BICT conference information

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## I: Presented Papers and Abstracts

*A Distribution Control of Weight Vector Set for Multi-objective Evolutionary Algorithms*

Tomoaki Takagi, Keiki Takadama, Hiroyuki Sato

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Abstract:

For solving multi-objective optimization problems with evolutionary algorithms, the decomposing the Pareto front by using a set of weight vectors is a promising approach. Although an appropriate distribution of weight vectors depends on the Pareto front shape, the uniformly distributed weight vector set is generally employed since the shape is unknown before the search. This work proposes a simple way to control the weight vector distribution appropriate for several Pareto front shapes. The proposed approach changes the distribution of the weight vector set based on the intermediate objective vector in the objective space. A user-defined parameter determines the intermediate objective vector in the static method, and the objective values of the obtained solutions dynamically determine the intermediate objective vector in the dynamic method. In this work, we focus on MOEA/D as a representative decomposition-based multi-objective evolutionary algorithm and apply the proposed static and dynamic methods for it. The experimental results on WFG test problems with different Pareto front shapes show that the proposed static and dynamic methods improve the uniformity of the obtained solutions for several Pareto front shapes and the dynamic method can find an appropriate intermediate objective vector for each Pareto front shape.

*A Scalable Parallel Framework for Multicellular Communication in Bacterial Quorum Sensing*

Satyaki Roy, Mohammad Aminul Islam, Dipak Barua, Sajal Das

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Abstract:

Certain species of bacteria are capable of communicating through a mechanism called Quorum Sensing (QS) wherein they release and sense signaling molecules, called autoinducers, to and from the environment. Despite stochastic fluctuations, bacteria gradually achieve coordinated gene expression through QS, which in turn, help them better adapt to environmental adversities. Existing sequential approaches for modeling information exchange via QS for large cell populations are time and computational resource intensive, because the advancement in simulation time becomes significantly slower with the increase in molecular concentration. This paper presents a scalable parallel framework for modeling multicellular communication. Simulations show that our framework accurately models the molecular concentration dynamics of QS system, yielding better speed-up and CPU utilization than the existing sequential model that uses the exact Gillespie algorithm. We also discuss how our framework accommodates evolving population due to cell birth, death and heterogeneity due to noise. Furthermore, we analyze the performance of our framework vis-a-vis the effects of its data sampling interval and Gillespie computation time. Finally, we validate the scalability of the proposed framework by modeling population size up to 2000 bacterial cells.

*Bio-inspired Approach To Thwart Against Insider Threats: An Access Control Policy Regulation Framework*

Usman Rauf, Mohamed Shehab, Nafees Qamar, Sheema Sameen

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Abstract:

With the ever increasing number of insider attacks (data breaches) and security incidents it is evident that the traditional manual and standalone access control models for cyber-security are unable to defend complex and large organizations. The new access control models must focus on auto-resiliency, integration and fast response-time to timely react against insider attacks. To meet these objectives, even after decades of development of cyber security systems, there still exist inherent limitations (i.e., understanding of behavioral anomalies) in current cyber-security architecture that allow adversaries to not only plan and launch attacks effectively but also learn and evade detection easily. In this research we propose a bio-inspired integrated access control policy regulation framework which not only allows us to understand anomalous behavior of an insider but also provides theoretical background to link behavioral anomalies to the access control regulation. To demonstrate the effectiveness of our proposed framework we use real-life threat dataset for the evaluation purposes.

*Bio-inspired System Identification Attacks in Noisy Networked Control Systems*

Alan Oliveira de Sa, António Casimiro, Raphael C. S. Machado, Luiz F. R. da C. Carmo

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Abstract:

The possibility of cyberattacks in Networked Control Systems (NCS), along with the growing use of networked controllers in industry and critical infrastructures, is motivating studies about the cybersecurity of these systems. The literature on cybersecurity of NCSs indicates that accurate and covert model-based attacks require high level of knowledge about the models of the attacked system. In this sense, recent works recognize that Bio-inspired System Identification (BiSI) attacks can be considered an effective tool to provide the attacker with the required system models. However, while BiSI attacks have obtained sufficiently accurate models to support the design of model-based attacks, they have demonstrated loss of accuracy in the presence of noisy signals. In this work, a noise processing technique is proposed to improve the accuracy of BiSI attacks in noisy NCSs. The technique is implemented along with a bio-inspired metaheuristic that was previously used in other BiSI attacks: the Backtracking Search Optimization Algorithm (BSA). The results indicate that, with the proposed approach, the accuracy of the estimated models improves. With the proposed noise processing technique, the attacker is able to obtain the model of an NCS by exploiting the noise as a useful information, instead of having it as a negative factor for the performance of the identification process.

