- Workshop website

  Event/Seminar Tab
  http://www.nims.go.jp/publicity/events/brain_like_computing.html

  Main website
  http://www.nims.go.jp/project/amcp/brain_like_computing/site/index.htm

- Workshop Accommodation-1

  http://www.epochal.or.jp/eng/access/index.html

  http://www.epochal.or.jp/eng/

  http://www.jsthouse.com/ninomiya/index.htm

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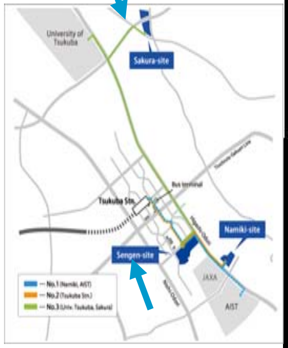

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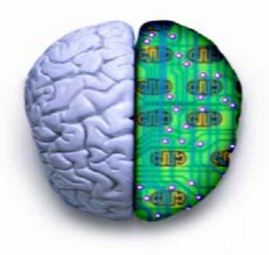

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独立行政法人 物質・材料研究機構 National Institute for Materials Science

2nd International workshop on

Brain Inspired Computing

4th and 5th June 2012, NIMS sengen-site, Main Auditorium

A closer look into the fundamental principles of neuroscience and its replication

BIC 2012 BIC 2012 BIC 2012 BIC 2012 BIC 2012 BIC 2012 BIC 2012 BIC 2012 BIC 2012 BIC 2012 BIC 2012

BIC 2012

Proceeding for the workshop

独立行政法人 物質・材料研究機構 National Institute for Materials Science

Edited by: Surface Characterization Group

Advanced Key Technologies Division, National Institute for Materials Science
1-2-1 Sengen, Tsukuba, Ibaraki Japan 305-0047, www.nims.go.jp

Message from the Managing director

Director of Advanced Key Technologies Division (AKTD)
Director of Nano Characterization Unit (NCU)
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I extend my thank for accepting our invitation to participate in the 2nd International workshop on Brain Inspired computing in 2012 (BIC 2012) which is held at National Institute for Materials Science, Japan on June 4th and 5th, 2012. The 1st International Symposium on fusion of materials and bioinformatics, BMI 2008, was successfully held at Rozenberg hotel, Florida, Orlando, USA 29th June to 2nd July 2008. In 2008, we brought two classes of scientists who were either pure materials Scientists, or hardcore computer scientists into a single platform. BIC 2012 aims at understanding the complexity science, and deciding strategic protocols for unraveling technologies hidden inside the biological computing devices, for the future generation advanced materials. This symposium will bring together key researchers from every sector of academy, national institution, and industry in the neuroscience, computer science, materials science with a special focus on brain inspired computing. The symposium will consist of keynote lectures by pioneers of particular associative fields and we have planned to organize brainstorming panel sessions. We appreciate your participation and be most obliged if you may send this message to related colleagues. We welcome you at BIC Symposium 2012 on 4th 5th June 2012 in Tsukuba, Japan.

The program

June 04, 2012: Monday

Welcome Address by Prof Daisuke Fujita, Managing Director, Advanced Key Technology Division (AKTD), Nano Characterization Unit (NCU)
Introduction of NIMS, & its Vision 9.30 AM to 9.45 AM.

Session A: 9.45-10.00 AM: Vision of the workshop & Introduction of the Day ONE~ Critical aspects of Brain Science: Anirban Bandyopadhyay

10.00 AM to 10.45 AM, Tomoki Fukai	Brain Circuits, RIKEN, Japan
10.45 AM to 11.20 AM, Jack Tuszynski	Neuronal Microtubule theory and experiments, Canada
11.25 AM to 12.10 PM, Tomaso Poggio	Visual cognition, MIT, USA

Lunch: 12.10 PM-1.05 PM: NIMS Cafeteria
Poster Session: Main Auditorium

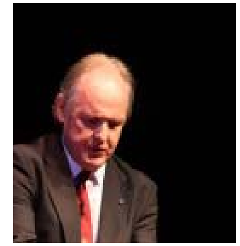
Session B: 1.05 PM-1.15 PM: Introduction of this session ~ Fundamentals of neural circuitry, Prof. Ferdinand Peper

