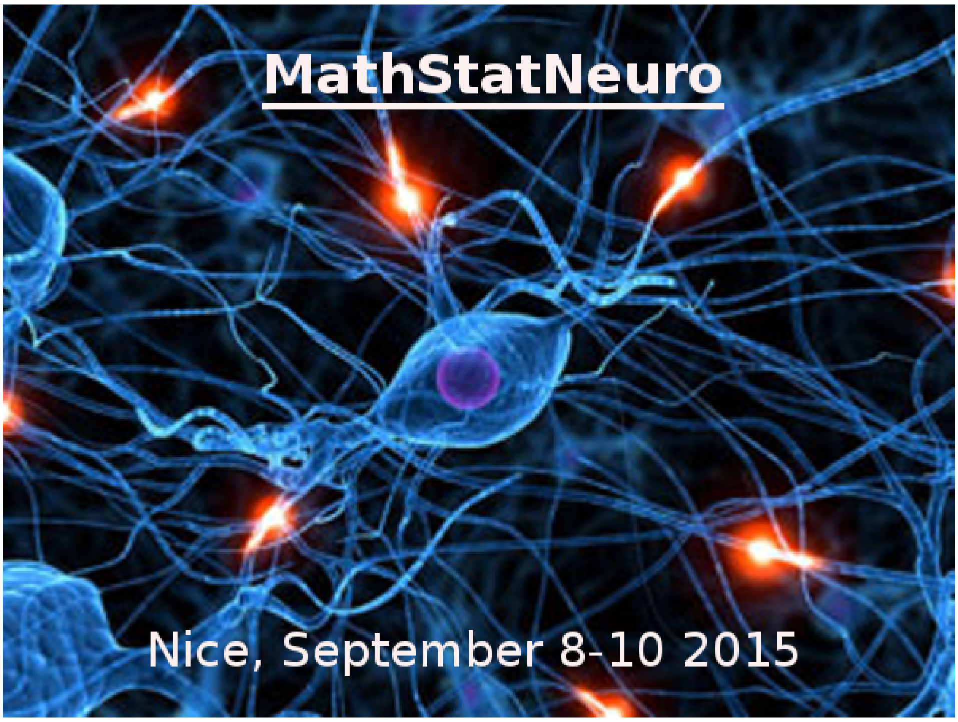
Mathematical Modeling and Statistical Analysis in Neuroscience workshop



Organized by Laboratory Jean-Alexandre Dieudonne and INRIA
University Nice Sophia Antipolis

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- la mission pour l'interdisciplinarité du CNRS
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- le laboratoire Jean-Alexzandre Dieudonné Nice Sophia Antipolis
- l'ANR Calibration

http://math.unice.fr/∼malot/mathstatneuro.html

Venue Information and Maps

Venue

University Nice Sophia Antipolis
Laboratory Jean-Alexandre Dieudonne
Parc Valrose
06108 Nice

All the coffee breaks will take place in the main all of the laboratory.

Lunch

Centre des Finances Publiques
22 rue Joseph Cadei
06100 Nice

Conference Dinner

Wednesday, September 9, 20:00
Club Nautique of Nice
50 Boulevard Franck Pilatte
06300 Nice

