroneurophysiologic mechanism for BCI, communication protocols, cognitive task-related EEG feature analysis, pattern classification, and multi-neurofeedback for motor functional rehabilitation. We will elaborate multi-neurofeedback training platform for motor functional rehabilitation. Large clinical rehabilitation experiments will be reported to confirm that the multi-neurofeedback paradigm is able to improve the rehabilitation performance of stroke patients.

22. **Neural Activity and Circuit Mechanisms Underlying Critical Period Plasticity of Visual Cortex**
Xiaohui Zhang
Beijing Normal University

Postnatal critical period (CP) is a defined time window during which neuronal connections in the brain are malleable to sensory experiences. This is best exemplified by visual input-dependent ocular dominance (OD) plasticity of developing primary visual cortex (V1) in mammals, whereby 3-4 days of closure of one eye (monocular deprivation) during the CP causes a dramatic shift of the eye input preference of V1 neurons towards the non-deprived eye. However, it remain largely unknow what circuitry mechanims underlie the form of experience-dependent critical period plasticity of developing visual cortex. In my talk, I will sumary our recent findings to address this fundamental question. First, using whole-cell recording in mouse V1, we demonstrate that visually-driven synaptic inputs from the two eyes to binocular cells in layers 2/3 and 4 became highly coincident specifically during the CP, and these conicident binocular synaptic inputs serves as neural substrates for the Hebbian synaptic competition underlying the experience-dependent OD plasticity. Second, we found that conditional deleltion of Rett-syndrome (RTT) gene MeCP2 (methyl-CpG binding protein 2) in parvalbumin-expressing (PV) GABAergic cells during the CP results in a defective GABAergic circuit and the absence of critical period OD plasticity, while conditional deletions in somatostatin- expressing GABAergic cells or glutamatergic pyramidal cells had no effects on critical period OD plasticity. However, enhancing cortical GABA inhibition with diazepam restored critical period plasticity in both young and adult conditional PV cell Knock-out mice, suggesting important role of PV-cell mediated GABA inhibition. Further detailed analysis of cortical layer-4 circuits showed that MeCP2 deletion in PV cells selectively reduced the efficacy of recurrent excitatory synapses from pyramidal cells to PV cells. Thus, our results from MeCP2 deficient mice reveal that inhibitory PV cell circuits-mediated cortical functions are important in regulating the experience-dependent critical period plasticity.

23. **Dynamical stability and fast algorithms of neuronal networks**

Douglas Zhou
Shanghai Jiao Tong University

It has been shown that a single integrate-and-fire (I&F) neuron under a general time-dependent stimulus cannot possess chaotic dynamics despite the firing-reset discontinuity. However, whether the dynamics of I&F neuronal networks can be chaotic was an open question. Through correct renormalization and augmented dynamics, we extend the classical Lyapunov exponents (LEs) theory, which is established for smooth dynamical systems, to the I&F like network dynamics and provide a stable and accurate numerical algorithm to compute the LEs of these non-smooth dynamical systems. Inspired by the low computational cost of I&F models, we further present an efficient library-based numerical method for simulating the Hodgkin–Huxley (HH) neuronal networks. Numerical simulations show that our library-based HH model can well capture the dynamical regimes, which are characterized by LEs, of the original HH model. In addition, our model can break the numerical stability requirement of Runge-Kutta methods for the original HH model, thus leading to much higher computational efficiency.