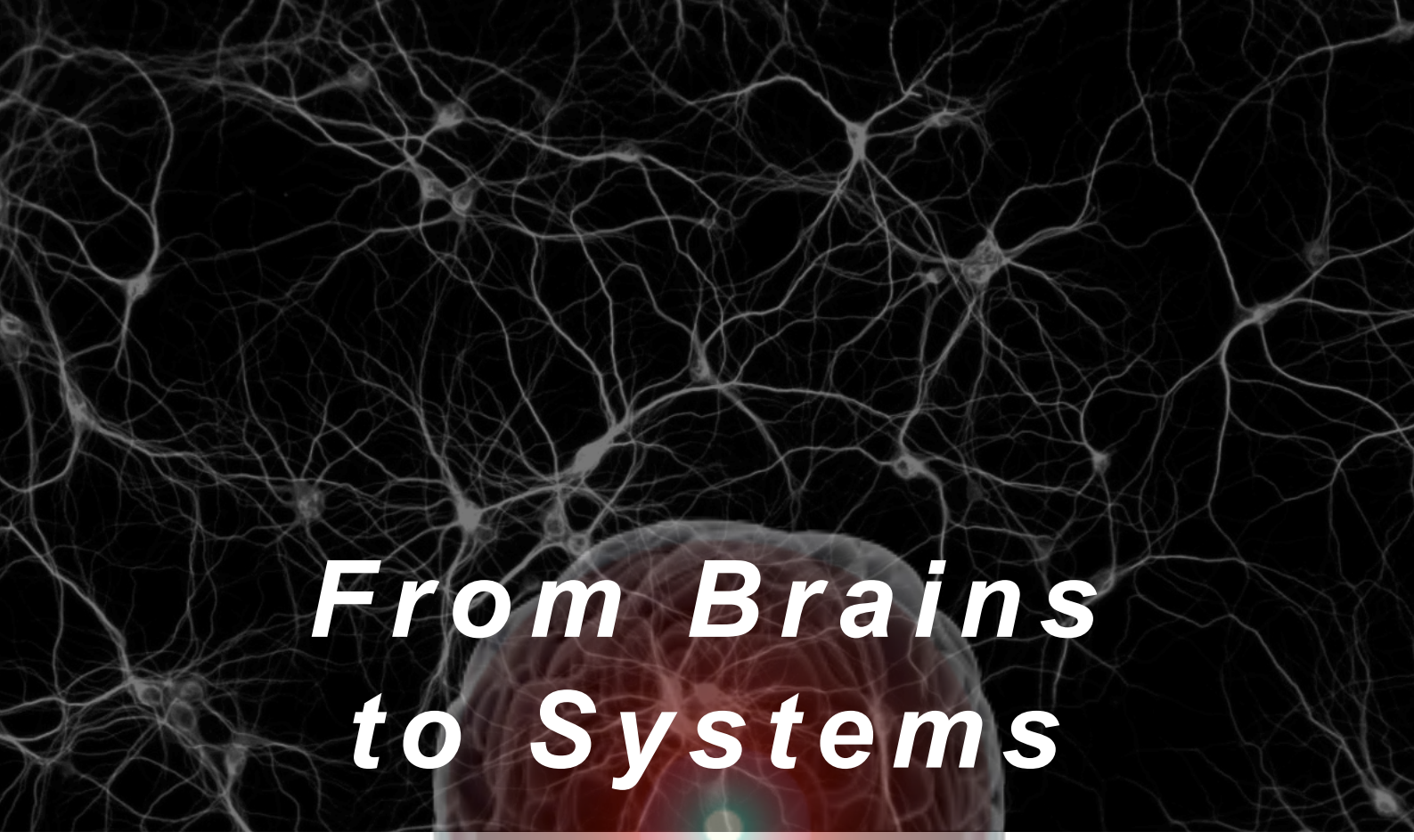

From Brains to Systems

Preprints of the BICS 2010 Conference on Brain-Inspired Cognitive Systems

14-16 July 2010, Madrid

www.bicsconference.org

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Editors:
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ICSC interdisiplinary research

Universidad Politécnica de Madrid

aslab

Autonomous Systems Laboratory

From Brains to Systems
Preprints of the
BICS 2010 Conference on Brain-Inspired Cognitive Systems
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Book of abstracts

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Summary

Motivation

Brain Inspired Cognitive Systems - BICS 2010 aims to bring together leading scientists and engineers who use analytic and synthetic methods both to understand the astonishing processing properties of biological systems and, specifically of the brain, and to exploit such knowledge to advance engineering methods to build artificial systems with higher levels of cognitive competence.

So, BICS is a meeting point of brain scientists and cognitive systems engineers where cross-domain ideas are fostered in the hope of getting emerging insights on the nature, operation and extractable capabilities of brains. This multiple approach is necessary because the progressively more accurate data about the brain, is producing a growing need of a quantitative understanding and an associated capacity to manipulate this data and translate it into engineering applications rooted in sound theories.

BICS 2010 is intended for both researchers that aim to build brain inspired systems with higher cognitive competences, and as well to life scientists who use and develop mathematical and engineering approaches for a better understanding of complex biological systems like the brain.

Four major interlaced focal symposia are planned for this conference and these are organized into patterns that encourage cross-fertilization across the symposia topics. This emphasizes the role of BICS as a major meeting point for researchers and practitioners in the areas of biological and artificial cognitive systems. Debates across disciplines will enrich researchers with complementary perspectives from diverse scientific fields.