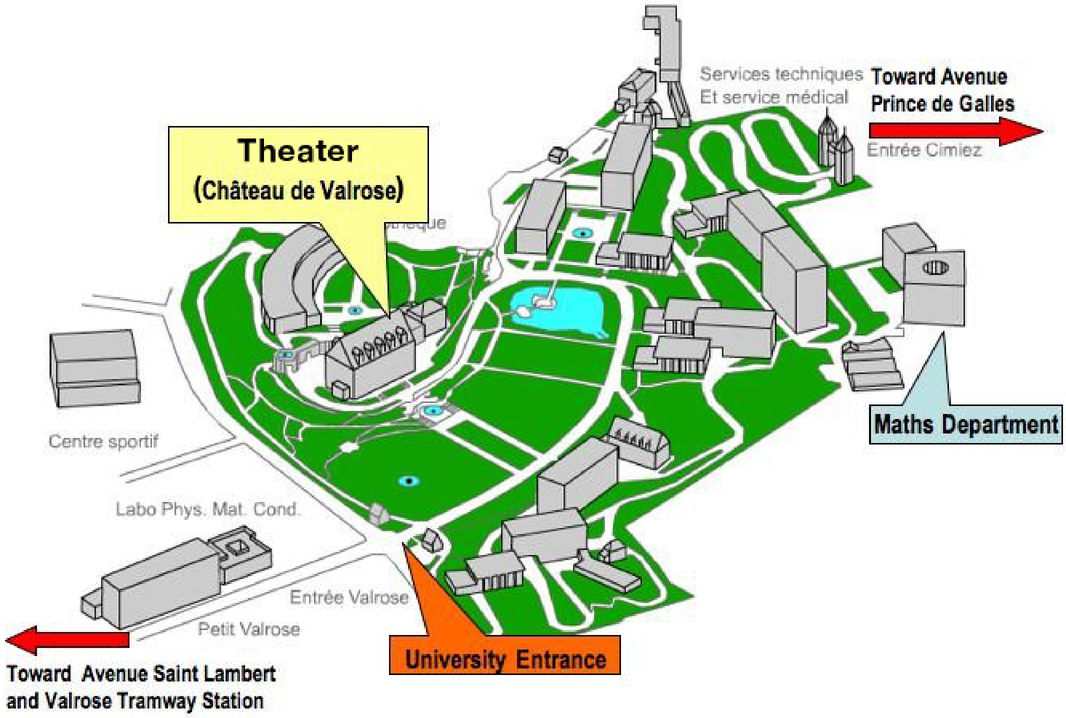
Internet

The entire laboratory is covered by the Eduroam wireless network. If you already have access to Eduroam from your home university you can use Eduroam. An alternative conference network is also available. Password access will be given during the workshop.

How to get to the university and the laboratory?

You can walk to the Valrose University from your hotel or take the tramway. In this case, get off at the station "Valrose Université" and the walk in the streets "Avenue du Doyen Jean Lépine" and "Avenue Joseph Vallot", in front of you.

To reach the Jean Alexandre Dieudonné Laboratory, look at the map. The laboratory is indicated on the map by Maths Department.


Theater
(Château de Valrose)
Services techniques
Et service médical
Toward Avenue
Prince de Galles
Entrée Cimiez
Maths Department
Centre sportif
Labo Phys. Mat. Cond.
Entrée Valrose
Petit Valrose
University Entrance
Toward Avenue Saint Lambert
and Valrose Tramway Station

Where to eat and drink

There are plenty of choice on where to eat and drink in the city center of Nice or in the historical town. Here is some ideas.

Where to eat

Some restaurants:

- La route du Miam (1 rue Molière): specialties from the west south of France
- Oliviera (8 bis rue du collet, old town): mediterranean specialties
- Le Safari (1 cours Saleya): mediterranean and french specialties

Where to drink

- La Petite Loge (10 rue de la loge): wine bar
- De Klomp (6 rue Mascoïnat): bar
- Les distilleries idéales (24 rue Préfecture): bar
- Fenocchio (6 rue de la Poissonnerie): ice cream

Program

Tuesday, September 8

08:30-09:00 **Registration**
09:00-09:30 *Roberto Fernandez*: Spike-train description: process or Gibbs?
09:30-10:00 *Frédéric Lavigne*: Inter-synaptic learning of combination rules in a cortical network model
10:00-10:30 *Théodora Karvouniari*: Bifurcation analysis of a reaction-diffusion model for stage II retinal waves
10:30-11:00 **Coffee Break**
11:00-11:30 *Olivier Renaud*: A model for a time and frequency specific Granger causality measure for intracranial electroencephalogram data
11:30-12:00 *Maureen Clerc*: Adaptive Waveform Learning
12:00-12:30 *Ulisse Ferrari*: Inferred Model of the Prefrontal Cortex Activity Unveils Cell Assemblies and Memory Replay
12:30-14:30 **Lunch**
14:30-15:00 *Mélisande Albert*: Multiple independence tests for point processes: a permutation Unitary Events approach based on delayed coincidence count
15:00-15:30 *Rune Berg*: Skewed firing rate distribution and fluctuation driven regime
15:30-16:00 **Coffee Break**
16:00-16:30 *Robert Kass*: Statistical Considerations in Making Inferences about Neural Networks: The Case of Synchrony Detection
16:30-17:30 **Discussion**

Wednesday, September 9

09:00-09:30 *François Delarue*: An integrate and fire model of mean-field type
09:30-10:00 *Eva Löcherbach*: On oscillating systems of interacting neurons
10:00-10:30 *Julien Chevallier*: Spiking neural models: from point processes to Partial Differential Equations
10:30-11:00 **Coffee Break**
11:00-11:30 *Stefan Rotter*: Inhibition-dominated random networks for stimulus processing in rodent visual cortex
11:30-12:00 *Matthias Hennig*: Variability and constraints in spontaneous neuronal network remodeling
12:00-12:30 *Gordon Pipa*: Encoding Through Patterns: Regression Tree-Based Neuronal Population Models
12:30-14:30 **Lunch**
14:30-15:00 *Asya Metelkina*: Joint risk-measurement model for the risk of decompression sickness accidents based on the biophysical model of decompression
15:00-15:30 *Michèle Studer*: A multidisciplinary approach in unravelling the basic mechanisms of cerebral cortical development in the mouse
15:30-16:00 **Coffee Break**
16:00-16:30 *Shigeru Shinomoto*: Relating neural firings to epidemics and tweets
16:30-17:30 **Discussion**
20:00- **Conference Dinner**