1.15 PM to 2.00 PM, Gouhei Tanaka	Remarkable rules of brain-like network, TU, Japan
2.10 PM to 2.55 PM, Steve Furber	Computing in the brain, UK
3.05 PM to 3.25 PM, Pradip K Mandal	Evolutionary molecular circuits, fundamentals (part I), India
3.25 PM to 4.00 PM, Anirban bandyopadhyay	Nano Brain Project (part II), NIMS, Japan
4.00 PM to 4.25 PM Takeshi Okada	The role of inspiration in artistic creation University of Tokyo

Tea Time: 4.25-4.35 PM: Snacks & Posters

Discussion Panel: 4.35 PM-5.30 PM: Unresolved mysteries of Brain Science: What are essential to know for replication? Tomoki, Jack (Tuszynski), Steve, Karlheinz, Tomaso & Ferdinand
Chairman: Prof. Ferdinand Peper

Dinner: 5.30 PM-7.00 PM: NIMS Cafeteria



Biologically-Inspired Massively-Parallel Computing

Steve Furber
ICL Professor of Computer Engineering, School of Computer Science, The University of Manchester, Oxford, UK
Tel: 0161 275-6129, steve.furber@manchester.ac.uk

- The SpiNNaker (Spiking Neural Network Architecture) project aims to deliver a massively-parallel computing platform for modelling large-scale systems of spiking neurons in biological real time. The architecture is based around a Multi-Processor System-on-Chip that incorporates 18 ARM processor subsystems and is packaged with a 128Mbyte SDRAM to form the basic computing node. An application-specific packet-switched communications fabric carries neural "spike" packets between processors on the same or different packages to allow the system to be extended up to a million processors, at which scale the machine has the capacity to model in the region of 1% of the human brain.

Towards Realization of Brain Inspired Pattern Recognition

Basabi Chakraborty
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- Human brains easily recognize complex patterns, solve messy real world problems and are able to draw conclusion from incomplete and vague information with an amazing speed. Though modern intelligent computers excel in solving a single problem having well defined parameters with high precision, the design of human- competitive pattern recognition machines remains a difficult task despite decades of research efforts. Day by day researches on brain science are revealing clues of human brain's information processing mechanism. Engineers are trying to design hardware with brain-like information processing capabilities based on new brain inspired soft computing tools such as artificial neural network, fuzzy and rough set, evolutionary computation and genetic algorithm.
- Traditional pattern recognition is a two step process, feature selection and classification or categorization. The success of autonomous pattern recognition systems depends heavily on successful extraction of salient features representing the characteristics of the particular problem and rejection of unwanted information. I proposed efficient algorithms based on brain inspired computation for effective feature selection related to real world applications like face recognition, online hand writing recognition, voice recognition etc. In order to extract only relevant features, they need to be evaluated. I developed a few measures for evaluating the efficiency of a feature or a feature subset with soft computing techniques. I proposed fractal architecture for artificial neural network and showed its effectiveness for classification and categorization of complex patterns. I worked on improving existing learning algorithms and proposed modified algorithms for multilayer perceptron classifiers for better understanding of the capabilities of artificial neural networks in solving real world complex problems. The proposed techniques are used for intelligent information processing and pattern discovery from vast pool of collected data.
- Currently I am working on modifications of my previously developed algorithms on identifying and categorizing tree structured data and to propose recognition algorithms for complex structured patterns with an objective of applications in bioinformatics such as gene expression data or glycan structure identification and analysis.

Poster 2 **1.** Z. Cai, et al., "Spatial auditory BCI/BMI paradigm" **2.** Y. Matsumoto, et al., "Steady-state auditory responses application to BCI/BMI" **3.** Nishikawa, et al., "Analysis of brain responses to spatial real and virtual sounds - A BCI/BMI approach" **4.** Wei Qiu and Ko sakai, Neura mechanisms for 3D shape representation by medial axis.

