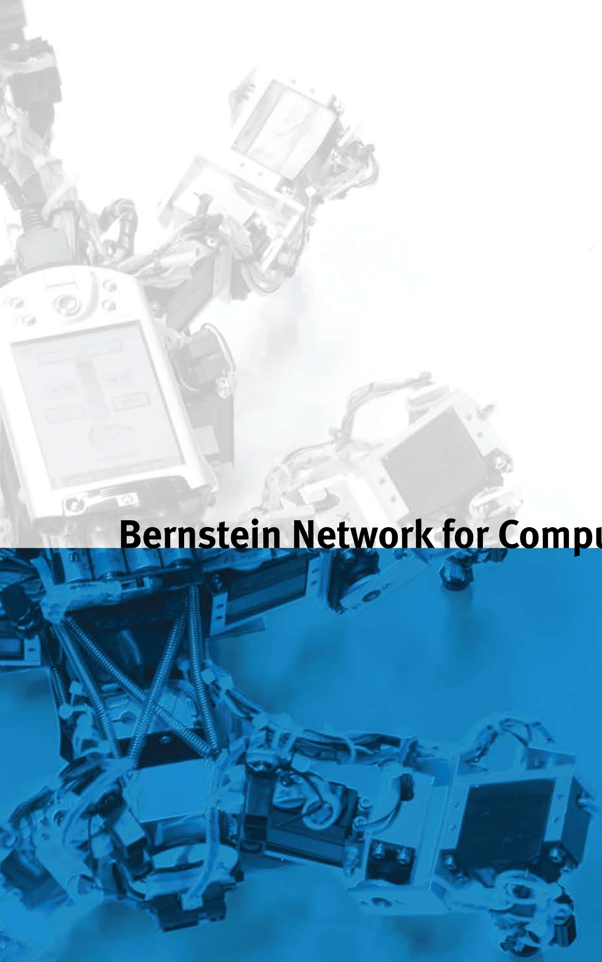
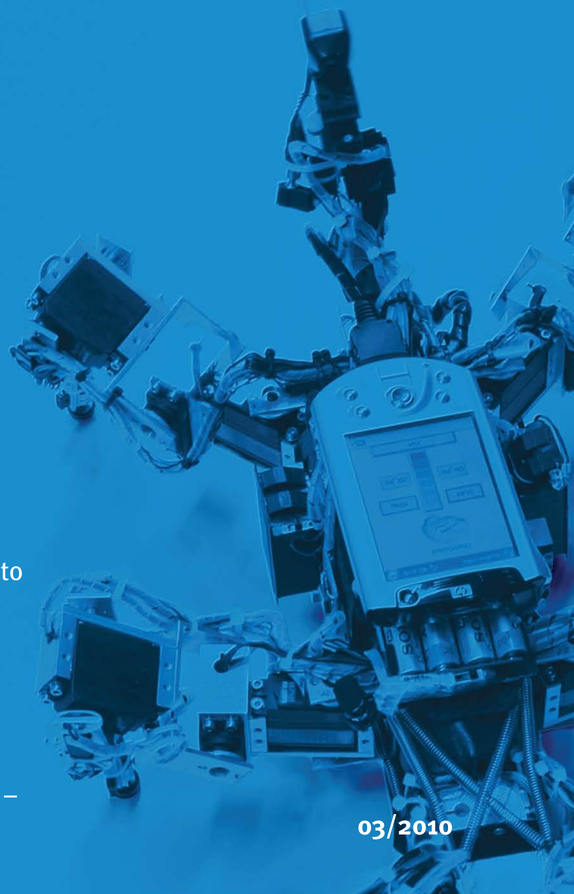


Bernstein Network for Computational Neuroscience

Bernstein Newsletter



Recent Publications
Robot with Chaos Control – How Neurons Calculate – Trunc Robot – Learning to Discriminate

Meet the Scientist
Tim Gollisch

News and Events
Leibniz Prizes – Personalia – German-Israeli Workshop – New CRC in Munich – Events for the Public – „Brains for Brains“ – Workshops and Meetings

03/2010

Organized chaos gets robots going

Even simple insects can generate quite different movement patterns with their six legs. The animal uses various gaits depending on whether it crawls uphill or downhill, slowly or fast. Scientists from Göttingen have now developed a walking robot, which – depending on the situation – can flexibly and autonomously switch between different gaits. The success of their solution lies in its simplicity: a small and simple network can create very diverse movement patterns. To this end, the robot uses a mechanism for "chaos control". The work was carried out by a team of scientists at the Bernstein Center for Computational Neuroscience Göttingen, the University of Göttingen and the Max Planck Institute for Dynamics and Self-Organization.