Thursday, September 10

09:00-09:30	*Antonio Galves*:
09:30-10:00	*Adeline Samson*: Estimation in hypoelliptic neuronal models
10:00-10:30	*Michèle Thieullen*: Periodic Ergodicity of a Hodgkin-Huxley model with random periodic dendritic input
10:30-11:00	**Coffee Break**
11:00-11:30	*Christophe Pouzat*: On the relation between neuronal size and extracellular spike amplitude and its consequence on extracellular recordings interpretation
11:30-12:00	*Olivier Faugeras*: On the Hamiltonian structure of large deviations in stochastic hybrid systems
12:00-12:30	*Susanne Ditlevsen*: Neural responses to stimulus pairs as probability mixtures of responses to single stimuli
12:30-13:00	**Conclusion**
13:00-14:00	**Lunch**

Abstract

Multiple independence tests for point processes: a permutation Unitary Events approach based on delayed coincidence count

Albert, Mélisande and **Bouret, Yann** and **Fromont, Magalie** and **Reynaud-Bouret, Patricia**
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The possible time dependence either between cerebral areas or between neurons, and in particular the synchrony phenomenon, has been vastly investigated as a potential element of the neuronal code [1]. Nowadays, it is possible to record simultaneously the occurrence times of action potentials (spikes) of several neurons. Then, one of the first steps is to understand if two simultaneously recorded spike trains modeled by point processes, corresponding to two different neurons, are independent or not. Several methods have been used to detect such dependence, or synchrony. Among the most popular ones, the Unitary Event (UE) method, due to Grün and collaborators [2], has been largely applied in the last decade. Indeed, this method gives a precise location in time of the dependence periods, and quantifies the degree of dependence by providing p-values for the independence tests. Moreover, substantial upgrades have been developed from the original method. Firstly, in order to overcome the information loss that the binning data pre-processing may involve in some cases, Grün et al. have introduced the notion of Multiple Shift coincidence in [3]. Secondly, the original UE method assumes the point processes to be Poisson (or Bernoulli). Nevertheless, no general model for spike trains is commonly accepted, and therefore, trial shuffling methods have been introduced (see e.g. [4]) in order to assess p-values using bootstrap paradigm, without making any assumption on the underlying point processes distribution. However, these surrogate data methods are based on binned coincidence count, for computational reasons. Thirdly, a recent work of Tuleau-Malot et al. [5] gives a generalization of the MS coincidence count, namely the delayed coincidence count for point processes, and introduces a multiple testing procedure based on a Gaussian approximation of the Unitary Events (MTGAUE). Notably, this new method corrects the multiple testing procedure by taking into account the multiplicity of the tests, and justifies the plug-in principle used in the p-values computation. Yet, it assumes that the point processes are homogeneous Poisson processes. Our aim is thus to propose a new multiple testing procedure, based on delayed coincidence count, not needing any binning pre-processing of the data, and without assuming any model on the underlying point processes. To do so, we first introduce a single test of independence between two point processes based on the delayed coincidence count of [5] and a permutation approach, which is close in spirit to trial shuffling. It is proved to exactly achieve the desired level, and to be consistent against any reasonable alternative, as illustrated in our simulation study. Then, we introduce the corresponding multiple testing procedure, which satisfies similar properties as existing UE methods, and this with as few assumptions as possible on the underneath distribution. In particular, we compare this new method to the trial-shuffling [4] and the MTGAUE methods [5] from a practical point of view on simulated data. Finally, an application on real data is also provided. Based on a joint work with Y. Bouret, M. Fromont and P. Reynaud-Bouret, available on http ://hal.archives-ouvertes.fr/hal-01154918.

1 W. Singer, Synchronization of cortical activity and its putative role in information processing and learning, Annual Review of Physiology 55, pp. 349-374, 1993.

2 S. Grün, M. Diesmann, A.M. Aertsen, Unitary Events Analysis, chapter in Analysis of Parallel Spike Trains, Grün, S., & Rotter, S., Springer Series in Computational Neuroscience, 2010.

3 S. Grün, M. Diesmann, F. Grammont, A. Riehle, Detecting unitary events without discretization of time, Journal of neuroscience methods, 94 (1), pp. 67-79, 2010.

4 G. Pipa and S. Grün, Non-parametric significance estimation of joint-spike events by shuffling and resampling, Neurocomputing, 52-54 :31-37, 2003.

5 C. Tuleau-Malot, A. Rouis, F. Grammont, and P. Reynaud-Bouret, Multiple tests based on a Gaussian approximation of the Unitary Events method, Neural Computation 26 (7), pp. 1-47, 2014.