Massively parallel processing on an organic molecular layer

Anirban Bandyopadhyay
Surface Characterization Group, National Institute for Materials Science, anirban.bandyo@gmail.com

- Several molecular machines are invented to solve three bottlenecks of human civilization, build nano-factories alleviating energy crisis, create nano-surgeons for blood-less, fatal-less surgery inside our body and build a creative and intelligent computer. Unless somebody/something is there at the nano-scale to control large number of such machines, instruct what to do, what not to, the machines invented in the last two decades would continue to face criticism for remaining in beaker forever. Therefore, all three singularities can be resolved with a nano-brain. Unfortunately, futurists and molecular engineers have remained silent on the essentiality of any such device. Our recent invention of 16-bit parallel processor operating in room temperature was a first step in this direction (PNAS-2008). Providing an operating platform for eight finest machines, nano-brain justified that chemists working on a future molecular society are not daydreamers.
- Our nano-brain is a future generation material that grows by itself. Decade's old phenomenon self-assembly is used to build decision-making architecture and thus a new class of materials science is opened before us. We start from one molecule and gradually build up the ultimate information-processing machine that can take 4 billion decisions is built by itself. Until now, historically, self-assembly was used to grow an architecture that can do only one job, that is processing one decision. However, now, it is just a molecular material that collectively processes billions of decisions.

On Nanocomputing, Fluctuations, and Brain-Inspired Information Processing

Ferdinand Peper
National Institute of Information and Communications Technology, Center for Information and Neural Networks, Osaka, peper@nict.go.jp

- His research interests include Cellular Automata, Nanocomputer Architectures, Noise- and Fluctuation-driven Systems, Chaotic Dynamical System-based Computation, Information Representation in the Brain, and Brain-Inspired Networking.
- In the last decade he and collaborators have proposed various Cellular Automata models that are promising for implementation by nanotechnology due to their low complexity (simple cells), lack of a need for clocking (asynchronous timing), and regular structure (facilitating bottom-up manufacturing technologies). The relevance of such models lies in the expectation that memory and logic in integrated circuits will become increasingly intertwined to the extent that, together as a unit, they can conduct simple operations. This may one day result in information processing technologies based on architectures that are radically different from today's.
- His recent research concerns the role of noise and fluctuations in information processing. Together with collaborators he has proven that fluctuations are the essential factor that sways the computational power of certain classes of circuits towards universality. This indicates that fluctuations, rather than being a nuisance that need to be suppressed, can be employed in nanoarchitectures as a resource to drive computations. It also supports the view that noise and fluctuations are likely to play an important role in nature underlying biological processes in cells. Very recently Ferdinand Peper has started to investigate brain-like information processing as an inspiration to design future computer and networking architectures.

Poster 1 **1.** Z. Struzik, T. Okada, et al. The role of inspiration in artistic creation, **2.** Subrata Ghosh, et al Design and chemical synthesis of organic nano-brain, **3.** Satyajit Sahu, et al Brain Microtubule and its resonant wireless communication bands, **4.** Yasuhiro Hatori and Ko Sakai, Roles of surface representation in early visual areas for the construction of curvature selectivity. **5.** Tatsuro Mashita and Ko Sakai, Representation of shape in cortical area V2.

The program

June 05, 2012: Tuesday

Session C: 9.15-9.30 AM: Introduction for the Day TWO ~ Signal from/to brain: Tomek Rutkowski

9.30 AM to 10.15 AM, Jack Gallant	Signal from Brain, for cognition, UC-Berkley, USA
10.20 AM to 11.05 AM, Yoshihiko Horio	Chaotic neurocomputing, Japan
11.05 AM to 11.35 AM, Yoichi Miyawaki	Optical signal processing in the brain, Japan
11.35 AM to 12.10 PM, Takaaki Musha	Hypercomputing in the brain, Japan

Lunch: 12.10 PM-1.05 PM: NIMS Cafeteria
Poster Session: Main Auditorium

Session D: 1.05 PM-1.15 PM: Introduction to the last session ~ Artificial Brain building, neuron to network, Prof. Basabi Chakraborty

