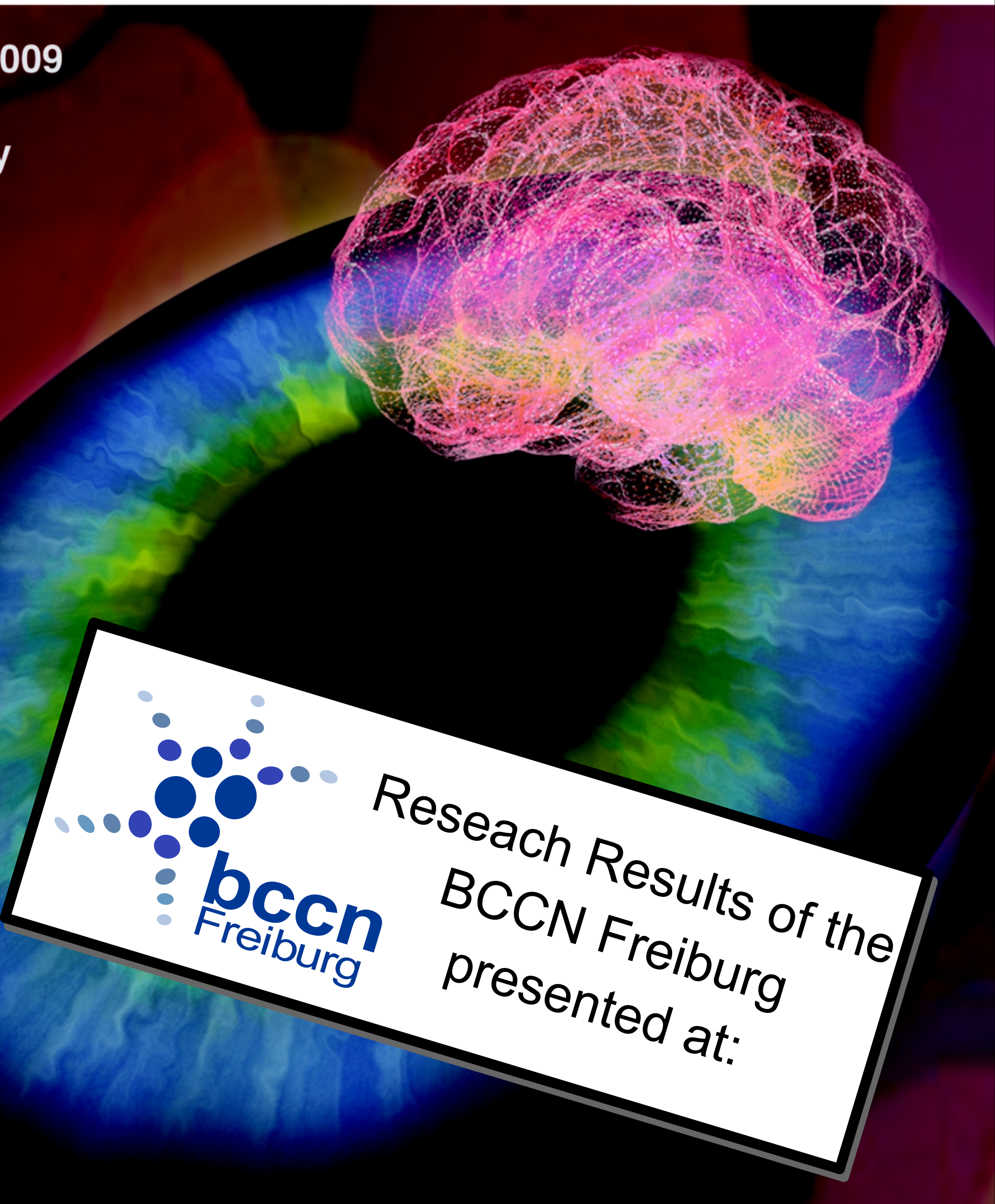
BCCN Bernstein Conference on Computational Neuroscience 2009

September 30 - October 2, 2009
Goethe University
Frankfurt am Main, Germany
http://www.bccn2009.org/

Invited speakers
Jòzsef Fiser (Brandeis)
Wulfram Gerstner (EPFL)
Amiram Grinvald (Weizmann)
Gilles Laurent (Caltech)
Klaus Obermayer (BCCN Berlin)
Mriganka Sur (MIT)
Bernstein Award 2009 winner