Skewed firing rate distribution and fluctuation driven regime

Berg, Rune W.

Department of neuroscience ans pharmacology, Faculty of health and medical sciences, University of Copenhagen, Denmark, runeb@sund.ku.dk

Motor patterns such as chewing, breathing, walking and scratching are primarily produced by neuronal circuits within the brainstem or spinal cord. These activities are produced by concerted neuronal activity, but little is known about the degree of participation of the individual neurons. Here, we use multi-channel recording (256 channels) in turtles performing scratch motor pattern to investigate the distribution of spike rates across neurons. We found that the shape of the distribution is skewed and can be described as "log-normal"-like, i.e. normally shaped on logarithmic frequency-axis. Such distributions have been observed in other parts of the nervous system and been suggested to implicate a fluctuation driven regime (Roxin et al J. Neurosci. 2011). This is due to an expansive nonlinearity of the neuronal input-output function when the membrane potential is lurking in subthreshold region. We further test this hypothesis by quantifying the irregularity of spiking across time and across the population as well as via intra-cellular recordings. We find that the population moves between super- and sub-threshold regimes, but the largest fraction of neurons spent most time in the sub-threshold, i.e. fluctuation driven regime.

Spiking neural models: from point processes to Partial Differential Equations

Chevallier, Julien

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The aim of this talk is to make a bridge between two scales of spiking neurons modeling. On the one hand, systems of Partial Differential Equations are studied for a macroscopic description. On the other hand, point processes are used to describe individual neurons. At a microscopic scale, two types of point processes seem well adapted: Hawkes processes for their ability to model interacting

neurons and renewal processes for their ability to reproduce refractory periods. In this talk, we propose an hybrid model combining both advantages. Moreover, we study the (mean-field) limit of this new model when the number of interacting neurons is very large. Finally, it appears that this limit is closely related with a system of PDEs previously studied by Pakdaman, Perthame and Salort.

Adaptive Waveform Learning

Clerc, Maureen and **Hitziger, Sebastian** and **Papadopoulo, Theodore**
Athena project-team, INRIA Sophia Antipolis-Méditerranée, France, maureen.clerc@inria.fr

When analyzing brain activity recorded through modalities such as electroencephalography (EEG), it is often desired to represent neural events by stereotypic waveforms. Due to noise in the recordings and neural background activity, an adequate waveform estimate typically requires to record multiple repetitions of the neural events. We propose a novel method called adaptive waveform learning (AWL). It is designed to learn multi-component representations of neural events while explicitly capturing and compensating for waveform variability, such as changing latencies or more general shape variations. This work combines and generalizes well-established signal processing methods, such as Woody's method, PCA, ICA, sparse coding techniques, and dictionary learning. Applications of AWL will be presented on neuroelectrical signals, accounting for different types of variability of the underlying neural phenomena and proving capable of producing insightful data representations.

An integrate and fire model of mean-field type

Delarue, François and **Inglis, James** and **Rubenthaler, Sylvain** and **Tanré, Etienne**
Laboratory Jean-Alexandre Dieudonnée, University Nice Sophia Antipolis, France, delarue@unice.fr

We discuss a networked integrate-and-fire model, introduced in earlier works by Lewis and Rinzel and by Brunel, Hakim and Ostojic, describing an infinite population of neurons which interact with one another through their common statistical distribution. The interaction is of the self-excitatory type as, at any time, the potential of a neuron increases when some of the others fire: precisely, the kick it receives is proportional to the instantaneous proportion of firing neurons at the same time. We show that such a mathematical model has a phase transition: the nature of the solutions varies with the value of the excitation parameter. When the excitation parameter is large, solutions admit so called "blow-ups" as, at some times, a massive proportion of neurons spike simultaneously.

Neural responses to stimulus pairs as probability mixtures of responses to single stimuli

Ditlevsen, Susanne and **Li, Kang** and **Bundesen, Claus** and **Kyllingsbaek, Soren**
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A fundamental question concerning the way the visual world is represented in our brain is how a cortical cell responds when its classical receptive field contains more than a single stimulus object. Two opposing models have been proposed. In the response-averaging model [1], the firing rate of the cell to a pair of stimulus objects is a weighted average of the firing rates to the individual objects. By contrast, in the probability-mixing model [2], the cell responds to the pair of objects as if only one of the objects was present in any given trial. Here we compare the abilities of the two models to account for spike trains recorded from single cells in the middle temporal visual area (MT) of rhesus monkeys. The results support the probability-mixing model.