1.15 PM to 2.00 PM Henry Markram	Blue Brain Project, EPFL, Switzerland
2.10 PM to 2.55 PM Chi-Sang Poon	Artificial neuro-circuit, MIT, USA
3.05 PM to 3.50 PM, Karlheinz Meier	Complexity of evolutionary network, Germany

Tea Time: 4.00-4.10 PM: Snacks and Poster
Discussion Panel: 4.15 PM-5.00 PM: How the brain-age will come? How materials, instruments, society will change? Jack (Gallant), Yoshihiko, Henry, Chi-Sang, Tomek Zbigniew F. Struzik & Basabi
Chairman & Chair-women: Prof. Basabi Chakraborty, and Tomek Rutkowski

Dinner: 5.30 PM-7.00 PM: NIMS Cafeteria

The Thesis

A Unifying Model of the Cortical Column

Henry Markram
Blue Brain Project
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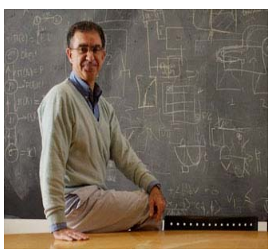
- A snapshot of the unifying model of a 14 day old rat somatosensory cortical column is revealed. It is the first such release of many to come, as the perpetual refinement process of the Blue Brain Project's unifying model concept accumulates new biological details and data-driven constraints, and is further validated and reviewed for consistency. A new release will be made every 6 months with a quantum leap of integrated data and knowledge.
- The model currently integrates decades of data on the structure and function of the neocortical column, and establishes the first virtual specimen and in silico experimentation platform with a battery of automated checks and balances. Presently, the model unifies most of what we know about neuronal morphology and types of neurons; neuronal electrical diversity; ion channels and their combinations supporting electrical features; gene expression in single neurons and patterns of expression across the tissue; types of neocortical synapses with pathway specific features such as synaptic facilitation and depression; stochastic spontaneous and evoked neurotransmitter release; synaptic connectivity in terms of the number and locations of synapses - all into a self-consistent model ready for hypothesis driven science.
- A multitude of techniques and a software ecosystem were developed to build and simulate the model while resolving consistency issues that become apparent during data integration and when validated against emergent properties.
- Insights where obtained far before a working model was established, including key anatomical and electrical features that distinguish neurons, principles of generalizing electrical properties across morphologies, how the connectome can be derived, and principles of neuronal composition, to name a few. The unifying model continues to yield predictions and insights difficult or impossible to obtain otherwise, such as the role of morphological diversity in ensuring an invariant and robust connectome and circuit-level physiology, the near complete input-output synaptome map for any neuron, boundaries for functional re-wiring, principles governing how shunting inhibition covers any neuron, and the resolution of a conflict between different sources of data on cortical synapse densities, to name a few.
- The study drove new theoretical and experimental studies such as those into a novel mechanism regulating STDP. A facility is being developed to make the model accessible through the Internet to facilitate further global collaborative building, validation and simulation of the model and begin building other unifying brain models.
- We have begun extracting progressively simpler versions of the detailed model for neural network simulations and implementation on neuromorphic hardware in the context of the BrainScales consortium. The result of these efforts is puch-button brain-derived architectures for brain-like computing systems.

Possibility to Realize a Hyper-computational System from the Standpoint of Superluminal Particles

Takaaki Musha
Ex Director, Advanced Science-Technology Research Organization, Namiki, Yokohama, Japan, takaaki.musha@gmail.com