Robot frees itself from a hole

In humans and animals, periodically recurring movements like walking or breathing are controlled by small neural circuits called "central pattern generators" (CPG). Scientists have been using this principle in the development of walking machines. To date, typically one separate CPG was needed for every gait. The robot developed by the Göttingen scientists now manages the same task with only one CPG that generates entirely different gaits and which can switch between these gaits in a flexible manner. This CPG is a tiny network consisting of two circuit elements. The secret of its functioning lies in the so-called "chaos control". If uncontrolled, the CPG produces a chaotic activity pattern. This activity, however, can very easily be converted into periodic patterns that determine the gait. Different periodic patterns then generate different gaits.

The robot receives information about its environment via several sensors – about whether there is an obstacle in front of it or whether it climbs a slope. Based on this information, the CPG selects the gait that is appropriate for the respective situation. The connection between sensory properties and CPG can either be preprogrammed or learned by the robot from experience. The scientists use a key example to show how this works: the robot can autonomously learn to walk up a slope with as little energy input as possible. As soon as the robot reaches a slope, a sensor shows that the energy consumption is too high. Thereupon, the connection between the sensor and the control input of the CPG is varied until a gait is found that allows the robot to consume less energy. Once the right connections have been established, the robot has learned the relation between slope and gait. When it tries to climb the hill a second time, it will immediately adopt the appropriate gait.

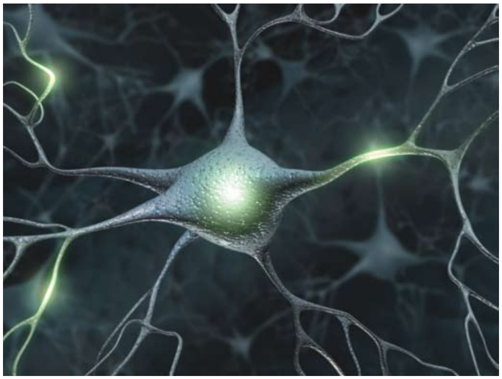
In the future, the robot will also be equipped with a memory device which will enable it to complete movements even after the sensory input ceases to exist. In order to walk over an obstacle, for instance, the robot would have to take a large step with each of its six legs. "Currently, the robot would hardly be capable of handling this task – as soon as the obstacle is out of sight, it no longer knows which gait to use," says Marc Timme, scientist at the Max Planck Institute for Dynamics and Self-Organization. "Once the robot is equipped with a motor memory, it will be capable to use foresight and plan its movements".

Steingrube, S., Timme, M., Wörgötter, F. and Manoonpong, P.
Nature Physics, 17 January 2010 (Online)

How neurons calculate

Nerve cells communicate via electrical signals – they send and receive so-called action potentials. Already in 1961, the future Nobel Prize Winner Eric Kandel discovered that neurons in the hippocampus of the brain produce not only action potentials, but also much smaller electrical signals – so called “spikelets”. Their function in the awake animal remained obscure for almost 50 years, since they could up to now only be measured in narcotized animals. Jérôme Epsztein, Albert K. Lee, Edith Chorev und Michael Brecht, scientists at the Bernstein Center for Computational Neuroscience and the Humboldt University Berlin, now show that spikelets are important for spatial memory and orientation and can trigger action potentials.

The hippocampus is important for memory formation and spatial orientation. Using a new technology, Brecht and his team have succeeded in measuring electrical signals from within single cells of the hippocampus while the animal was freely moving around in its cage. This technique has allowed a major breakthrough in understanding the role of spikelets in the brain during certain behaviors. So-called place cells in the hippocampus are active and generate action potentials whenever the animal walks through a defined area of a familiar surrounding. Brecht and his colleagues discovered that these place cells produce not only action potentials, but also spikelets. In addition, the scientists could show that there is a direct link between the generation of action potentials and spikelets: about 1/3 of the action potentials are triggered by spikelets.