1 Reynolds, J. H., Chelazzi, L. and Desimone, R. Competitive mechanisms subserve attention in macaque areas V2 and V4. Journal of Neuroscience 19, 1736-1753 (1999)

2 Bundesen, C., Habekost, T. and Kyllingsbæk, S. A neural theory of visual attention: bridging cognition and neurophysiology. Psychological Review 112, 291 (2005)

On the Hamiltonian structure of large deviations in stochastic hybrid systems

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We develop the connection between large deviation theory and more applied approaches to stochastic hybrid systems by highlighting a common underlying Hamiltonian structure. A stochastic hybrid system involves the coupling between a piecewise deterministic dynamical system in Rd and a time-homogeneous Markov chain on some discrete space ?. We assume that the Markov chain on ? is ergodic, and that the discrete dynamics is much faster than the piecewise deterministic dynamics (separation of time-scales). Using the Perron-Frobenius theorem and the calculus-of-variations, we evaluate the rate function of a large deviation principle in terms of a classical action, whose Hamiltonian is given by the Perron eigenvalue of a |?|-dimensional linear equation. The corresponding linear operator depends on the transition rates of the Markov chain and the nonlinear functions of the piecewise deterministic system. The resulting Hamiltonian is identical to one derived using path-integrals and WKB methods. We illustrate the theory by considering the example of stochastic ion channels.

Spike-train description: process or Gibbs?

Fernandez, Roberto

Department of Mathematics, University of Utrecht, The Netherlands, R.Fernandez1@uu.nl

The distribution of spike trains is naturally modeled through stochastic processes where the probability of future states depend on the pattern of past spikes. Mathematically, this corresponds to distributions conditioned on past patterns. From a signal-theoretic point of view, however, one could wonder whether a more efficient description could be obtained through the simultaneous conditioning of past *and* future. Furthermore, such a formalism could be appropriate when discussing issues related to anticipation and prediction. On the mathematical level this double conditioning would correspond to a Gibbsian description analogous to the one adopted in statistical mechanics. In this talk I will introduce and contrast both approaches —process and Gibbsian based— reviewing existing results on scope and limitations of them.

Inferred Model of the Prefrontal Cortex Activity Unveils Cell Assemblies and Memory Replay

Ferrari, Ulisse

Vision Institut, France, ulisse.ferrari@gmail.com

Cell assemblies are thought to be the units of information representation in the brain, yet their detection from experimental data is arduous. Here, we propose to infer effective coupling networks and model distributions for the activity of simultaneously recorded neurons in prefrontal cortex, during the performance of a decision-making task, and during preceding and following sleep epochs. Our approach allows us to define putative cell assemblies as the groups of co -activated neurons in the models of the three recorded epochs. It reveals the existence of task-related changes of the effective couplings between the sleep epochs. The assemblies which strongly coactivate during the task epoch are found to replay during subsequent sleep, in correspondence to the changes of the inferred network. Across sessions, a variety of different network scenarios is observed, providing insight in cell assembly formation and replay.

To be announced

Galves, Antonio

Statistics Department, Instituto de Matemática e Estatística, Universidade de São Paulo, Brazil, galves@usp.br

Variability and constraints in spontaneous neuronal network remodeling

Hennig, Matthias

Institute for Adaptive and Neural Computation School of Informatics, University of Edinburgh, United Kingdom, m.hennig@ed.ac.uk

Various plasticity mechanisms continuously remodel neural circuits, yet the behavior and function of neuronal assemblies are generally found to be stable over time. What factors enable this stability despite ongoing changes in single neurons and synapses? We addressed this question by investigating the stability of cultured network activity recorded with high density multielectrode arrays over several days. To this end, we constructed parametric models of multi-neuron activity patterns, and analysed their sensitivity to parameter changes. We found that the models had large regions in parameter space where the model behaviour was largely insensitive to changes. The activity of neurons associated with insensitive parameters showed faster and larger fluctuations than the activity of a small subset of neurons associated with highly sensitive parameters. We propose that this form of near-degeneracy endows neuronal networks with the flexibility to continuously remodel without compromising stability and function.

Bifurcation analysis of a reaction-diffusion model for stage II retinal waves

Karvouniari, Théodora and **Cessac, Bruno** and **Gil, Lionel**
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Retinal waves are spontaneous waves of spiking activity observed in the retina, during development only, playing a central role in shaping the visual system and retinal circuitry. Understanding how these waves are initiated and propagate in the retina could enable one to control, guide and predict them in the in vivo adult retina as inducing them is expected to reintroduce some plasticity in the retinal tissue and in the projections to the LGN. In this context, we propose a physiologically realistic reaction-diffusion model for the mechanisms of the emergence of stage II cholinergic retinal waves during development. We perform the bifurcation analysis when varying two biophysically relevant parameters, the conductances of calcium and potassium g_{Ca}, g_K respectively. The two main goals of our work are: firstly, reproduce the experimental recordings of developmental retinal waves by simulating our model and secondly, explore the different dynamical behaviours observed when varying these two parameters.