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BICS 2010 Program

TIME	JULY 14th	JULY 15th	JULY 16th
8:30-9:00	REGISTER BICS	REGISTER BICS	REGISTER BICS
9:15-10:00	**KEYNOTE PLENARY**	**KEYNOTE PLENARY David Gamez**	**KEYNOTE PLENARY Andree Ehresmann**
10:05:10:30	COFFE	COFFE	COFFE
10:30:11:00	Supervised Architectures for Internal Simulation of Perceptions and Actions *Magnus Johnsson*	Informational Theories of Consciousness: A Review and Extension *Igor Aleksander*	Mental Causation In a Physical Brain? *Igor Farkas*
11:00-11:30	The role of feedback in a hierarchical model of object perception *Salvador Dura-Bernal*	STDP Pattern Onset Learning Depends on Background Activity *James Humble*	Correlation between Eye Movements and Mouth Movements to Detect Driver Cognitive Distraction *Afizan Azman*
11:30-12:00	Adaptive perception-action-based cognitive modelling of human driving behavior using control, gaze and signal inputs *Affan Shaukat*	A sparse implementation of dynamic competition in continuous neural fields *Jean-Charles Quinton*	Self-Conscious Robotic System Design Process - from Analysis to Implementation *Antonio Chella - Valeria Seidita*
12:00-12:30	The emergence of feature sensitivity in a recurrent model of auditory cortex with spike timing dependant plasticity *Martin Coath*	Emergence of small-world structure in networks of spiking neurons through STDP learning *Gleb Basalyga*	Machine free will: is free will a necessary ingredient of machine consciousness? *Antonio Chella Riccardo Manzotti*
12:30-13:00	A psychological and neurophysiological plausible model for emulating human behavior in decision making tasks *Ángel Iglesias*	Hippocampal Categories: a mathematical foundation for navigation and memory *Jaime Gómez*	Machine Consciousness: A Computational Model *Janusz Starzyk*
13:00-13:55	LUNCH	LUNCH	LUNCH
14:00-14:30	Autonomy, Intelligence and Animat Mesmerization *Ricardo Sanz*	Oscillatory Neural Network for Image Segmentation with Biased Competition for Attention *Tapani Raiko*	Towards the Generation of Visual Qualia in Artificial Cognitive Architectures *Raul Arrabales*
14:30-15:00	A Generic Framework for the Analysis of Emotion Mechanisms in Autonomous Agents *Timothy Rumbell*	Aiding conceptual development by grounding spoken words: an infant inspired model *Aneesh Chauhan*	Crude, Cheesy, Second-Rate Consciousness *Joanna J. Bryson*
15:00-15:30	Learning Saliency. An ICA based model using Bernoulli mixtures *Andrea Carbone*	A bio-inspired neural model to discriminate visual sequences *Mauricio Cerda*	A computational modelling approach to investigate alpha rhythm slowing associated with Alzheimer's Disease *Basabdatta Bhattacharya*
15:30-16:00	Dense crowd analysis through bottom-up and top-down attention *Matei Mancas*	Reverse engineering biological brains. Exploring Brain-inspired Neural Models within Cognitive Robotics *Guadalupe Sánchez*	The Way We Get Bio-Inspired: A Critical Analysis *Andreas Schierwagen*
16:00-16:30	BREAK	BREAK	BREAK
16:30-17:00	Fuzzy-4D/RCS for Unmanned Aerial Vehicles *Miguel A. Olivares-Mendez*	The Ouroboros Model, Selected Facets *Knud Thomsen*	Distributed Functional Architectures *Marmaduke Woodman*
17:00-17:30	The effects of working memory load on negative priming in an n-back task *Ewald Neumann*	Self-organization of neural maps using a modulated BCM rule within a multimodal architecture *Mathieu Lefort*	Assessment of Text Essay Quality by a Computational Model of Memory *J. Ignacio Serrano*
17:30-18:00	NEMO: Need-inspired Emotional Expressions within a Task-independent Framework *Syaheerah L. Lutfi*	Evolutionary Path to Biological Kernel Machines *Magnus Jändel*	FINAL Panel Discussion
18:00-18:30	Dynamical System Approach in Modeling Addiction *Selin Metin*	OOP: Object-Oriented-Priority for Motion Saliency Maps *Anna Belardinelli*	
18:00-18:30	Panel Discussion Day		
21:30		**DINNER**	

Symposia

- BIS
- CNS
- NC
- MoC

Keynote Speakers

David Gamez

Dr. Gamez is at Imperial College, London and he is currently working on new techniques for analyzing neural networks for information integration. He is PhD at the Department of Computing and Electronic Systems, University of Essex and BA at Trinity College, University of Cambridge. Dr. Gamez is the author of two books: What We Can Never Know and What Philosophy Is. The former explores the limits of philosophy and science through studies of perception, time, madness and knowledge and the second is a collection of essays on the nature of philosophy and other topics.

Andrée Ehresmann

Andrée Ehresmann is Emeritus Professor at the "Université de Picardie Jules Verne", and Director of the international Journal "Cahiers de Topologie et Géométrie Différentielle Catégoriques". In 50 years of mathematical research she has published about a hundred papers on Functional Analysis and Category theory and edited and commented the 7 volumes of "Charles Ehresmann: Oeuvres complètes et commentées". Since 25 years she has developed with J.- P. Vanbremeersch the theory of Memory Evolutive Systems.

Sixth International ICSC Symposium on

Neural Computation

(NC'2010)

A sparse implementation of dynamic competition in continuous neural fields

Jean-Charles Quinton and Bernard Girau

Abstract

This paper introduces a sparse implementation of the Continuum Neural Field Theory, promoting a trade-off in accuracy for higher computational efficiency and alleviated constraints on the underlying model. The sparse version reproduces the main properties of previous discrete 2D implementations, such as dynamic com- petition leading to localized focus activity or robustness to noise and distracters, with a much higher computational speed on standard computer architectures.