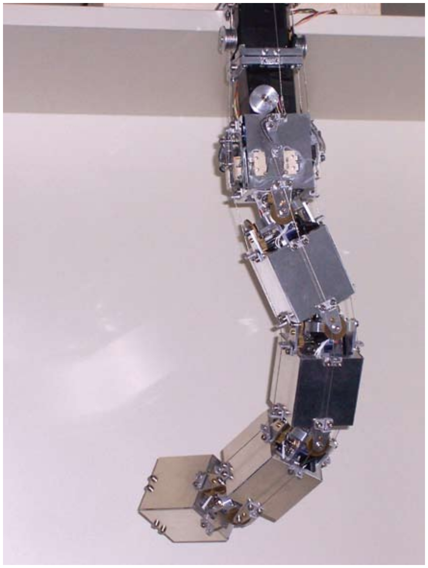


Through around 30.000 contacts, each neuron in the hippocampus receives information from other neurons. At these contact sites, the transmission of the electrical signal is interrupted and it is converted into a chemical one. Up until now, it was commonly accepted that neurons generally elicit action potentials only after receiving sufficient input from upstream cells via such chemical synapses. This picture has now been qualified by Brecht and his colleagues with their observation that action potentials can also be triggered by spikelets.

The origin of spikelets has not yet been unambiguously clarified. “It is assumed that they are generated by electrical coupling between cells,” says Brecht. A typical cell in the hippocampus not only has about 30 000 chemical synapses, but also a small number of electrical synapses. Through these synapses the cells are “electrically coupled”: the electrical signal can be conveyed directly, without chemical transmitters. In the receiving cell, it can then be measured as a spikelet. “To date, these contacts have not received sufficient attention, as they are so rare. Our data, however, point to the assumption that electrical couplings specifically connect cells with similar functions in spatial memory and that they are thus presumably far more important than previously assumed,” Brecht explains.

Epsztein, J., Lee, A.K., Chorev, E. & Brecht, M. Science, 327 (5964), 474 (Jan 2010)

Trunk robot adds a splash of color



© F. Wörgötter

While a human being cannot reach behind himself without twisting his shoulder, an elephant trunk can carry out almost every conceivable movement. Therefore, trunks serve as an interesting model in robotics – a trunk robot could be extremely flexible in its applications. Nevertheless, there are currently hardly any trunk robots available on the market, because their strength is also their weakness. Due to the great number of degrees-of-freedom and joints, it is extremely difficult and energy-consuming to control the motions of a trunk robot. Florentin Wörgötter and Kejun Ning from the Bernstein Center for Computational Neuroscience and the University of Göttingen have now developed a trunk robot that can solve these problems. The robot is able to perform complex movements. This is shown by its ability to paint Chinese characters with great precision.

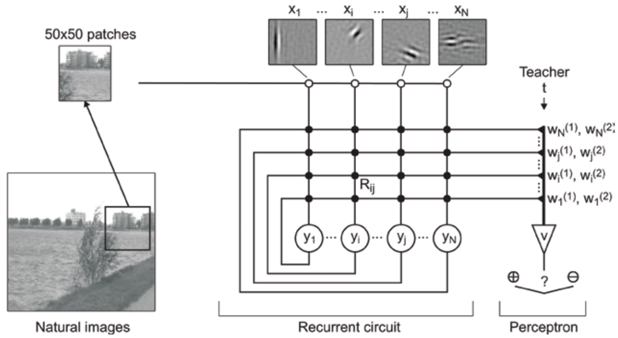
The great number of joints poses a special problem when constructing trunk robots. Gravity pulls at each joint – it must carry the trunk's own weight plus the weight of the object to be handled. An enormous energy input is required to counteract gravity and to move the trunk or even just to hold it in the same position. In the case of their trunk robot, the Göttingen scientists solved this problem in an elegant way. When the robot holds its position, its joints are blocked, thus not consuming any energy. During each movement, the joints are released one at a time, just for the short time that is needed to bring them into the right angle. The joints are controlled by four fine wires that run along the edges of the trunk. The wires' tractive force is regulated via small motors attached to the trunk body. By controlling the force exerted on the wires and the sequence of the joints' release, almost any movement can be achieved with a minimum of energy consumption.