Statistical Considerations in Making Inferences about Neural Networks: The Case of Synchrony Detection

Kass, Robert E.
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Representations of network functional connectivity typically involve nodes (neurons or brain regions) and edges (their co-activation) in a graph. When the number of nodes and edges is large it becomes difficult to make reliable statistical inferences about the details of graphical structure, and the way it changes with stimulus or behavior. I will discuss some strategies used to attack this problem. In particular, I will focus on a measure of neural synchrony that combines point process regression mod-

els of individual-neuron activity with loglinear models of multiway synchronous interaction (Kelly and Kass, 2012, Neural Computation), and will describe a method based on Bayesian control of false discoveries that does a good job of distinguishing real from spurious edges in the graph. I will also give some thoughts on the role of replication in scientific investigations.

Inter-synaptic learning of combination rules in a cortical network model

Lavigne, Frédéric and **Avnaïm, Francis** and **Dumercy, Laurent**
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Selecting responses in working memory while processing combinations of stimuli depends strongly on their relations stored in long-term memory. However, the learning of XOR-like combinations of stimuli and responses according to complex rules raises the issue of the non-linear separability of the responses within the space of stimuli. Based on the non-linear integration of synaptic inputs within dendritic compartments, we propose here an inter-synaptic learning algorithm that determines the probability of potentiating/depressing each synapse as a function of the co-activity of the other synapses within the same dendrite. The IS starting with random connectivity and without a priori wiring without additional neurons. Our results show that IS learning generates efficacy values that are sufficient for the processing of XOR-like combinations, on the basis of the sole correlational structure of the stimuli and responses. We analyze the types of dendrites involved in terms of the number of synapses from pre-synaptic neurons coding for the stimuli and responses. The synaptic efficacy values obtained show that different dendrites specialize in the detection of different combinations of stimuli. The resulting behavior of the cortical network model is analyzed as a function of inter-synaptic vs. Hebbian learning. Combinatorial priming effects show that the retrospective activity of neurons coding for the stimuli trigger XOR-like combination-selective prospective activity of neurons coding for the expected response.

On oscillating systems of interacting neurons

Loecherbach, Eva and **Ditlevsen, Susanne**
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We consider multi class systems of interacting nonlinear Hawkes processes modeling several large families of neurons. We prove propagation of chaos for such systems and associated central limit theorems. Moreover, we discuss situations in which the limit system exhibits oscillatory behavior. Finally, we show how these results can be related to certain PDMP's (piecewise deterministic Markov processes) and the study of their longtime behavior.

Joint risk-measurement model for the risk of decompression sickness acci-

dents based on the biophysical model of decompression

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We present a new approach to modeling of decompression sickness accidents in the human scuba diving based on a non-homogeneous Poisson process. It takes into account: (i) the biophysical model of decompression, (ii) the individual variability of response to the decompression stress expressed through the longitudinal biomarker and (iii) the functional control variable - the dive profile. The main goal of our modeling is to establish the relationship between the control variable and the survival function in order to control the risk exposure at both population and individual levels. In this direction, the joint risk-measurement model offers a unified framework and solves the observability problems concerning the individual biophysical parameters of divers influencing the survival. This is done by relating these parameters to the longitudinal biomarker of decompression stress. An important difficulty, when compared to other risk assessment studies, relies on the functional control variable in the entry of the risk model and on the censure done with respect to this variable leading to few observations for the functional regressors assumed to lead to a greater risk. We propose a methodology to overcome this major challenge and present the results obtained on simulated data and on real scuba diving data.

Encoding Through Patterns: Regression Tree-Based Neuronal Population Models

Pipa, Gordon

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Although the existence of correlated spiking between neurons in a population is well known, the role such correlations play in encoding stimuli is not. We address this question by constructing pattern-based encoding models that describe how time-varying stimulus drive modulates the expression probabilities of population-wide spike patterns. The challenge is that large populations may express an astronomical number of unique patterns, and so fitting a unique encoding model for each individual pattern is not feasible. We avoid this combinatorial problem using a dimensionality-reduction approach based on regression trees. Using the insight that some patterns may, from the perspective of encoding, be statistically indistinguishable, the tree divisively clusters the observed patterns into groups whose member patterns possess similar encoding properties. These groups, corresponding to the leaves of the tree, are much smaller in number than the original patterns, and the tree itself constitutes a tractable encoding model for each pattern. Our formalism can detect an extremely weak stimulus-driven pattern structure and is based on maximizing the data likelihood, not making a priori assumptions as to how patterns should be grouped. Most important, by comparing pattern encodings with independent neuron encodings, one can determine if neurons in the population are driven independently or collectively. We demonstrate this method using multiple unit recordings from area 17 of anesthetized cat in response to a sinusoidal grating and show that pattern-based encodings are superior to those of independent neuron models. The agnostic nature of our clustering approach allows us to investigate encoding by the collective statistics that are actually present rather

than those (such as pairwise) that might be presumed.