- In mathematics and computer science, an accelerated Turing machine is a hypothetical computational model related to Turing machines, which can perform the countable infinite number of computational steps within a finite time. It is also called a Zeno machine, the concept of which was proposed by B.Russdel, R.Blake and H.Weyl independently, which performs its first computational step in one unit of time and each subsequent step in half the time of the step before, that allows an infinite number of steps to be completed within a finite interval of time. Zeno machines allow us to compute some functions those are not Turing-machine computable and it is known that the halting problem for Turing machines can be easily solved by them. But this machine cannot be physically realized from the standpoint of the Heisenberg uncertainty principle, because the energy required to perform the computation will be exponentially increased when the computational step is accelerated. Thus it is considered that the Zeno machine is mere a mathematical concept and there is no possibility for its realization in a physical world. However, from the assumption that the evanescent photon is a superluminal particle, the author has studied the possibility to realize the high performance computing system by utilizing superluminal evanescent photons and he has shown that the microtubular structure of neurons permits the human brain to function as a quantum hyper-computational system at the room temperature. By applying these results, it can be shown the possibility to realize a hyper-computational system which has a capability to function beyond the ordinary Turing machines by the information processing conducted inside macrotuble structures of neurons from the standpoint of superluminal particles..



A mathematical theory of the ventral stream of visual cortex

Tomaso Poggio
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- I conjecture that the sample complexity of object recognition is mostly due to geometric image transformations and that the main goal of the ventral stream is to learn-and-discount image transformations. From this hypothesis I develop a theory providing a simple, biologically plausible onelayer module for learning generic affine transformations in R^2 and become invariant to them for any new image. The module properties can be understood in terms of a slight extension of the Johnson-Lindenstrauss theorem. The theory then argues that although this approach is likely to have been discovered early by evolution and can deal with a few very important objects, it is not robust enough to local image deformations. Robustness to local deformations is obtained by a similar but hierarchical, multi-layer architecture for which I prove local and global invariance of parts and wholes, respectively, to the affine group on R^2. With the additional assumption of online, Hebbian-like learning mechanisms, the theory predicts the tuning of neurons in V1, V2, V4 and IT in terms of the spectral properties of the covariance of the learned transformations for different receptive fields sizes. The theory predicts that class-specific transformations are learned and represented at the top of the ventral stream hierarchy; it also explains why a patch of mirror-symmetric tuned face neurons should be expected before pose invariance in the face network of visual cortex. If the theory were true, the ventral system would be a mirror of the symmetry properties of image transformations in the physical world.

Towards Understanding Robustness of Dynamics and Function in Neural Networks

Gouhei Tanaka
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- The normal function of the brain and nervous system is thought to be maintained by firing activities of biological neurons. Although dynamical activities in neural networks are tolerant to some internal and external perturbations, other perturbations can cause a cascade of damages, resulting in a breakdown of the whole network function. Such biological robustness has not been fully discussed in a mathematical framework, because of the complexity in structure and dynamics in biological systems.
- As a first step towards understanding dynamical and functional robustness in neural networks, we study dynamical robustness in oscillator network models with complex topology. The analysis of the model shows a property on dynamical robustness of complex networks, which is opposite to that on structural robustness of complex networks. The results would provide an insight into effective prevention of diseases and efficient design of resilient brain-inspired devices..
- We quote from his website “2012 Jan.25: Our paper entitled "Dynamical robustness in complex networks: the crucial role of low-degree nodes" has been published online in Scientific Reports. OPEN ACCESS”
- http://www.nature.com/srep/2012/120125/srep00232/full/srep00232.html

Neural decoding and visual image reconstruction from human brain activity

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- Neural decoding is an approach to investigate information representation in the brain by devising a “neural decoder” that can read out information contents represented in the brain activity patterns. Recent functional magnetic resonance imaging (fMRI) studies have shown that presented visual stimuli can be predicted from fMRI activity patterns by a decoder, which is trained by statistical machine learning so as to classify the brain activity patterns into one of several pre-specified stimulus categories. However, such a simple classification approach becomes difficult if the number of stimulus categories increases, since decoders need to be trained for all the possible candidate stimuli. Furthermore, the approach predicts a categorical value as a result of classification, but does not reveal a visual image as it is.
- We have recently developed “visual image reconstruction” technique that overcomes these limitations and allows us to reconstruct a visual image from the brain activity pattern directly. We assume that an image is represented by a linear combination of local image elements of multiple scales, whose contrasts are independently predicted from the multi-voxel patterns. Since each local image element has less variation compared with the whole image, the training of the local decoders needs only a small number of training samples. Each local decoder thus serves as a “module” for the simple image element, and the combination of the modular decoders can predict large variations of complex images.
- In this talk, we present the basic methodology of neural decoding techniques and visual image reconstruction from human brain activity patterns. Further, we demonstrate findings about 1) multi-scale visual image representation, 2) information carried by correlative activity patterns, and 3) optimal image bases estimated from brain activity patterns. Our approach provides a powerful means to predict human perceptual contents, and also serves as a novel approach to investigate information representation in the human brain.