Domesticated elephants trained by the charity organization "The Asian Elephant Art & Conservation Project" can use their trunk to draw flowers, patterns and even themselves. These incredible skills inspired the scientists to make their robot paint as well. Its repertoire is currently still limited to pre-programmed movements – it paints Chinese characters. A computer program calculates the energetically most favorable sequence of wire traction and joint release to obtain a desired trajectory. "Elephants learn by themselves– by copying," says Wörgötter. "The next goal of our research will be to provide the trunk robot with the capability to learn, so that it will be able to autonomously find optimal solutions for certain tasks by trial and error." The realization of learning processes in computer-based systems is one of the objectives of Florentin Wörgötter's research group. For this purpose, insights from brain research about the principles of learning are included into mathematical algorithms that control the robot. In this way, it will learn to accomplish complex movements all by itself.

Source / Quelle: Ning, K. & Wörgötter, F. IEEE Transactions on Robotics 25(6), 1237-1248 (Dec 2009)

Videos:
The painting trunc robot
„The Asian Elephant Art & Conservation Project"

Learning to discriminate



Schematic representation of the model. The image is seperated into subcomponents, which are then analyzed in a recurrent network. The readout neuron (at the right) classifies the image into two categories (+ or -)

Not everyone can tune a piano: First, you have to learn to discern even slight differences in pitch. And also the visual system is able to learn: We learn to distinguish between different lengths of lines, angles or shades – that is what scientists call “discrimination learning”. During each learning process, the synapses – the contact points between nerve cells in the brain – change. Using a computer model, scientists around Christian Leibold, Bernstein Center for Computational Neuroscience and Ludwig Maximilians University of Munich, examined which changes in the synapses can be of the greatest advantage for discrimination learning. The computer model learns to classify image data; it is based on a biologically plausible model of synaptic short-term memory. It provides an explanation of how a neural network with a limited number of neurons can learn to classify a large quantity of image data.

The computer model analyzes image data in three steps. First, the image data are separated into a number of subcomponents, each of which activates certain groups of nerve cells. In a second step, these cell groups exchange information. This step serves the so-called decorrelation: The neural representation of the image data is modified in such a way that, before and after decorrelation, a neuron represents aspects of the image stimulus that are as diverse as possible. Finally, in a third step, the data are read out by a neuron. This “readout” neuron learns to categorize the received data. As in biology, the readout neuron in the model learns through changes in the synaptic parameters. If the category was determined correctly, the synapses remain unchanged. But if errors occur, the synaptic weights are adjusted.

Synaptic learning is not completely trivial, though, because the same synapses send data at several consecutive time points to the readout neuron – once before and once after decorrelation. The network can only achieve optimal learning if the properties of the individual synapses can be changed at both points of time as independently of each other as possible.

Upon each signal transmission, the molecular and physical properties of the synapses change. Some of the changes persist over a longer time, others are short-lived. Some of the short-term changes lead to a better transmission of subsequent signals, while others have the opposite effect. Thus – metaphorically speaking – during the learning process, different adjusting screws of the synapse are turned. The remarkable fact about the model developed by the scientists around Leibold is that exactly this is taken into account: Both long-term as well as short-term synaptic changes are considered. Only by this feature it is possible to adjust the conditions of a single synapse at different successive time points of signal transmission as independently of each other as possible. The effect of this new degree of freedom – as the scientists show – is a considerably improved discrimination learning.

Leibold C, Bendels MH. Neural Comput. 21(12):3408-28. (Dec 2009)

Tim Gollisch

The code of the retina

Seeing is a dynamic and fast process. With quick eye movements – several per second – we continuously scan our environment. Within a few milliseconds, the eye must capture an image. "In everyday life, we are not aware of the complex processes going on in our brain in order for us to see," says Tim Gollisch, scientist at the Munich Bernstein Center for Computational Neuroscience and since 2007 head of an independent research group at the Max Planck Institute for Neurobiology in Martinsried. Every light signal that reaches the retina must be converted into neural signals, which can be processed and interpreted by the brain. Which code is used by the retina for this conversion of image information? And what are the underlying neuronal circuits? These questions are addressed by Tim Gollisch. For his work, he was honored with the Bernard Katz Lecture Award in 2009.