May 4:
Abstract submission opens

May 17:
Abstracts due

June 15:
Demonstration proposals due

July 13:
Publication of schedule

August 15:
Early registration ends

Selected abstracts will be published in the journal Frontiers in Computational Neuroscience

Topics include:
learning and plasticity, sensory processing, motor control, reward system, brain computer interface, neural encoding and decoding, decision making, information processing in neurons and networks, dynamical systems and recurrent networks, neurotechnology

Organizing committee:
Jochen Triesch (general); Jörg Lücke, Gordon Pipa, Constantin Rothkopf (program); Cornelius Weber (demonstrations and finance); Junmei Zhu (publications); Prashant Joshi (publicity); Gaby Schmitz (local arrangements); Cristina Savin (PhD-symposium)

Finite synaptic potentials cause a non-linear instantaneous response of the integrate-and-fire model

Moritz Helias, Moritz Deger, Markus Diesmann, Stefan Rotter

The integrate-and-fire neuron model with exponential postsynaptic potentials is widely used in analytical work and in simulation studies of neural networks alike. For Gaussian white noise input currents, the membrane potential distribution is described by a population density approach [1]. The linear response properties of the model have successfully been calculated and applied to the dynamics of recurrent networks in this diffusion limit [2]. However, the diffusion approximation assumes the effect of each synapse on the membrane potential to be infinitesimally small. Here we go beyond this limit and allow for finite synaptic weights. We show, that this considerably alters the absorbing boundary condition at the threshold: in contrast to the diffusion limit, the probability density goes to zero on the scale of the amplitude of a postsynaptic potential (suppl. Fig B). We give an analytic approximation for the density (suppl. Fig A) and calculate how its behavior near threshold shapes the response properties of the neuron. The neuron with finite synaptic weights responds arbitrarily fast to transient positive inputs. This differs qualitatively from the behavior in the diffusion limit, where the neuron acts as a low-pass filter [3]. We extend the linear response theory [3] and quantify the instantaneous response of the neuron to an impulse like input current. Even for realistically small perturbations (s) of the order of a synaptic weight, we find a highly non-linear behavior of the spike density (suppl. Fig C). Direct simulations in continuous time [4] confirm the analytical results. For numerical simulations in discrete time, we provide an analytical treatment which quantitatively explains the distortions of the membrane potential density. We find that temporal discretization of spikes times amplifies the effects of finite synaptic weights. Our demonstration of a non-linear instantaneous response amends the theoretical analysis of synchronization phenomena and plasticity based on the diffusion limit and linear response theory.

Supported by the DIP F1.2, BMBF Grant 01GQ0420 to the Bernstein Center for Computational Neuroscience Freiburg, EU Grant 15879 (FACETS), and Next-Generation Supercomputer Project of MEXT, Japan. All simulations are performed using NEST [5]

[1] Ricciardi LM, Sacerdote L: The Ornstein-Uhlenbeck process as a model for neuronal activity. Biol Cybern35 :1979, 1-9
[2] N, Hakim V: Fast Global Oscillations in Networks of Integrate-and-Fire Neurons with Low Firing Rates.Neural Comput1999, 11(7) : 1621-1671
[3] Brunel N, Chance FS, Fourcoud N, Abbott LF: Effects of Synaptic Noise and Filtering on the Frequency Response of Spiking Neurons. PRL 2001, 86(10) : 2186-2189
[4] Morrison A, Straube S, Plesser HE, Diesmann M: Exact subthreshold integration with continuous spike times in discrete time neural network simulations. Neural Comput. 2007, 19(1): 47-79
[5] Gewaltig M-O, Diesmann M: NEST (NEural Simulation Tool), Scholarpedia 2007, 2(4): 1430

Self-sustained activity in networks of integrate and fire neurons without external noise

Marc-Oliver Gewaltig

There is consensus in the current literature that stable states of asynchronous irregular firing require (i) very large networks of 10000 or more neurons [and (ii) diffuse external background activity or pacemaker neurons.

Here, we demonstrate that random networks of integrate and fire neurons with current based synapses assume stable states of self-sustained asynchronous and irregular firing even without external random background (Brunel 2000) or pacemaker neurons (Roudi and Latham 2007). These states can be robustly induced by a brief pulse to a small fraction of the neurons. If another brief pulse is applied to a small fraction of the inhibitory population, the network will return to its silent resting state.