*Classification of Permutation Distance Metrics for Fitness Landscape Analysis*

Vincent A Cicirello

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Abstract:

Commonly used computational and analytical tools for fitness landscape analysis of optimization problems require identifying a distance metric that characterizes the similarity of different solutions to the problem. For example, fitness distance correlation is Pearson correlation between solution fitness and distance to the nearest optimal solution. In this paper, we survey the available distance metrics for permutations, and use principal component analysis to classify the metrics. The result is aligned with existing classifications of permutation problem types produced through less formal means, including the A-permutation, R-permutation, and P-permutation types, and has also identified subtypes. The classification can assist in identifying appropriate metrics based on optimization problem feature for use in fitness landscape analysis. Implementations of all of the permutation metrics, and the code for our analysis, are available as open source.

*Cyber Regulatory Networks: Towards A Bio-inspired Auto-resilient Framework for Cyber-Defense*

Usman Rauf, Mujahid Mohsin, Wojciech Mazurczyk

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Abstract:

After decades of deploying cyber-security systems, it has become a well-known fact that the existing cyber-security architecture has numerous inherent limitations that make the maintenance of the current network security devices unscalable and provide the adversary with asymmetric advantages. These limitations include: (1) difficulty in obtaining the global network picture due to lack of mutual interactions among heterogeneous network devices, (2) poor device self-awareness in current architectures, (3) error-prone and time consuming manual configuration which is not effective in real-time attack mitigation, (4) inability to diagnose misconfiguration and conflict resolution due to multi-party management of security infrastructure. In this paper, as an initial step to deal with these issues, we present a novel bio-inspired auto-resilient \emph{security} architecture. The main contribution of this paper includes: (1) investigation of laws governing the dynamics of correct feedback control in Biological Regulatory Networks (BRNs), (2) studying their applicability for synthesizing correct models for bio-inspired communication networks, i.e. Firewall Regulatory Networks (FRNs), (3) verification of the formal models of real network scenarios, to prove the correctness of the proposed approach through model checking techniques.

*Evolutionary Multi-objective Optimization for Evolving Soft Robots in Different Environments*

Jun Ogawa

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Abstract:

Conventional evolutionary robotics assigns a task and an evaluation to a virtual robot and acquires an optimal control system. In many cases, however, the robot is composed of a few rigid primitives and the morphology imitates that of real animals, insects, and artifacts. This paper proposes a novel approach to evolutionary robotics combining morphological evolution and soft robotics to optimize the control system of a soft robot. Our method calculates the relational dynamics among morphological changes and autonomous behavior for neuro-evolution (NE) with the development of a complex soft-bodied robot and the accomplishment of multiple tasks. We develop a soft-bodied robot composed of heterogeneous materials in two stages: a development stage and a locomotion stage, and we optimize these robotic structures by combining an artificial neural network (ANN) and age-fitness pareto optimization (AFP). In terms of our experimental results, our approach enabled us to develop some adaptive structural robots that simultaneously acquire behavior for crawling both on the ground and underwater. Subsequently, we discovered an unintentional morphology and behavior (e.g., walking, swimming, and crawling) of the soft robot through the evolutionary process. Some of the robots have high generalization ability with the ability to crawl to any target in any direction by only learning a one-directional crawling task.

*Field coverage for weed mapping toward experiments with a UAV swarm*

Dario Albani, Tiziano Manoni, Arikhan Arik, Daniele Nardi, Vito Trianni

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Abstract:

Precision agriculture represents a very promising domain for swarm robotics, as it deals with expansive fields and tasks that can be parallelised and executed with a collaborative approach. Weed monitoring and mapping is one such problem, and solutions have been proposed that exploit swarms of unmanned aerial vehicles (UAVs). With this paper, we move one step forward towards the deployment of UAV swarms in the field. We present the implementation of a collective behaviour for weed monitoring and mapping, which takes into account all the processes to be run onboard, including machine vision and collision avoidance. We present simulation results to evaluate the efficiency of the proposed system once that such processes are considered, and we also run hardware-in-the-loop simulations which provide a precise profiling of all the system components, a necessary step before final deployment in the field.