Symmetry breaking in conventional liquid crystals and biomaterials

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- Liquid crystals are essential not only for billion dollar low power consuming display industry spanning from wrist watches to mobile phones to laptops to LCD projectors, they are important for understanding a significant area of nature - the phenomena of phase transitions. A rich variety of compounds – starting from simple anisotropic organic molecules in the form of rods to complex molecules in the form of discs – are found to exhibit various liquid crystalline phases either as a function of temperature and/or as a function of solvent concentration. They combine the flow property of liquids with the anisotropic property of crystalline substances. Their textures, which is a visual image of topological defects in a thin specimen – observed under a polarizing microscope, not only helps in identifying various LC phases present in a system but also transmit their aesthetic beauty. Nature of ordering of constituent molecules is intermediate between completely disordered isotropic phase and perfectly ordered crystalline phase. It may be simply orientational ordering in highest symmetric nematics, or the molecules may be ordered in layers as in smectics. Within a layer molecules may be arranged randomly as in a liquid, they may be normal or tilted or there may be short range or quasi-long range positional ordering within the layers, resulting in various types of smectic phases. Symmetry breaking plays an important role in the formation of various phases and their properties. Contrary to usual expectations appearance of lower ordered phase from a higher ordered one under cooling is also observed in many systems. Chiral molecules, if found to exhibit tilted smectic phase, are found to give rise to ferro-, ferri- and antiferrolectric properties, generating new kind fluid ferroelectric materials. Many biologically important compounds also show liquid crystal phases under appropriate conditions and liquid crystallinity is believed to play a crucial role in their functioning. Such a delicate phase of nature will be reviewed briefly.

EEG components separation and brain patterns elucidation method: data driven Huang-Hilbert Transform and neural connectivity analysis application to a novel auditory BCI/BMI paradigm

Tomek Rutkowski
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- Spatial sound localization mechanism is one of the major topics in auditory neuroscience and combines the spatial attention mechanism and “cocktail party effect”. While the EEG-based visual paradigms are routinely used in the brain-computer/machine-interface (BCI/BMI) community, the auditory modality is under-explored but has the potential to give users a vastly enhanced listening experience. We here illuminate the paradigm of spatial sound stimuli localization and introduce signal processing methodology that elucidates evoked responses to simple sources in the auditory space. The EEG signals and especially ERP responses are nonstationary, classical linear methods including those assuming partial/short-time signal stationarity are not appropriate. The proposed EEG preprocessing and ERP response identification method is data-driven and is capable of separating the information bearing sources, thus allowing us to remove electrophysiological artifacts in single trial experiments, together with separating EEG subcomponents into those related to ERP and clutter. This is achieved by analyzing the multichannel correlation of spectral domain ridges from the evoked responses in the Hilbert-Huang domain. This allows for the clustering of common oscillations of amplitude and frequency ridges related to the propagation of evoked responses to EEG electrodes. Similarity of these oscillations identified by amplitude and frequency ridges correlations is a feature used in further time-domain reconstruction of so identified components within each channel, thus preventing information leakage (permutation). It is shown that the proposed EEG separation approach allows for the identification of the multiple-command BCI/BMI based on the P300 response to various spatial directions. Next, in order to obtain separable feature sets, we apply transfer entropy analysis on EEG data, which allows for drawing classifiable patterns of non-Gaussian signal sources from the brain. This result is a quantum step forward in comparison to existing auditory BCI/BMIs, since it facilitates all the directions in the horizontal auditory sound surround plane, as well as simple tonal or environmental stimuli.