STDP Pattern Onset Learning Depends on Background Activity

James Humble, Steve Furber, Sue Denham and Thomas Wennekers

Abstract

Spike-timing dependent plasticity is a learning mechanism used extensively within neural modelling. The learning rule has been shown to allow a neuron to find the beginning of a repeated spatio-temporal pattern among its afferents. In this study we adduce that such learning is dependent on background activity, and is unstable when in a noisy framework. We also present insights into the neuron's encoding.

Informational Theories of Consciousness: A Review and Extension

Igor Aleksander and David Gamez

Abstract

In recent years a number of people have suggested that there is a close link between conscious experience and the differentiation and integration of in- formation in certain areas of the brain. The balance between differentiation and integration is often called information integration, and a number of algorithms for measuring it have been put forward, which can be used to make predictions about consciousness and to understand the relationships between neurons in a network. One of the key problems with the current information integration measures is that they take a lot of computer processing power, which limits their application to networks of around a dozen neurons. There are also more general issues about whether the current algorithms accurately reflect the consciousness associated with a system. This paper addresses these issues by exploring a new automata- based algorithm for the calculation of information integration. To benchmark different approaches we have implemented the Balduzzi and Tononi algorithm as a plugin to the SpikeStream neural simulator, which is used in this paper to carry out some preliminary comparisons of the liveliness and Φ measures on a simple four neuron network.

Emergence of small-world structure in networks of spiking neurons through STDP learning

Gleb Basalyga, Pablo M. Gleiser and Thomas Wennekers

Abstract

In this paper, we use the complex network approach to investigate how a neural network structure changes under spike-timing-dependent plasticity (STDP). We numerically demonstrate that, under certain conditions, a nontrivial small-wold like structure can emerge from a random initial network subject to STDP learning.

An Integrated Model of a Bio-inspired Rat Brain with Design Patterns

Pierre Philippe

Abstract

Robot controller are often specially developed for a task, for some specific behaviour or for biologically inspired machines. There is a need for interface to facilitate the integration between different models. In this paper we propose a generic bio-inspired framework in UML, adaptable, reusable and extendable. From the challenge to integrate different models in one whole architecture for the ICEA project, we have developed an original base using design patterns in respect to neuroscience. Firstly, an UML class diagram which includes a Cortical Hierarchy and a GasNet is described. Secondly, an extended diagram combining an evolved version of the previous model, a Microbial Fuel Cell module and design patterns is proposed. The result is a flexible robot control system.

Hippocampal Categories: a mathematical foundation for navigation and memory

Jaime Gómez and Ricardo Sanz

Abstract

It goes without saying that in science, experiments are essential; hypothesis need to be contrasted against empirical results, in order to build scientific theories. In a system of overwhelming complexity like the brain, it is very likely that hidden variables, unknown by the experimentalist are interacting with those few elements of which the values are expected and can be validated or rejected in the laboratory. Thus, at the end of the day, the experimentalist is refuting or validating models that are somehow prisoner of the lack of knowledge about the structure of the system.

The global picture is missing, the key is to reveal the structure which must be found not in the objects, but in the relationships between the objects-morphisms. How components at the same level interact (objects in the category of neurons) and how superior levels constrain those levels below and emerge from those above is tackled here with a mathematical outlook.

The mathematical theory of categories is proposed as a valid foundational framework for modeling in brain sciences.

Fifth International ICSC Symposium on

Biologically Inspired Systems

(BIS 2010)

Supervised Architectures for Internal Simulation of Perceptions and Actions

Magnus Johnsson, David Gil, Christian Balkenius and Germund Hesslow

Abstract

We present a study of supervised neural network architectures capable of internal simulation of perceptions and actions. These architectures employ the novel Associative Self-Organizing Map (A-SOM) as a hidden layer (for the representation of perceptions), and a neural network adapted by the delta rule as an output layer (for the representation of actions). The A-SOM develops a representation of its in- put space, but in addition it also learns to associate its activity with an arbitrary number of additional (possibly delayed) inputs. We test architectures, with as well as without, recurrent connections. The simulation results are very encouraging. The architecture without recurrent connections correctly classified 100% of the training samples and 80% of the test samples. After ceasing to receive any input the best of the architectures with recurrent connections was able to continue to produce 100% correct output sequences for 28 epochs (280 iterations), and then to continue with 90% correct output sequences until epoch 42.

The role of feedback in a hierarchical model of object perception

Salvador Dura-Bernal, Thomas Wennekers and Susan L. Denham

Abstract

We present a model which stems from a well-established model of object recognition, HMAX, and show how this feedforward system can include feedback, using a recently proposed architecture which reconciles biased competition and predictive coding approaches. Simulation results show successful feedforward object recognition, including cases of occluded and illusory images. Recognition is both position and size invariant. The model also provides a functional interpretation of the role of feedback connectivity in accounting for several observed effects such as enhancement, suppression and refinement of activity in lower areas. The model can qualitatively replicate responses in early visual cortex to occluded and illusory contours; and fMRI data showing that high-level object recognition reduces activity in lower areas. A Gestalt-like mechanism based on collinearity, co-orientation and good continuation principles is proposed to explain illusory contour formation which allows the system to adapt a single high-level object prototype to illusory Kanizsa figures of different sizes, shapes and positions. Overall the model provides a biophysiologically plausible interpretation, supported by current experimental evidence, of the interaction between top-down global feedback and bottom-up local evidence in the context of hierarchical object perception.