*Medical Diagnostics Based on Encrypted Medical Data*

Kelsey Horan, Delaram Kahrobaei, Kayvan Najarian, Jonathan Gryak, Vladimir Shpilrain, Reza Soroushmehr, Alexey Gribov

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Abstract:

We utilize a type of encryption scheme known as a Fully Homomorphic Encryption (FHE) scheme which allows for computation over encrypted data. Our encryption scheme is more efficient than other publicly available FHE schemes, making it more feasible. We conduct simulations based on common scenarios in which this ability is useful. In the first simulation we conduct time series analysis via Recursive Least Squares on both encrypted and unencrypted data and compare the results. In simulation one, it is shown that the error from computing over plaintext data is the same as the error for computing over encrypted data. In the second simulation, we compute two known diagnostic functions over publicly available data in order to calculate computational benchmarks. In simulation two, we see that computation over encrypted data using our method incurs relatively lower costs as compared to a majority of other publicly available methods. By successfully computing over encrypted data we have shown that our FHE scheme permits the use of machine learning algorithms that utilize polynomial kernel functions.

*Membrane computing Aggregation (MCA): An upgraded Framework for Transition P-Systems.*

Alberto Arteta, Luis Fernando Mingo, Nuria Gomez, Yanjun Zhao

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Abstract:

MCA (Membrane computing aggregation is experimental computational frame. It is inspired by the inner properties of membrane cells (Bioinspired system). It is capable of problem solving activities by maintaining a special, "meaningful" relationship with the internal/external environment, integrating its self-reproduction processes within the information flow of incoming and outgoing signals. Because these problem solving capabilities, MCA admits a crucial evolutionary tuning by mutations and recombination of theoretical genetic "bridges in a so called “aggregation” process ruled by a hierarchical factor that enclosed those capabilities. Throughout the epigenetic capabilities and the cytoskeleton and cell adhesion functionalities, MCA model gain a complex population dynamics specifics and high scalability. Along its developmental process, it can differentiate into meaningful computational tissues and organs that respond to the conditions of the environment and therefore "solve" the morphogenetic/configurational problem. MCA, above all, represents the potential for a new computational paradigm inspired in the higher level processes of membrane cells, endowed with quasi universal processing capabilities beyond the possibilities of cellular automata of and agent processing models.

*Self-Assembly from a Single-Molecule Perspective*

Kevin Richard Pilkiewicz, Pratip Rana, Michael Mayo, Preetam Ghosh

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Abstract:

As manipulating the self-assembly of supramolecular and nanoscale constructs at the single-molecule level increasingly becomes the norm, new theoretical scaffolds must be erected to replace the thermodynamic and kinetics based models used to describe traditional bulk phase active syntheses. Like the statistical mechanics underpinning these latter theories, the framework we propose uses state probabilities as its fundamental objects; but, contrary to the Gibbsian paradigm, our theory directly models the transition probabilities between the initial and final states of a trajectory, foregoing the need to assume ergodicity. We leverage these probabilities in the context of molecular self-assembly to compute the overall likelihood that a specified experimental condition leads to a desired structural outcome. We demonstrate the application of this framework to a simple toy model in which three identical molecules can assemble in one of two ways and conclude with a discussion of how the high computational cost of such a fine-grained model can be overcome through approximation when extending it to larger, more complex systems.

*Blinded by Biology: Bio-Inspired Tech-Ontologies in Cognitive Brain Sciences*

Paola Hernández-Chávez

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Abstract:

In his pioneering paper on neuromorphic systems, Carver Mead conveyed that: “Biological information-processing systems operate on completely different principles from those with which most engineers are familiar” (Mead 1990: 1629).1 This paper challenges his assertion. While honoring Mead’s exceptional contributions, specific purposes, and correct conclusions, I will use a different line of argumentation. I will make use of a debate on the classification and ordering of natural phenomena to illustrate how background notions of causality permeate particular theories in science, as in the case of cognitive brain sciences. This debate shows that failures in accounting for concrete scientific phenomena more often than not arise from (1) characterizations of the architecture of nature, (2) singular conceptions of causality, or (3) particular scientific theories – and not rather from (4) technology limitations per se. I aim to track the basic bio-inspiration and show how it spreads bottom-up throughout (1) to (4), in order to identify where bioinspiration started going wrong, as well as to point out where to intervene for improving technological implementations based on those bio-inspired assumptions.