We demonstrate states of self-sustained activity in a wide range of network sizes, ranging from as few as 1000 neurons to more than 100,000 neurons. Networks previously described (Amit and Brunel 1997, Brunel 2000) operate in the diffusion limit where the synaptic weight is much smaller than the threshold. By contrast, the networks described here operate in a regime where each spike has a big influence on the firing probability of the post-synaptic neuron. In this “combinatorial regime” each neuron exhibits very irregular firing patterns, very similar to experimentally observed delay activity. We analyze the networks, using a random walk model (Stein 1965).

Supported by the BMBF Grant 01GQ0420 to the Bernstein Center for Computational Neuroscience Freiburg.

[1] D.J. Amit and N. Brunel (1997) Cereb. Cortex, 7:237-252
[2] N. Brunel(2000) J Comput Neurosci, 8(3):183-208
[3] Y. Roudi and P.E. Latham (2007) PLoS Comput Biol, 3 (9):e141
[4] R. B. Stein (1965) Biophysical Journal,5:173-194;

Matching network dynamics generated by a neuromorphic hardware system and by a software simulator

Daniel Brüderle, Jens Kremkow, Andreas Bauer, Laurent Perrinet, Ad Aertsen, Guillaume Masson, Karlheinz Meier, Johannes Schemmel

We introduce and utilize a novel methodological framework for the unified setup, execution and analysis of cortical network experiments on both a neuromorphic hardware device and a software simulator. In order to be able to quantitatively compare data from both domains, we developed hardware calibration and parameter mapping procedures that allow for a direct biological interpretation of the hardware output. Building upon this, we integrated the hardware interface into the simulator-independent modeling language PyNN. We present the results of a cortical network model that is both emulated on the hardware system and computed with the software simulator NEST. With respect to noise and transistor level variations in the VLSI device, we propose that statistical descriptors are adequate for the discrimination between states of emerging network dynamics. We apply measures for the rate, the synchrony and the regularity of spiking as a function of the recurrent inhibition within the network and of the external stimulation strength. We discuss the biological relevance of the experimental results and the correspondence between both platforms in terms of the introduced measures.

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Effect of structural network composition on network stability and dynamics

Sarah Jarvis, Stefan Rotter, Ulrich Egert

Dissociated cortical cultures grown on micro-electrode arrays (MEA) are an established model for nervous systems, retaining key features of neural circuits while having reduced dimensionality, thus making them particularly attractive in the study of neural dynamics. Present in their dynamics are periods of strongly synchronized spiking, termed 'bursting', which act to saturate network dynamics and are not observed within in vivo networks. It is verified that bursting is not random activity due to the presence of repeat patterns or motifs within bursts. However, what role bursting plays within network dynamics is unknown: whether it acts as a mechanism for activity maintenance or is instead a symptom of quasiinstability. Regardless, we aim to minimize their occurrence and would therefore like to identify any criteria linked to their appearance.

In order to functionally understand what structural conditions are necessary for bursting to arise, we have previously established [1] a recurrent network model that extends an Echo State Network architecture [2]. Using this model, we investigated the effect of introducing hierarchically clustered reservoirs as well as other factors, such temporal resolution, and examined the effects of both on the presence of bursting as well as on characteristics such as memory capacity. While we were able to identify basic structural criteria required for bursting related to the configuration of clusters, we were unable to reliably reproduce bursting, suggesting that additional criteria exist.

Here, we present our findings after further considering the networks in terms of in and out degrees of cluster connectivity, eigenvalue spectra of connection weights and unequal weight distributions. By examining the distribution of path lengths, we are able to relate criteria for networks that preferentially burst to the relative impact of the input population to any network node. We also discuss the inhomogeneities of the system by identification of the sinks and sources within the network, and propose how their presence may influence stability of the network.

Supported by the German Federal Ministry of Education and Research (BMBF, 01GQ0420) and EU-NEURO (12788)

[1] Jarvis, Rotter, Egert “Aiming for stable instability: introducing hierarchy to reservoir networks” submitted to Frontiers in Neuroinformatics

[2] Jäger (2001) “The 'echo state' approach to analysing and training recurrent neural networks ” Technical Report 148, German National Research Center for Information Technology