Gollisch studied physics in Heidelberg. "Right from the beginning of my studies, I had this idea of someday using physical methods for working in biology," Gollisch reveals. Even if this idea had temporarily waned, Gollisch came back to it at the end of his studies – also inspired by a seminar given by Andreas Herz in Berlin. In this seminar, he realized that the knowledge of a physicist can make a major contribution to solving biological problems – especially in neuroscience. Thus, Gollisch had not only found his field of research, but also the adequate laboratory for his doctoral thesis – he later obtained his doctorate under the supervision of Andreas Herz. After that, he worked as a postdoc in the laboratory of Markus Meister at the Harvard University in Boston, USA.

Already during his postdoc period, Gollisch investigated the function of the retina and discovered a central mechanism that explains the enormous speed of neural coding in the retina. Gollisch showed that some ganglion cells in the retina, nerve cells that transmit the signal of the retina to the brain, use a neural code that is exceptionally quick. Each ganglion cell processes a certain section of an image. "We found that certain ganglion cells react to every change in light conditions in the respective image section, no matter whether it gets darker or lighter. The exact onset time of their reaction, however, differs depending on the content of the image section," says Gollisch. If the image section gets darker, the cells react within 60 milliseconds. If the new image in this section also contains lighter components, they react a little more slowly. The rough outlines of a new image – which reaches the retina after an eye movement, for example – can be captured very quickly by comparing these latency times.

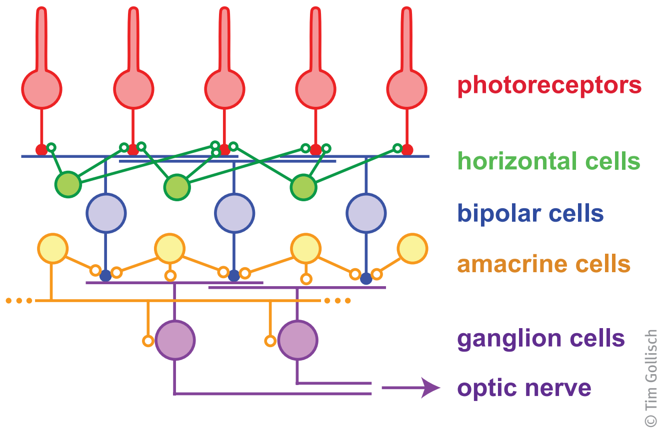
In his group at the Max Planck Institute, Gollisch uses a special technique to examine the neural function of the retina. "I combine a method we developed during my doctorate in the lab of Andreas Herz with the system I worked on as a postdoc," says Gollisch. When scientists investigate the relation between sensory stimuli and neural response, they have to go through endless repetitions of presenting a sensory stimulus to nerve cells and measuring their respective responses. How the stimulus changes from trial to trial depends on the exact question addressed by the experiment. In collaboration with Jan Benda and Christian Machens in the group of Andreas Herz, then in Berlin, Gollisch automated this procedure. Based on the measurements of neural activity, the sensory stimulus is automatically varied and adapted for the next measurement. At the time, Gollisch used this technology to investigate how grasshoppers react to acoustic signals. Now, the same procedure serves to examine the retina.

In one of his research approaches, Gollisch uses this tech-nology to determine which visual stimuli trigger the same response in a neuron. “We look at ganglion cells that process an image section consisting of two different parts – e.g. dark on the right and light on the left side,” Gollisch explains. He examines how the neuron integrates the right and the left part. Does it plainly sum up the inputs of both halves, such that a darker right part can compensate for a lighter left one? “It’s not as simple as that,” says Gollisch. “Astonishingly, the cells we currently examine are particularly active when the image is as homogeneous as possible – i.e. when the parts of the right and left side are similar. Thus, cells react better when they receive relatively weak signals from all upstream cells, and they are less active when they receive strong signals from some cells and no signals from others.” Gollisch is now interested in understanding the synaptic properties on which this functioning of the cells is based. Also in other experiments, Gollisch starts from a mathematical question (how does a nerve cell compute its input signals?) in order to finally learn something about the biology of the retina, its circuit structures and synaptic properties.

Gollisch not only examines the properties and computations of single cells in the retina, but also how cell groups are coordinated and adjusted to one another. When it is dark and the retina does not receive any visual information, the ganglion cells show a spontaneous activity – a certain background noise. Upon closer examinations of this background noise, scientists noticed that neighboring cells often send out signals simultaneously – they are synchronized. This leads to the conclusion that the cells in the retina adjust their activities to one another. “We want to examine this phenomenon more closely,” says Gollisch. “We would like to know which neural circuits it is based on and what this coordination of cells means for image processing.”