Adaptive, Perception-Action-based Cognitive Modelling of Human Driving Behaviour using Control, Gaze and Signal inputs

Affan Shaukat, David Windridge, Erik Hollnagel, Luigi Macchi and Josef Kittler

Abstract

A perception-action framework for cognition represents the world in terms of an embodied agent's ability to bring about changes within that environment. This amounts to an affordance-based modelling of the environment. Recent psychological research suggests that a hierarchical perception-action model, known as the Extended Control Model (ECOM), is employed by humans within a vehicle driving context. We thus seek to use machine learning techniques to identify ECOM states (i.e. hierarchical driver intentions) using the modalities of eye-gaze, signalling and driver control input with respect to external visual features. Our approach consists in building a deductive logical model based on a priori highway-code and ECOM rules, which is then to be applied to non-contextual stochastic classifications of feature inputs from a test-car's camera and detectors so as to determine the currently active ECOM state. Since feature inputs are both noisy and sparse, the goal of the logic system is to adaptively impose top-down consistency and completeness on the input. The cognitively-motivated combination of stochastic bottom-up and logical top-down representational induction means that machine learning problem is one of symbol tethering in Sloman's sense.

The emergence of feature sensitivity in a recurrent model of auditory cortex with spike timing dependent plasticity

Martin Coath, Robert Mill, Susan Denham and Thomas Wennekers

Abstract

Since Hubel and Wiesel showed that, for neurons in visual cortex, there were 'preferred stimuli' which evoked a more vigorous response in neurons than all other stimuli, it has become commonplace to think of neurons, or clusters of neurons, as having stimulus preferences - or alternatively as responding to 'features' of the stimulus. Although it is widely believed that auditory perception is based on the responses of neurons that are tuned to features of the stimulus it is not clear what these features are or how they might come in to existence. There is however evidence that cortical responses develop to reflect the nature of stimuli in the early post-natal period and that this plasticity persists beyond early development. In addition it has been shown that excitatory cortico-fugal projections to the thalamus are likely to be crucial in thalamic plasticity and hence in the representation of the stimulus that is available to the cortex. The work presented here is motivated by the desire to investigate whether a recurrently connected cortico-thalamic model exhibiting spike time dependent plasticity (STDP) can be sensitized to specific features of a stimulus by exposure. We employ a model of plasticity that depends on times of pre-synaptic spikes and a variable representing the post-synaptic activity and avoids the problem of unlimited weights by using synapses that are bi-stable, that is, over time the weights of all synapses tend to one or zero. We show that a model of auditory cortex incorporating lateral spread of excitation, recurrent connections between layers, and exhibiting STDP (learning) adapts during exposure to training patterns (stimuli) in a way that is determined partly by the stimuli themselves and partly by the architecture of the network. As a result the network exhibits 'feature preferences' that could support the representation of the input in a high dimensional feature space.

A psychologically and neurophysiologically plausible model for emulating human behavior in decision making tasks

A. Iglesias, M. D. del Castillo, J. I. Serrano and J. Oliva

Abstract

Decision making is a cognitive process that has motivated the study of psychological and neurophysiological phenomena about human decisions in order to achieve a better understanding of the human behavior. This paper proposes a framework for implementing psychologically and neurophysiologically plausible decision making systems, coherent with recent neuroeconomics research, for emulating human behavior in decision making tasks. The proposed framework, called MAIDEN, divides the decision making process in two phases. The first phase lies in the estimation of the possible consequences of a decision using a net of concepts. In the second phase, MAIDEN uses a value function to score each possible decision. MAIDEN assumes that the combination of both neurophysiological and psychological evidences may obtain better results in decision making modeling.

A Generic Framework for the Analysis of Emotion Mechanisms in Autonomous Agents

Timothy Rumbell, John Barnden, Sue Denham and Thomas Wennekers

Abstract

Emotion mechanisms are often used to perform roles in artificial agents with the aim of improving task performance. A basis for making comparisons be- tween these agents is proposed, in the form of a framework constructed from an analysis of architectural qualities (the agent architecture, the action selection mechanism, and the emotion mechanism along with the emotion model it was based on). This helps to place the agents within an architectural space, highlights contrasting methods of implementing similar theoretical components and suggests which architectural aspects are important to performance of tasks. Three autonomous agents incorporating emotion mechanisms are evaluated within this framework exemplarily, and the extent to which this type of framework can aid future research is briefly discussed.

A bio-inspired neural model to discriminate visual sequences

Mauricio Cerda and Bernard Girau

Abstract

The capacity to perceive and interpret highly complex visual patterns such as body movements and face gestures, is remarkably efficient in humans and many other species. Among others tasks, the classification of visual sequences without context is a key problem to understand both the coding and the retrieval of spatiotemporal patterns in the human brain. In this work we present a model able to discriminate visual sequences. This model is based on asymmetric neural fields. We apply it to the classification of synthetic sequences. Our model takes into ac- count several properties exhibited by experimental psychophysics and physiology. The presented model shows that sparse spatial coding of spatiotemporal sequences could be sufficient to explain some of these properties, such as classification with partial sequence information and tolerance to time-warping. We are also able to code a temporal sequence with a single population of units, without the need of explicit “snapshots” at each time instant.

Oscillatory Neural Network for Image Segmentation with Biased Competition for Attention

Tapani Raiko and Harri Valpola

Abstract

We study the emergent properties of an artificial neural network which combines segmentation by oscillations and biased competition for perceptual processing. The aim is to progress in image segmentation by mimicking abstractly the way how the cerebral cortex works. In our model, the neurons associated with features belonging to an object start to oscillate synchronously, while competing objects oscillate with an opposing phase. The emergent properties of the network are confirmed by experiments with artificial image data.