APPROACHING BRAINSCALES IN NEUROMORHIC SYSTEMS

Karlheinz Meier
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- The brain is fundamentally different from numerical information processing devices. On the system level it features very low power consumption, fault tolerance and the ability to learn. On the microscopic level it is composed of constituents with a high degree of diversity and adaptability forming a rather uniform fabric with universal computing capabilities. Neuromorphic architectures attempt to build physical models of such neural circuits with the aim to capture the key features and exploit them for information processing.
- The lecture will introduce the basic concepts, discuss existing systems and their computational performance and finally provide an outlook into future plans.

Hybrid High-Dimensional Chaotic Neuro Computational Systems

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- A novel computational paradigm is explored, where analog computations with chaotic neuro-dynamics and digital computation through algorithms are combined. This hybrid complex computational system was inspired by the interactions between conscious and subconscious processes in the brain. That is, the heuristic algorithm and the analog chaotic neuro-dynamics correspond to the conscious and subconscious processes, respectively. Hardware prototypes are constructed using analog chaotic-neuron integrated-circuits, and applied to combinatorial optimization problems. In the system, high-dimensional analog chaotic neuro-dynamics drive a heuristic algorithm.
- We demonstrate experimentally that the prototype system efficiently solves quadratic assignment problems (QAPs). We also qualitatively analyze the underlying mechanism of the highly parallel and collective analog computations by observing global and local dynamics. Furthermore, we quantitatively evaluate the system dynamics using temporal mutual information. In addition, we extend the asynchronous dynamics to synchronous dynamics for large-scale hardware systems.

The role of inspiration in artistic creation

Takeshi Okada
University of Tokyo, Graduate School of Education, and Interfaculty Initiative in Information Studies, okadatak@p.u-tokyo.ac.jp

Inspiration is a process in which someone or something motivates people to do something, by giving new ideas or causing a particular emotion. Artwork often inspires people to participate in their own artistic expression. One of the situations in which artistic inspiration can be saliently seen is where people encounter with others' work at a deep level, such as copying others' artwork. Using three experiments and two case studies, we investigated processes of artistic inspiration. The three experiments share a pre-post design. In Experiment 1, 30 non-art major undergraduates were assigned to one of the three groups: (1) create own drawing after copying a model drawing, (2) create a drawing in the model's style after copying it, (3) create own drawing without copying a model. In Experiment 2, the style of the model drawing was manipulated (i.e., abstract style, semi-abstract style, academic style). In Experiment 3, the type of intervention was manipulated (i.e., copying artwork, watching artwork, verbal suggestion to create a different style of drawing, and control).

Toward real-time multiscale brain modeling on iono-neuromorphic silicon neuron chips

Chi-Sang Poon
Harvard-MIT Division of Health Sciences and Technology, Massachusetts Institute of Technology, 617-258-5405 (phone), cpoon@mit.edu

- Neural modeling in current literature relies heavily on computer simulation "in silico". However, even today's supercomputers cannot simulate large-scale brain networks in real time. Biological neurons excel in performing massive analog computations in parallel at minute power consumption within a tiny anatomic space while neuron-to-neuron communication is predominantly digital via all-or-none spiking. Neuromorphic silicon neurons fabricated on very-large-scale integrated (VLSI) circuits with complementary metal-oxide-semiconductor (CMOS) transistor technology allow neuronal spiking dynamics to be directly emulated on silicon chips with much better power and space efficiencies and computing speed than digital simulation. Iono-neuromorphic silicon neurons go even further in mimicking not only neuronal spiking dynamics at the network level but also ion channel and intracellular ionic dynamics at the cellular level. Such iono-neuromorphic silicon neuron networks offer a highly efficient computational platform that is particularly well-suited for multiscale biophysically-based neural computing in real time under stringent power and space/weight constraints, with potential applications in cognitive neuroprosthesis, brain–computer interface, and embedded machine intelligence devices. In this talk, I will discuss: 1) recent advances in iono-neuromorphic silicon neuron modeling of various complex neuronal dynamics including chaotic pacemaker bursting, single-neuron mnemonics with long-lasting persistent activity, and spike-rate-dependent/spike-timing-dependent plasticity with retrograde endocannabinoid signaling; 2) challenges facing large-scale iono-neuromorphic computation on CMOS silicon chips and other nanodevices; 3) recent advances in ultralow-power and three-dimensional CMOS technology that will empower the next generation of large-scale iono-neuromorphic silicon neuron networks and applications.