The correlations between neighboring cells seem to be especially relevant for vision when the light conditions are bad and the image is low in contrast. In a way, correlations thus serve to sharpen images. If contrasts are low, noise predominates in the nerve cells’ responses – they react imprecisely, sometimes a little earlier and sometimes slightly later. “We found out that the coordination between cells keeps this imprecision in the cells’ responses relatively low. If one cell responds a little earlier, it can be observed that neighboring cells do the same,” says Gollisch. Thus, coordinated cell behavior counteracts the noise.

“What is fascinating about working on the retina is that it is an ideal system to investigate how a large number of neurons act together in order to convert a visual signal into a neural one,” says Gollisch. The system is ideally suited to analyze which biological properties and neural circuits underlie the reaction of the cells and how an entire neural network produces a code that converts image properties into neural signals.



Schematic respresentation of the structure of the retina

Leibniz Prize for three scientists of the Bernstein Network

Jan Born Ulmann Lindenberger Stefan Treue

On December 3, 2009, the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG) announced the awardees of the “Förderpreis im Gottfried Wilhelm Leibniz-Programm” (Leibniz Prize) 2010. Among the ten selected Leibniz awardees, three are members of the Bernstein Network. The most renowned German research award is since 1986 annually awarded by the DFG for excellence in research and is endowed with up to 2.5 Mio. Euros.

Jan Born, director of the Department of Neuroendocrinology at the Universität zu Lübeck, receives the Leibniz Prize for his work in the field of memory formation during sleep. He could demonstrate that there is a causal relation between sleep and learning. Furthermore, Born investigates the influence of sleep on the metabolic and the immunologic memory.

Jan Born completed his diploma studies in experimental psychology and his doctoral studies in Tübingen. Afterwards, he habilitated in physiology in Ulm and since 2002 is professor at the Universität zu Lübeck. Jan Born is principal investigator within the joint research project “State Dependencies of Learning” of the funding measure “Bernstein Focus: Neuronal Basis of Learning”.

Ulman Lindenberger, Director of the Center for Lifespan Psychology at the Max Planck Institute for Human Development Berlin, is awarded for his research on the aging of mind and brain. In his work, he combines approaches from cognitive aging, developmental psychology, and behavioural neuroscience. He investigated how cognitive and sensorimotor abilities co-evolve across the human lifespan and how older adults can influence the course of cognitive aging through their behaviour.

Lindenberger received his doctorate and habilitation in psychology at the Free University Berlin. Afterwards, he was professor in Saarbrücken before joining the Max Planck Institute for Human Development in Berlin. Lindenberger participates in the joint research project “Complex Human Learning” of the funding measure “Bernstein Focus: Neuronal Basis of Learning”.

Stefan Treue, director of the German Primate Center receives the award for his studies in the field of attention. He could show how attention influences the processing of visual stimuli. For a long time it was believed that attention influences the process of vision only in higher brain regions – like a filter that allows only relevant information to enter consciousness. Treue, however, demonstrated that attention already influences the early steps of cortical image processing and the corresponding neuronal activity.

Treue received his PhD in neuroscience from M.I.T. and habilitated in animal physiology at the University Tübingen. Since 2001, he is director of the German Primate Center Göttingen and head of the Cognitive Neuroscience Laboratory. Treue is a member of the Bernstein Center Göttingen as well as the Bernstein Focus: Neurotechnology Göttingen.

Sources:
Jan Born: http://www.mu-luebeck.de/aktuelles/pressemitteilungen/2010/1203born.php
Ulmann Lindenberger: http://idw-online.de/de/news347510
Stefan Treue: http://idw-online.de/pages/de/news347664

Personalia

Tim Gollisch (BCCN Munich) was honored for his outstanding achievements in the field of visual coding with the Bernard Katz Lecture at last year's meeting of the "Israel Society for Neuroscience".

Henning Sprekeler received the Humboldt Award 2009 of the Humboldt-University zu Berlin for his dissertation: "Slowness Learning: Mathematical Approaches and Synaptic Mechanisms", performed in the lab of Laurenz Wiskott (BCCN Berlin).