Aiding categorization by grounding spoken words - an infant inspired approach to concept formation and language acquisition

Aneesh Chauhan and Luís Seabra Lopes

Abstract

Naming is a powerful cognitive tool that facilitates categorization by form- ing an association between words and their referents. There is evidence in child development literature that strong links exist between word-learning and concept formation. A growing view is also emerging that language is a cultural product acquired through social interactions. Inspired by these studies, this paper presents a novel learning architecture for category formation and vocabulary acquisition in robots through active interaction with humans. This architecture is open-ended and is capable of acquiring new categories and category names incrementally. The intention here is to emulate the language grounding process in children at single-word stage. The robot is embodied with visual and auditory sensors for world perception. A human instructor teaches the robot the names of the objects present in a visually shared environment. The robot uses its perceptual input to ground these words and dynamically form/organize category descriptions in order to achieve better categorization. An experiment was conducted using a simple language game involving naming and corrective feedback actions from the human user. The results acquired from this game are discussed in detail to evaluate the learning system at word learn- ing and concept formation tasks.

Dense crowd analysis through bottom-up and top-down attention

Matei Mancas and Bernard Gosselin

Abstract

Video analysis of difficult scenarios like dense crowds can highly benefit from the use of algorithms which model part of human attention. Interesting motion which is new or surprising can be computed on large groups of people based on a two step approach. A bottom-up attention model built upon motion rarity compared to the rest of the motion in the same frame and a top-down approach which inhibits regions from the image which have a too repetitive behavior. This algorithm points out abnormal activities which can be used in surveillance but also to analyze and even foster social interaction.

Learning Saliency. An ICA based model using Bernoulli mixtures

Andrea Carbone and Fiora Pirri

Abstract

In this work, we present a model of both the visual input selection and the gaze orienting behaviour of a human observer undertaking a visual exploration task in a specific scenario. Our input is made of a sequence of gaze-tracked fixations acquired from a custom designed wearable device. We aim at characterising the statistical properties and regularities of the selected visual input. While the structure of the visual context is specified as a linear combination of basis functions, which are independent hence uncorrelated, we show how low level features characterising a scan-path of fixations can be obtained by hidden correlations to the context. Samples from human observers are collected both in free-viewing tasks, in the specified visual scene. These scan-paths show important and interesting dependency from the context. We show that a scan-path, given a database of a visual context, can be suit- ably induced by a system of filters that can be learned by a two stages model: the independent component analysis (ICA) to gather low level features and a mixtures of Bernoulli distributions identifying the hidden dependencies. Finally these two stages are used to build the cascade of filters.

Autonomy, Intelligence and Animat Mesmerization

Ricardo Sanz, Carlos Herńandez, Jaime Gómez, Guadalupe Śanchez, Julita Bermejo and Adolfo Hernando

Abstract

The intelligence needed for autonomously controlling systems in high un- certainty conditions seems to be part of animal competences. An important part of the research in autonomous machine construction is focused in build- ing robots by replicating extant animals. The question is if this is a valuable strategy for engineering autonomous intelligent systems. In this paper we will address the very issue of animat construction, the rationale behind this, their current implementations and the value they are producing for the intelligent control and robotics domains. It will be shown that current activity, as it is done today, is deeply flawed and useless as research in the science and engineering of autonomous intelligent controllers.

Reverse engineering biological brains. Exploring Brain-inspired Neural Models within Cognitive Robotics

Guadalupe Sánchez, Carlos Hernández, Ricardo Sanz, Jaime Gómez and Julita Bermejo

Abstract

This paper analyses the scientific and technological background and the current practices in neuro-inspired cognitive robotics. It specifically targets a concrete research methodology in brain-inspired robotics which we prove flawed in the perspective of both the scientific method and the established engineering practices.The intention is to make a strict analysis of the present situation to envision satisfactory solutions to overcome the obstacles that currently prevent not only domain-wide understanding, but progress towards the goals of cognitive robotics and science in general.

Fourth International ICSC Symposium on
Cognitive Neuroscience
(CNS 2010)

The Ouroboros Model, Selected Facets

Knud Thomsen

Abstract
The Ouroboros Model features a biologically inspired cognitive architecture. At its core lies a self-referential recursive process with alternating phases of data acquisition and evaluation. Memory entries are organized in schemata. The activation at a time of part of a schema biases the whole structure and, in particular, missing features, thus triggering expectations. An iterative recursive monitor process termed 'consumption analysis' is then checking how well such expectations fit with successive activations. Mismatches between anticipations based on previous experience and actual current data are highlighted and used for controlling the allocation of attention. A measure for the goodness of fit provides feed- back as (self-) monitoring signal. The basic algorithm works for goal directed movements and memory search as well as during abstract rational reasoning. It is sketched how the Ouroboros Model can shed light on different characteristics of human behavior including attention, emotions, priming, masking and learning.

Self-organization of neural maps using a modulated BCM rule within a multimodal architecture

Mathieu Lefort, Yann Boniface and Bernard Girau

Abstract

Human beings interact with the environment through different modalities, i.e. perceptions and actions. Different perceptions as view, audition or proprioception for example, are picked up by different spatially separated sensors. They are processed in the cortex by dedicated brain areas, which are self-organized, so that spatially close neurons are sensitive to close stimuli. However, the processings of these perceptive flows are not isolated. On the contrary, they are constantly interacting, as illustrated by the McGurk effect. When the phonetic stimulus
/ba/ is presented simultaneously with a lip movement corresponding to a /ga/, people perceive a /da/, which does not correspond to any of the stimuli. Merging several stimuli into one multimodal perception reduces the ambiguities and the noise of each perception. This is an essential mechanism of the cortex to interact with the environment. The aim of this article is to propose a model for the assembling of modalities, in- spired by the biological properties of the cortex. We have modified the Bienenstock Cooper Munro (BCM) rule to include it in a model that consists of interacting maps of multilayer cortical columns. Each map is able to self-organize thanks to a continuous decentralized and local learning modulated by a high level signal. By assembling different maps corresponding to different modalities, our model creates a multimodal context which is used as a modulating signal and thus it influences the self-organization of each map.