*Physics-Based Nanomedicine to Alleviate Anomalous Events in the Human Kidney*

Huber Nieto-Chaupis

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Abstract:

One of the irreversible complications of type-2 diabetes is known as diabetic nephropathy by which is characterized by the abundance of giant proteins in the urine. In most cases nephropathy might be identified in late stages of disease. In this paper we present a multidisciplinary methodology that combines physiology and physics that targets to identify in the very early phase the diabetic nephropathy through the deployment of a nano device that has capabilities to detect anomalous ux of albumin and others proteins along the area belonging to the renal glomerulus. From the fact that most of the proteins contain negative charge this turns out to be advantageous to deploy a nanodevice with a dual superficial charge density: positive and negative, in the sense that its electric interaction with proteins gives as result either attraction or repulsive displacements fact that is seen as indirect measurement of the Rate Albumin Excretion, an indicator to evaluate the degradation of the kidney in time. We propose in a coherent and sustainable manner all these ideas through simulations where the prospective capability of a nanodevice as to measure the pass of electric charges inside the renal glomerulus is analized. We use electromagnetic pulses in order to carry out tasks of surveillance with respect to the transition of proteins of albumin from the microvascularity systems to the zone of urine formation. The results of this paper would support the prospective implementation

*Cheating the Beta Cells To Delay the Beginning of Type-2 Diabetes Through Artificial* *Segregation of Insulin*

Huber Nieto-Chaupis

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Abstract:

In this paper we focus in artificial mechanisms to detain the beginning of the type-2 diabetes. We propose a nanosensor whose central role is that of emitting and receiving signals. From purely electrical interactions between the nanosensor and Calcium 2+ ions through artifical entrance of Calcium ions inside the beta-cells allowing them to segregate insulin. The permanent segregation of insulin is seen from the angle of advanced networks in the sense that the segregation of insulin granules can be done to distance. In order to guarantee the permanent segregation of insulin granules by avoiding the intake of pharmacology for large periods. The electrical interactions inside the beta cells is the main assumption of this paper. We propose a full Internet of Bio-Nano Things network (IOBNT) aimed to regulate the continuous segregation of insulin in prediabetes patients through a prospective nanosensor that would play a double role as to acquire signals derived from the electromagnetic interaction between the Calcium ions and the nanosensor. Our scheme proposes the concept by which the nanosensor is permanently under communication with a bio-cyber interface fact that enables to upload data to the cloud in an unstoppable manner. It is expected that IOBNT runs in circuit of unstoppable communication involving also clouds, servers and endocrinologists in a sustainable manner for a continuous surveillance that guarantee the regulate segregation of insulin by the beta cells.

## *Space partitioning and maze solving by bacteria*

Ayyappasamy Sudalaiyadum Perumal, Monalisha Nayak, Viola

Tokárová, Ondřej Kašpar, Dan V. Nicolau

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Abstract:

Many bacteria dwell in micro-habitats, e.g., animal or plant tissues, waste matter, and soil. Consequently, bacterial space searching and partitioning is critical to their survival. However, the vast majority of studies regarding the motility of bacteria have been performed in open environments. To fill this gap in knowledge, we studied the behaviour of E. coli K12-wt in microfluidic channels with sub-10 µm dimensions, which present two types of geometries, namely a diamond-like network and a maze. The velocity, average time spent and distance required to exit the networks, have been calculated to assess the intelligent-like behaviour of bacteria.

## II: Panels and Sessions

Session

***Human Machine Teaming (Cybernetics)***

**Chair: Ryan McKendrick**

Abstracts:

*The Evolution of Vigilance*

William Helton

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Abstract:

Psychologists have proposed cognitive resource theories of human and other animal behavior. An example of where such theories have utility is understanding the increased lapses of attention with time-on-task. Vigilance, awareness of external critical stimuli, over time typically declines. Animals often become less responsive to environmentally important stimuli. An example in people would be failing to detect a car parked ahead on the road while driving for an extended trip. Behavioral lapses can occur because of either reallocation of cognitive resources to some other task, including internal thoughts – processing streams, or because of depletion of necessary cognitive resources. Since processing ability increases after a rest break of sufficient duration cognitive resources are renewable. The exact underlying mechanisms of depletion and renewal remain uncertain, but comparative research may elucidate the critical role rest and recuperation of cognitive resources has in understanding behavior.