On the relation between neuronal size and extracellular spike amplitude and its consequence on extracellular recordings interpretation

Pouzat, Christophe and **Detorakis, Georgios Is**
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Neurophysiologists using extracellular techniques to record neuronal spiking activity know by experience that larger neurons are easier to record from because they give rise to larger extracellular spikes (action potentials). There is empirical evidence (Grover and Buchwald, 1970, J Neurophys 33: 160-171) supporting this "tacit knowledge" but, as far as we know, no proper theoretical justification. We will show that by combining elementary "ingredients": i) the law of the electrostatic potential generated by a current source; ii) the cable equation; iii) the relationship between cable diameter and action potential propagation speed; the extracellular potential generated by a spike is proportional to the cable / neurite diameter. Empirical and numerical illustrations of this result will be shown. Going one step further, this result implies that when recordings are done from neurons with active somato-dendritic compartments, the extracellular spike reflects what appends in the latter compartment rather than in the axon. This opens the way to wrong interpretations of extracellular recordings when spikes in the somato-dendritic compartments strongly adapt. Published data will be discussed in the light of this implication.

A model for a time and frequency specific Granger causality measure for intracranial electroencephalogram data

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Often, brain signal data are recorded during an experimental situation where stimuli are presented at fix time and are expected to induce a subject reaction. The causal links between recorded signals (e.g. from different part of the brain) may therefore vary in time and be frequency specific and the ability to compute a dynamic and frequency specific statistic of "causality" is essential. Granger causality comes very naturally as a strong statistical tool allowing us to test for dynamical causal relationships, its properties being assessed a few decades ago (Granger, 1969, Geweke, 1984). However, Granger's original model is neither time varying, nor frequency specific. We propose its extension based on a Bayesian vector autoregressive model with time varying coefficients. Many issues will be discussed, including the estimation through the variational Bayesian approximation methodology, the selection of the priors and the way to select the model order. The frequency part is achieved through the use of the Haar "à trou" wavelet transform. I will present an application of this methodology to real intracranial electroencephalogram data recorded in the regions of amygdala and medial orbitofrontal cortex during an experimental task of emotional auditory stimuli recognition.

Inhibition-dominated random networks for stimulus processing in rodent visual cortex

Rotter, Stefan and **Sadeh, Sadra**
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The visual cortex of rats and mice appears to lack the orderly structure that leads to the very prominent feature maps well-known from cats and monkeys [1]. Therefore, random networks have been suggested as a model of the primary visual cortex in rodents, and it is now known that contrast-independent orientation tuning, for example, emerges naturally as a consequence of the recurrent dynamics of inhibition-dominated spiking neuronal networks in the balanced state [2-5]. This notion finds a lot of support by recent experiments probing the functional physiology of single neurons at the time of eye opening. Later in development, however, feature-specific connectivity emerges in the network [6-10]. In my talk, I will highlight some recent theoretical insight into the inner workings of dynamic random networks during stimulus processing in sensory networks.
Supported by the German Ministry of Education and Research (BFNT Freiburg Tubingen, grant 01GQ0830) and the German Research Foundation (DFG, grant EXC 1086).

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Estimation in hypoelliptic neuronal models

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Stochastic models have been proposed for neuronal modeling of intra-cellular recordings. Standard models are systems of differential equations with some additive noise on some of the components (stochastic Morris-Lecar model, stochastic Hodgkin-Huxley model, stochastic FitzHugh-Nagumo, etc). When some coordinates have no noise, hypoellipticity appears and parametric estimation of these models from intra-cellular data is more difficult. In this talk, we present a new estimation method based on particle filter and stochastic approximation.

Relating neural firings to epidemics and tweets

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Propagation of firing activity in neuronal circuits is similar to contagion of infectious diseases or spreads of tweets, in that the event occurrence is influenced by past events. The degree of influence is represented by the reproduction number defined as the expected number of extra events induced by a single event. If the reproduction number is greater than unity, the event occurrence exhibits pandemic divergence as in nuclear fission. Even if the explosion is avoided by diluting connections or weakening the influence, the occurrence rate may still exhibit large fluctuation; we have recently proven that a system exhibits spontaneous fluctuation if the reproduction number is greater than $1 - 1/\sqrt{2} \approx 0.3$; otherwise the observed occurrence rate remains stationary [1]. This criticality condition was derived for the Hawkes process under an assumption that individuals are interacting with equal strength. In the present contribution, we firstly show that SIS (susceptible-infectious-susceptible) model of epidemics exhibits fluctuation under the same condition. Secondly, we consider the cases of non-trivial network structures, including random, small-world, and scale-free networks, and prove that the threshold decreases with the dispersion of degree distribution and vanishes in the limit of infinite dispersion.