Babette Dellen, Bernstein Fellow of the BCCN Göttingen in the lab of Florentin Wörgötter, received a "Ramon y Cajal" fellowship of the Spanish Ministry of Science and Innovation. Starting from February 1, 2010, the fellowship enables her to continue her research at the Institut de Robòtica i informàtica Industrial (CSIP-UPC) in Barcelona, Spain.

Christoph Kolodziejski, PhD student in the group of Florentin Wörgötter (BCCN Göttingen), was honored for his dissertation: „Mathematical Description of Differential Hebbian Plasticity and its Relation to Reinforcement Learning" with the 2009 Berliner-Ungewitter-Foundation Award.

German-Israeli workshop on vision

Within the framework of the German-Israeli Year of Science and Technology 2008, which was launched on the initiative of the Federal Minister of Education and Research, Dr. Annette Schavan, and the Israeli Minister of Science, Culture and Sports, Galeb Majadle, the Bernstein Group Bremen organized a visit to the group of Misha Tsodyks at the Weizmann-Institute, Rehovot, Israel. During the visit in September 2009 they held a joint workshop entitled: "Visions of visual cortical functions". Current research projects of the German and Israeli groups were presented and discussed. The visit was supported by the Federal Ministry of Education and Research (BMBF) and the Minerva Foundation.

New CRC in Munich

In January 2010, the new Collaborative Research Center (CRC) "Assembly and Function of Neuronal Circuits in Sensory Processing" started at the Ludwig-Maximilians-University (LMU) Munich. Spokesman is Benedikt Grothe (Munich Center for Neurosciences – Brain and Mind, BCCN Munich).

Due to rapid technological progress, molecular and cellular mechanisms underlying the processes in our brain have become more and more accessible to scientific analyses. Concurrently, the activity of our brain "as a whole" can be observed in great detail. Improved imaging methods reveal the activation patterns in the brain: which areas are active during specific activities? "What is still missing is an understanding of how processes on the molecular-cellular scale translate into macroscopic activity and function", Grothe says. The new CRC bridges this gap by analyzing specific neuronal circuits at intermediate stages of sensory processing. Apart from the LMU, the TU Munich, the MPI of Neurobiology Munich and the Helmholtz Center Munich contribute to the CRC.

Source: http://idw-online.de/pages/de/news345796 (in German)

"Brains for Brains" Award

The Bernstein Computational Neuroscience Association for the first time announced the international "Brains for Brains" Junior Researchers' Award. It is targeted at students who plan to pursue a research career in Computational Neuroscience and who have at least one scientific publication that resulted from predoctoral studies. The award contains 500 € prize money and a travel grant for a one-week trip to Germany, incl. a talk at the Award Ceremony and an individually planned visit to up to three German research institutions in Computational Neuroscience. Application deadline is May 31, 2010. (www.nncn.de/brains4brains).

Events for the general public

The Bernstein Network this year organizes two events that are targeted at the general public. At the event "Entscheidung wider die Vernunft?" ("Making decisions against all reason?"), Armin Falk (Experimental Economics Laboratory, University of Bonn) and Hauke Heekeren (BFNL Complex human Learning, Free University Berlin) will adress questions about decision making from the perspective of economics as well as neurosciences. (Urania, Berlin; March 17, 2010, 7:30 pm, the event will be held in German).

The scientific session "How much can robots learn?" will take place at this year's ESOF (Euroscience Open Forum) in Torino. Florentin Wörgötter (Universität Göttingen) und Edgar Körner (Honda Research Institute Europe Offenbach/Main) from the Bernstein Network together with Giulio Sandini of the Italian Institute of Technology will provide insight into the field of modern robotics. The ESOF is an international and multidisciplinary conference with the aim of presenting European research to a broader pubic. (Torino, Italy, July 2-7, 2010, www.esof2010.org).