Evolutionary Path to Biological Kernel Machines

Magnus Jändel

Abstract

A neural implementation of a support vector machine is described and applied to one-shot trainable pattern recognition. The model is compared to anatomical and dynamical properties of the olfactory system. In the olfactory model, inputs from the olfactory bulb are captured and stabilized in the anterior olfactory cortex and the kernel is computed in the posterior piriform cortex. The anterior piriform cortex contains associative memory populated by support vectors. The associative memory oscillates incessantly between support vector states. Misclassified odours are imprinted as new support vector candidates and the machinery is tuned in sleep. It is demonstrated that there is a plausible evolutionary path from a simple hard- wired pattern recognizer to a full implementation of a biological kernel machine. Simple and individually beneficial modifications are accumulated in each step along this path.

The effects of working memory load on negative priming in an n-back task

Ewald Neumann and Paul N. Russell

Abstract

Two issues are addressed in this study. First, it addresses the viability of the assertion that working memory is crucial for reducing distraction by maintaining the prioritization of relevant over irrelevant information in visual selective attention tasks. The authors tested this hypothesis in an experiment involving a modified n- back task with attention displays consisting of a distractor word superimposed on a target picture. Working memory load is deemed to be low in a 1-back task and high in a 2-back task. Here we report the results from 1- and 2-back versions of an n-back task using negative priming to assess the degree of distractor word process- ing. The second issue addressed a controversy in the negative priming literature involving whether it is possible to obtain negative priming effects with a large pool of stimuli. It is generally thought that in order to obtain negative priming effects it is necessary for stimuli to have been encountered repeatedly as targets be- fore becoming an ignored distractor in the prime display of a prime-probe couplet. Thus, negative priming is ostensibly only produced when a relatively small pool of items is used, and these items exchange roles, acting as targets on some trials and distractors on others in the course of the task. In the present study, we report significant negative priming effects, despite using a large pool of stimuli and without the other aforementioned constraints. A possible resolution of the opposing findings is provided.

Correlation between Eye Movements and Mouth Movements to Detect Driver Cognitive Distraction

Afizan Azman and Qinggang Meng

Abstract

Issues related to driver distraction like eating, drinking, talking to a passenger, us- ing IVIS (In-Vehicle Information System) like MP3 and CD players, or even thinking are some of the main reasons of road deaths and road crashes. Driver dis- traction can be categorized into 3 different types: visual distraction, manual dis- traction and cognitive distraction. This paper proposes a physiological measurement to detect driver cognitive distraction. Two types of physiological measurements, eye and mouth movements are obtained using the faceLab Seeing Machine and their relationship to each other is analyzed using Pearson-r correlation. The data obtained from these two measurements showed that they are correlated to each other by more than 50%. Experimental data captured from three participants with 4936 frames each. The analysis proved that using a combination of eye and mouth movement as well as other existing features can greatly improve the performance of a driver cognitive distraction detection system.

Dynamical System Approach in Modeling Addiction

Selin Metin and N. Serap Şengör

Abstract

A computational model combining reinforcement learning approach with an action selection (A-S) module is proposed to initiate a model for addiction. The A-S module is realized as a nonlinear dynamical system. The reinforcement mechanism adapts the parameters of the A-S module till the acquisition of nicotine addiction is set up. The interpretation of the parameters from the point of view of neuroscience is given and in order to investigate the dynamical behavior of A-S module, its bifurcation diagram is obtained. The result obtained encourages expanding the model to include the role of limbic structures on acquisition of addiction further.

Assessment of Text Essay Quality by a Computational Model of Memory

J. Ignacio Serrano and M. Dolores del Castillo and J. Oliva and A. Iglesias

Abstract

Assessment of essay quality, also called essay scoring, is a task that has been commonly carried out by human judges. The judges are usually asked to give their scores according to several determined linguistic/semantic criteria. These criteria are related to lexical, syntactical, semantical and discourse features of the texts. In order to replace human judges, automated essay scoring systems make use of statistics on the latter features to quantify the quality of the essays. However, there is a subjective component within the evaluation of the text quality that cannot be measured by artificial scorers. The main evolutionary purpose of language is to communicate something to other subjects in order to cause some effect on them. Text essays are a form of natural language communication and therefore they cause effects on the readers. In the work presented in this paper, a connectionist model of memory during reading is used to study a way of quantifying the dynamic effects that the read text causes on the working memory of the readers, as well as the correlation of those effects with the essay quality scores.

OOP: Object-Oriented-Priority for Motion Saliency Maps

Anna Belardinelli, Werner X. Schneider and Jochen J. Steil

Abstract

The ability to attend to motion is paramount for living beings. The human visual system is able to detect coherent motion and select within multiple mov- ing objects the most conspicuous or most relevant to the task at hand. Similarly, any artificial agent operating in dynamic environments needs to be endowed with a mechanism for rapid detection and prioritization of moving stimuli in its field of view. In this paper, we present a biologically and psychologically inspired model of this ability and tune it for the extraction of motion at different scales and velocities. Unlike many computational models that compute saliency pixel-wise, we extract moving proto-objects through segmentation of motion energy features. These perceptual units, so called proto-objects, are identified as consistently moving blobs. A proto-object based priority map is hence obtained by assigning a single saliency value to the region confining a segmented object. Priority stems from a combination of bottom-up saliency, evaluated in a center-surround fashion, and from top-down biasing of motion features or motion saliency. Experimental simulations on synthetic displays and real sequences show the effectiveness of the proposed approach.