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A multidisciplinary approach in unravelling the basic mechanisms of cere-

bral cortical development in the mouse

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The mammalian cerebral cortex underlies major cognitive functions such as learning, memory, perception, abstract thinking, and more. Developmental aberrations affecting the cortex lead to severe abnormalities, such as mental retardation and autism spectrum disorders. While much is known about the anatomical structure of the cerebral cortex, little is known about the molecular and cellular mechanisms that control its development and assembly during embryonic development. The neocortex, the most complex structure of the cerebral cortex, is composed of billions of neurons divided into specific subpopulations and functional areas. Early in embryonic development, the brain establishes separate compartments of subpopulations, which migrate to colonize different regions of the developing cortex and form specific synaptic connections. The goal of my laboratory is to identify and characterize the key molecular and cellular signaling mechanisms underlying embryonic cortical development, using multidisciplinary approaches that combine embryonic genetic manipulation, mouse genetics, biochemistry, morphological analysis, as well as electrophysiology methodologies. Contributing in unravelling the mechanisms of these basic events in embryonic brain development will help in gaining more insights into severe human neurodevelopmental disorders.

Periodic Ergodicity of a Hodgkin-Huxley model with random periodic dendritic input

Thieullen, Michèle, **Höpfner, Reinhard** and **Löcherbach, Eva**

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This talk is based on a joint work with Reinhard Höpfner (Univ. Mainz) and Eva Löcherbach (Univ. Cergy-Pontoise). We consider a stochastic Hodgkin-Huxley model for a spiking neuron including its dendritic input. This input carries some deterministic periodic signal coded in its drift coefficient and is the only source of noise for the whole system. We prove ergodicity for this system. In this talk I will present our model and focus on a key argument of the proof based on the existence of an attainable point and the construction of control systems.

List of Participants

- **Mélisande Albert** (Université Nice-Sophia Antipolis)
- **Rune Berg** (University of Copenhagen)
- **Enrico Bibbona** (University of Torino)
- **Maria Caceres** (University of Granada)
- **Luigia Caputo** (University of Napoli)
- **Bruno Cessac** (INRIA Nice-Sophia Antipolis)
- **Julien Chevallier** (Université Nice-Sophia Antipolis)
- **Maureen Clerc** (INRIA Nice-Sophia Antipolis)
- **Rodrigo Cofre** (University of Genova)
- **François Delarue** (Université Nice-Sophia Antipolis)
- **Joelle Despeyroux** (INRIA, I3S, Nice-Sophia Antipolis)
- **Susan Ditlevsen** (University of Copenhagen)
- **Marie Doumic** (INRIA Paris Rocquencourt)
- **Olivier Faugeras** (INRIA Nice-Sophia Antipolis)
- **Ulisse Ferrari** (Institut de la vision, Paris)
- **Roberto Fernandez** (University of Utrecht)
- **Galligo André** (Université Nice-Sophia Antipolis)
- **Antonio Galves** (Universidade de São Paulo)
- **Franck Grammont** (Université Nice-Sophia Antipolis)
- **Matthias Hennig** (University of Edinburgh)
- **Pierre Hodora** (Université de Cergy Pontoise)
- **Theodora Karvouniari** (INRIA Nice-Sophia Antipolis)
- **Robert Kass** (Carnegie Mellon University)
- **Thomas Laloe** (Université Nice-Sophia Antipolis)
- **Frédéric Lavigne** (Université Nice-Sophia Antipolis)
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- **Asya Metelkina** (Laboratoire d'Informatique, Signaux et Systèmes de Sophia-Antipolis)
- **Marco Palma** (University of Bologna)
- **Gordon Pipa** (University of Osnabrueck)
- **Enrica Pirozzi** (University of Napoli Frederico II)
- **Christophe Pouzat** (Université Paris Descartes)
- **Olivier Renaud** (Université de Genève)
- **Patricia Reynaud-Bouret** (Université Nice-Sophia Antipolis)
- **Alexandre Richard** (INRIA Nice-Sophia Antipolis)
- **Vincent Rivoirard** (Université de Paris Dauphine)
- **Stefan Rotter** (University of Freiburg)
- **Adeline Samson** (Université Joseph Fourier)
- **Shigeru Shinomoto** (Kyoto University)
- **Michèle Studer** (Université Nice-Sophia Antipolis)
- **Etienne Tanré** (INRIA Nice-Sophia Antipolis)
- **Michèle Thieullen** (Université Pierre et Marie Curie)
- **Christine Tuleau-Malot** (Université Nice-Sophia Antipolis)