Upcoming Events

Termin / Date	Titel / Title	Organizers / Organisation	URL
March 9, Frankfurt/M	42nd Heidelberg Forum for Image Processing	AEON Verlag & Studio Walter H. Dorn e.K. with support of J. Triesch (BFNT Frankfurt)	http://www.bv-forum.de/
May 7-8, Göttingen	Symposium: Calcium Signals in Sensory Processing	Thomas Frank, Martin Göpfert (BCOL Information Code), Tobias Moser (BCCN and BFNT Göttingen)	http://www.sensory-calcium-signaling.uni-goettingen.de
June 29-July 2, Reutlingen	7th International Meeting on Substrate-Integrated Micro Electrode Arrays	NMI Reutlingen (BFNT Freiburg/Tübingen), BCCN Freiburg, BIOPRO Baden-Württemberg GmbH	http://www.nmi.de/meameeting2010/
July 3-7, Amsterdam, The Netherlands	Bernstein Network Booth (#634) at FENS	7th FENS Forum of European Neuroscience	http://www.nncn.de/termine-en/fens2010/
August 2-27, Freiburg	15th Advanced Course in Computational Neuroscience	J. Rinzel, P. Latham, Y. Prut, C. van Vreeswijk / F. Dancoisne and G. Grah (BCCN Freiburg, Admin. Directors)	http://neuroinf.org/courses/EUCOURSE/F10/index.shtml
August 30 -September 1, Kobe, Japan	3rd INCF Congress of Neuroinformatics	Shiro Usui (RIKEN, Japan)	http://neuroinformatics2010.org/
October 10-15, Freiburg	BCCN/NWG Course: Analysis and Models in Neurophysiology	S. Rotter, S. Gruen, U. Egert, A. Aertsen / J. Kirsch (BCCN Freiburg / BFNT Freiburg/Tübingen)	http://www.bcf.uni-freiburg.de/events/conferences/101010-nwgcourse

The Bernstein Network

Bernstein Centers for Computational Neuroscience (BCCN)
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Freiburg – Coordinator: Prof. Dr. Ad Aertsen
Göttingen – Coordinator: Prof. Dr. Theo Geisel
Munich – Coordinator: Prof. Dr. Andreas Herz

Bernstein Focus: Neurotechnology (BFNT)
Berlin – Coordinator: Prof. Dr. Klaus-Robert Müller
Frankfurt – Coordinators: Prof. Dr. Christoph von der Malsburg, Prof. Dr. Jochen Triesch, Prof. Dr. Rudolf Mester
Freiburg/Tübingen – Coordinator: Prof. Dr. Ulrich Egert
Göttingen – Coordinator: Prof. Dr. Florentin Wörgötter

Bernstein Focus: Neuronal Basis of Learning
Visual Learning – Coordinator: Prof. Dr. Siegrid Löwel
Plasticity of Neural Dynamics – Coordinator: Prof. Dr. Christian Leibold
Memory in Decision Making – Coordinator: Prof. Dr. Dorothea Eisenhardt
Sequence Learning – Coordinator: Prof. Dr. Onur Güntürkün
Ephemeral Memory – Coordinator: Dr. Hiromu Tanimoto
Complex Human Learning – Coordinator: Prof. Dr. Christian Büchel
State Dependencies of Learning – Coordinators: PD Dr. Petra Ritter, Prof. Dr. Richard Kempter
Learning Behavioral Models – Coordinator: Dr. Ioannis Iossifidis

Bernstein Groups for Computational Neuroscience (BGCN)
Bochum – Coordinator: Prof. Dr. Gregor Schöner
Bremen – Coordinator: Prof. Dr. Klaus Pawelzik
Heidelberg – Coordinator: Prof. Dr. Gabriel Wittum
Jena – Coordinator: Prof. Dr. Herbert Witte
Magdeburg – Coordinator: Prof. Dr. Jochen Braun

Bernstein Collaborations for Computational Neuroscience (BCOL)
Berlin-Tübingen, Berlin-Erlangen-Nürnberg-Magdeburg, Berlin-Gießen-Tübingen, Berlin-Constance, Berlin-Aachen, Freiburg-Rostock, Freiburg-Tübingen, Göttingen-Jena-Bochum, Göttingen-Kassel-Ilmenau, Munich-Göttingen, Munich-Heidelberg

Bernstein Award for Computational Neuroscience (BPCN)
Dr. Matthias Bethge (Tübingen), Dr. Jan Benda (Munich), Dr. Susanne Schreiber (Berlin), Dr. Jan Gläscher (Hamburg)

Project Committee
Chairman of the Bernstein Project Committee: Prof. Dr. Andreas Herz
Deputy Chairman of the Project Committee: Prof. Dr. Theo Geisel

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Title Image: The hexapod robot AMOS-WD06. © modified after Network Dynamics Group, MPI ds (see article page 2).

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