A computational modelling approach to investigate alpha rhythm slowing associated with Alzheimer's Disease

Basabdatta Sen Bhattacharya, Damien Coyle and Liam Maguire

Abstract

Attenuation of power in the alpha band (8–13 Hz) of Electroencephalograhy (EEG) is identified as a hallmark symptom of Alzheimer's Disease (AD). There is general agreement in existing literature that the thalamocortical circuitry play a key role in generation of alpha rhythms. Our research is to gain a better understanding of the cause of alpha rhythm slowing in the thalamocortical circuitry, which in turn might help in early detection of Alzheimer's Disease. We adopt a computational approach and base our work on a classic computational model of the thalamocortical circuitry associated with the generation of alpha rhythms proposed by Lopes Da Silva. In this work, we use the model to do a preliminary study on the power spectrum of the alpha rhythms by varying model parameters corresponding to inhibitory and excitatory synaptic activity. We observe that an increased inhibitory synaptic activity in the network leads to a decrease in the power of the upper alpha frequency band (11–13 Hz) and an increase in that of the lower alpha frequency band (8–10 Hz). Thus we observe an overall slowing of alpha rhythm corresponding to an increase in the inhibitory synaptic activity in the thalamocortical circuitry.

The Way We Get Bio-Inspired: A Critical Analysis

Andreas Schierwagen

Abstract

Research initiatives on both sides of the Atlantic try to utilize the operational principles of organisms and brains to develop biologically inspired, artificial cognitive systems. This paper describes the way bio-inspiration is normally gained. Key features of the standard method applied in the cognitive and brain sciences, i.e. decompositional analysis, are reviewed. The claim is discussed that non-decomposability is not an intrinsic property of complex systems but is only in our eyes, due to insufficient mathematical techniques. Using Robert Rosen's modelling relation, the scientific analysis method itself is made a subject of discussion. It is concluded that the fundamental assumption of cognitive science, i.e., complex cognitive systems are decomposable, must be abandoned. Implications for investigations of organisms and behavior as well as for engineering artificial cognitive systems are discussed.

Building Neurocognitive Networks with a Distributed Functional Architecture

Marmaduke Woodman, Dionysios Perdikis, Ajay S Pillai, Silke Dodel, Raoul Huys, Steven Bressler and Viktor Jirsa

Abstract

In the past few decades, behavioral and cognitive science have demonstrated that many human behaviors can be captured by low-dimensional observations and models, even though the neuromuscular systems possess orders of magnitude more potential degrees of freedom than are found in a specific behavior. We suggest that this difference, due to a separation in the time scales of the dynamics guiding neural processes and the overall behavioral expression, is a key point in understanding the implementation of cognitive processes in general. In this pa- per we use Structured Flows on Manifolds (SFM) to understand the organization of behavioral dynamics possessing this property. Next, we discuss how this form of behavioral dynamics can be distributed across a network, such as those recruited in the brain for particular cognitive functions. Finally, we provide an example of an SFM style functional architecture of handwriting, motivated by studies in human movement sciences, that demonstrates hierarchical sequencing of behavioral processes.

Fuzzy-4D/RCS for Unmanned Aerial Vehicles

Miguel A. Olivares-Méndez, Pascual Campoy, Iván Mondragón and Carol Martínez

Abstract

This paper presents an improvement of the cognitive architecture, 4D/RCS, developed by the NIST. This improvement consist of the insertion of Fuzzy Logic cells (FLCs), in different parts and hierarchy levels of the architecture, and the adaptation of this architecture for Unmanned Aerial Vehicles (UAVs). This advance pro- vides an improvement in the functionality of the system based on the uses of the Miguel Olivares' Fuzzy Software for the definition of the FLCs and its adaptive learning algorithm. These adaptive-FLCs contribute with the reduction of the un- certainty in the data sensor acquisition, a more adaptive behavior of the system to the real world and the reduction of the computational cost in the decision making.

Third International ICSC Symposium on

Models of Consciousness

(MoC 2010)

Machine Consciousness: A Computational Model

Janusz A. Starzyk and Dilip K. Prasad

Abstract

Despite many efforts, there are no computational models of conscious- ness that can be used to design conscious intelligent machines. This is mainly attributed to available definitions of consciousness being human centered, vague, and incomplete. Most researchers give up attempts of defining consciousness in physical terms, saying that consciousness is a metaphysical phenomenon. In this paper, we explain why it is important to define consciousness in physical terms. Through a biological analysis of consciousness and concept of machine intelligence, we propose a physical definition of consciousness with the hope to model it in intelligent machines.

Towards the Generation of Visual Qualia in Artificial Cognitive Architectures

Raúl Arrabales, Agapito Ledezma and Araceli Sanchis

Abstract

The nature and the generation of qualia in machines is a highly controversial issue. Even the existence of such a concept in the realm of artificial systems is often neglected or denied. In this work, we adopt a pragmatic approach to this problem using the Synthetic Phenomenology perspective. Specifically, we explore the generation of visual qualia in an artificial cognitive architecture inspired on the Global Workspace Theory (GWT). We argue that preliminary results obtained as part of this research line will help to characterize and identify artificial qualia as the direct products of conscious perception in machines. Additionally, we provide a computational model for integrated covert and overt perception in the framework of the GWT. A simple form of the apparent motion effect is used as a preliminary experimental context and a practical case study for the generation of synthetic visual experience. Thanks to an internal inspection subsystem, we are able to analyze both covert and overt percepts generated by our system when con- fronted with visual stimuli. The inspection of the internal states generated within the cognitive architecture enable us to discuss possible analogies with human cognition processes.

Crude, Cheesy, Second-Rate Consciousness

Joanna J. Bryson

Abstract

If we aren't sure what consciousness is, how can we be sure we haven't already built it? In this article I speak from the perspective of someone who routinely builds small-scale machine intelligence. I begin by discussing the difficulty in finding the functional utility for a convincing analog of consciousness when considering the capabilities of modern computational systems. I then move to considering several animal models for consciousness, or at least for behaviours humans report as conscious. I use these to propose a clean and simple definition of consciousness. I use this definition to suggest which existing artificial intelligent systems we might call conscious. I then contrast my theory with related literature before concluding.