Noisy brain - Is noise benefit or disadvantage to computations with spikes?

Tomoki Fukai
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- In the absence of sensory stimulation, cortical networks are far from silent, but generates rich and ubiquitous forms of electrical activity that represent internal brain states. There has been much recent interest in the genesis and functional roles of such spontaneous activity or noise in the brain. In this talk, I will argue the possibility that cortical networks purposely generate internal noise for optimal spike-based communications between neurons. Our modeling is based on a recent experimental finding that cortical networks have both strong-sparse and weak-dense synaptic connections. The connectivity of complex networks, such as small-world topologies, has been attracting much interest and its functional implications are being studied in many physical, biological and social systems. However, the significance of the link weight distributions remains largely unknown. Our findings suggest that spike-based computations are efficient in "weighted" excitable networks.

Discovering how information is represented in visual and cognitive systems

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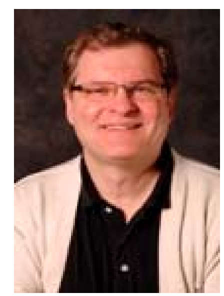
- Current estimates suggest that the human brain consists of several hundred distinct areas, each of which explicitly represents different aspects of sensory, cognitive and motor information. Although efforts to model peripheral stages of sensory processing have been successful, modeling aimed at more central cognitive systems has not yet proved fruitful. One tool that is useful for modeling higher brain areas is linearized regression. The purpose of linearized regression is to discover a feature space within which the stimulus-feature mapping is nonlinear, but the feature-response mapping is linear. Such models make it straightforward to conduct hypothesis testing, to fit models with limited data and to perform decoding. I will review our use of linearized regression to model neurons and non-neuronal metabolic signals in several different visual and cognitive brain areas.
- Jack Gallant is Professor of Psychology at the University of California at Berkeley, and is affiliated with the graduate programs in Bioengineering, Biophysics, Neuroscience and Vision Science.
- He received his Ph.D. from Yale University and did post-doctoral work at the California Institute of Technology and Washington University Medical School. His research program focuses on constructing quantitative computational models that accurately describe how the brain encodes information during natural tasks, and to use these models to decode information in the brain in order to reconstruct mental experiences. This computational framework can be used to understand and decode brain activity measured by different methods (e.g., functional MRI, NIRS, EEG or ECOG), and in different modalities (i.e., vision, audition, imagery and so on).



A Critical Assessment of Quantum Information Processing Capabilities of Neuronal Microtubules

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- Evidence for signaling, communication and conductivity in microtubules (MTs) has been shown through both direct and indirect means, and theoretical models predict their potential use in both classical and quantum information processing in neurons. The notion of quantum information processing within neurons has been implicated in the phenomena of consciousness, although controversies have arisen in regards to adverse physiological temperature effects on these capabilities. To investigate the possibility of quantum processes in relation to information processing in MTs, a biophysical MT model is presented based on the electrostatic interior of the tubulin protein. The interior is taken to constitute a double-well potential structure within which a mobile electron is considered capable of occupying at least two distinct quantum states. These excitonic states together with MT lattice vibrations determine the state space of individual tubulin dimers within the MT lattice. Tubulin dimers are taken as quantum well structures containing an electron that can exist in either its ground state, or first excited state. Following previous models involving the mechanisms of exciton energy propagation, we estimate the strength of exciton and phonon interactions, and their effect on the formation and dynamics of coherent exciton domains within MTs. Also, estimates of energy and time scales for excitons, phonons, their interactions and thermal effects are presented. Our conclusions provide physical limitations on the possibility of sufficiently long-lived coherent exciton/phonon structures existing at physiological temperatures in the absence of thermal isolation mechanisms. These results are discussed in comparison with previous models based on quantum effects in non-polar hydrophobic regions, which have yet to be disproven. We also discuss involvement of microtubules in molecular level memory formation.