Mental Causation In a Physical Brain?

Igor Farkaš

Abstract

Mental causation is a philosophical concept attempting to describe the causal effect of the immaterial mind on subjects' behavior. Various types of causality have different interpretations in the literature. I propose and explain this concept within the framework of the reciprocal causality operating in the brain bidirectionally between local and global brain levels. While committing myself to the physical closure assumption, I leave room for the suggested role of mental properties. Mental level is viewed as an irreducible perspective of description supervening on the global brain level. Hence, mental causation is argued to be interpreted as a convenient metaphor because mental properties are asserted to be causally redundant. Nevertheless, they will eventually help us identify and understand the neural and computational correlates of consciousness. Within cognitive science, the proposed view is consistent with the connectionist and dynamic systems paradigms, and within the philosophy of mind, I see it as a form of non-reductive physicalism.

NEMO: Need-inspired Emotional Expressions within a Task-independent Framework

Syaheerah L. Lutfi, R. Barra-Chicote, J.M Lucas-Cuesta and J.M. Montero

Abstract

This paper presents the underlying algorithms of an emotion model within a task-independent framework. This model, called NEMO is a task independent model that integrates a module of needs for emotional expressions. We suggest that appraisals can be confined within various scopes of needs. In other words, the emotion framework allows control over appraisals based on a set of pre-defined levels of needs. This way, the agent is able to sort out his priorities, and express emotions according to his needs. The definitions of the needs and appraisals concepts along with their computations are presented to demonstrate their relations with the emotion generation mechanism in a multi-tasking environment of an autonomous emotive agent.

Self-Conscious Robotic System Design Process - from Analysis to Implementation

Antonio Chella, Massimo Cossentino and Valeria Seidita

Abstract

Developing robotic systems endowed with self-conscious capabilities means realizing complex sub-systems needing ad-hoc software engineering techniques for their modelling, analysis and implementation. In this paper the whole process (from analysis to implementation) for modelling the development of self- conscious robotic systems is presented together with the new created design process - PASSIC - supporting each part of it.

Machine free will
Is free will a necessary ingredient of machine consciousness?

Antonio Chella and Riccardo Manzotti

Abstract

Sooner or later, machine consciousness will have to address the elusive notion of free will either to dismiss it or to produce a machine implementation. It is unclear whether freedom and consciousness are independent aspects of the human mind or correlate by-product of the same underlying structure. In this paper we will review the relevant literature focusing particularly on the connection be- tween determinism and freedom – namely on compatibilism. Then we will con- sider a model for machine free will.

Contributions

Neural Computation

- A sparse implementation of dynamic competition in continuous neural fields
  Jean-Charles Quinton and Bernard Girau
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- STDP Pattern Onset Learning Depends on Background Activity
  James Humble, Steve Furber, Sue Denham and Thomas Wennekers
  Slides: **PDF** **.pptx**
- Informational Theories of Consciousness: A Review and Extension
  Igor Aleksander and David Gamez
  Slides: **PDF** **.ppt**
- Emergence of small-world structure in networks of spiking neurons through STDP learning
  Gleb Basalyga, Pablo M. Gleiser, and Thomas Wennekers
  Slides: **PDF** **.pptx**
- An Integrated Model of a Bio-inspired Rat Brain with Design Patterns
  Pierre Philippe
- Hippocampal Categories: a mathematical foundation for navigation and memory
  Jaime Gómez and Ricardo Sanz
  Slides: **PDF**

Biologically Inspired Systems

- Supervised Architectures for Internal Simulation of Perceptions and Actions
  Magnus Johnsson, David Gil, Christian Balkenius and Germund Hesslow
  Slides: **PDF**
- The role of feedback in a hierarchical model of object perception
  Salvador Dura-bernal, Thomas Wennekers and Susan Denham
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- Adaptive perception-action-based cognitive modelling of human driving behavior using control, gaze and signal inputs
  Affan Shaukat, David Windridge, Erik Hollnagel, Luigi Macchi and Josef Kittler
  Slides: **PDF** **.zip**
- The emergence of feature sensitivity in a recurrent model of auditory cortex with spike timing dependant plasticity.
  Martin Coath, Robert Mill and Susan Denham
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- A psychological and neurophysiological plausible model for emulating human behavior in decision making tasks
  A. Iglesias, M. D. del Castillo, J. I. Serrano and J. Oliva
  Slides: **PDF** **.ppt**
- A Generic Framework for the Analysis of Emotion Mechanisms in Autonomous Agents
  Timothy Rumbell, John Barnden, Sue Denham and Thomas Wennekers
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- A bio-inspired neural model to discriminate visual sequences
  Mauricio Cerda and Bernard Girau
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- Oscillatory Neural Network for Image Segmentation with Biased Competition for Attention
  Tapani Raiko and Harri Valpola
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- Aiding conceptual development by grounding spoken words: an infant inspired model
  Aneesh Chauhan and Luís Seabra Lopes
  Slides: **PDF** **.pptx**

- Dense crowd analysis through bottom-up and top-down attention
  Matei Mancas and Bernard Gosselin
  Slides: **PDF** **.zip**
- Learning Saliency. An ICA based model using Bernoulli mixtures.
  Andrea Carbone and Fiora Pirri
  Slides: **PDF**

Cognitive NeuroScience

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  Knud Thomsen
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  Mathieu Lefort, Yann Boniface and Bernard Girau
  Slides: **PDF**
- Evolutionary Path to Biological Kernel Machines
  Magnus Jändel
  Slides: **PDF** **.ppt**
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