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*Human Traits Embedded in Labels for Supervised Learners*

Ryan McKendrick, Brian Falcone, Amanda Harwood, Bradley Feest

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Abstract:

There are a number of key data-centric questions that must be answered when developing classifiers for operator functional states. Here we focus exclusively on the labeling of cognitive load data for supervised learning. We explored three methods of labeling cognitive states for three-state classification. The first method labeled states as either high, adequate or low cognitive load, this labeling was derived from a tertiary split of the amount of information an individual had to hold on each trial of a spatial memory task. The second method was more adaptive, it employed a mixed effects stress-strain curves and estimated individual’s performance asymptotes with respect to the same spatial task. The final method was similar to the second approach, yet it employed using mixed effects Rasch modeling to estimate individual capacity limits within the spatial task within the context of item response theory. To assess the strength of each of these labeling approaches we compared area under the curve (AUC) for receiver operating curves (ROC) as well the AUC of precision-recall ROCs (PR-ROC) from elastic net and random forest classifiers. We also transferred these classifiers to a synthetic intelligence, surveillance and reconnaissance (ISR) task.

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*Human-Machine Teaming*

David Burke

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Abstract:

Our work on human-machine teaming is based on two design principles.  The first is that a successful science of human-machine teaming requires a practical theory of group rationality.  Game theory is often described as the science of strategic rationality, but it is fundamentally built on the concept of individual rationality.  Likewise, social choice theory studies group decision-making, but only through the aggregation of individual preferences.  We claim that there needs to be an explicit conception of a group, including its beliefs and preferences, in order to accurately model human-machine teaming dynamics.

The second design principle is captured in the following dynamic: for all agents, attention is a finite and precious resource.  Being embedded in a high-tempo, complex environment containing both human and machine partners places severe cognitive demands on that agent.  The key challenge here is for the agent to update its mental models, including its model of other agent’s mental models. This is accomplished by minimizing expected information-theoretic surprisal over a characteristic time scale.  If the surprisal rate is too high, agents aren’t able to learn and cope with change effectively.  Adaptation is demonstrated when agents are able to take actions that are congruent with their mental models and the current stream of sensory inputs.

Session

***PHILOSOPHY OF SCIENCE SESSION: “RE-ENGINEERING PHILOSOPHY OF NATURE, MULTIPLE***

***REALISATION AND NATURAL KINDS”***

**Chair: Paola Hernández-Chávez**

Abstracts:

*What is “biological” about biologically-inspired computational models in cognitive science?: Implications for the multiple realisation debate.*

Author: Mahi C. Hardalupas

PhD student, Department of History and Philosophy of Science, University of Pittsburgh

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Abstract:

In this talk, I investigate the use of biologically-inspired computational models in cognitive

science and their implications for the multiple realisation debate in philosophy of mind.

Multiple realisation is when the same state or process can be realised in different ways. For

example, flight is a potential multiply realised process. Birds, planes and helicopters all fly

relying on the same aerodynamic principles but their mechanisms for flying differ substantially:

birds have two wings which they flap in order to achieve flight, planes also have two wings, but

they are static rather than flapping and helicopters use rotors on the top to produce enough lift

for flight. If these “ways” of flying are considered sufficiently different, then we can conclude

that flight is a multiply realised process. Philosophers of mind (such as Putnam (1967) and

Fodor (1974) but more recently Polger & Shapiro (2016)) have frequently taken multiple

realisation to be significant for metaphysical debates about whether mental processes can be

reduced to neural processes. The idea being that if mental processes such as pain are multiple

realised, then pain does not reduce to a neural process since it can be instantiated in other

ways.

The current literature on multiple realisation (for example, Polger and Shapiro (2016) and

Aizawa (2018a; 2018b)) doesn’t consider how artificial and engineered systems such as

biologically-inspired computational models fit into this debate. I argue that the use of these

models in cognitive science motivates the need for a new kind of multiple realisation, which I

call ‘engineered multiple realisation’ (or EMR). By this, I mean that scientists aim to create

multiple realisations of cognitive capacities (such as object recognition) through engineering

systems. I describe various examples of this in cognitive science and explain how these models

incorporate biological elements in different ways. Given this, I claim that EMR cannot bear on

metaphysical debates about the nature of mental processes. Instead, I argue that, when

building computational models as EMRs, there are different payoffs for incorporating biology

into the models. For example, one approach is that researchers are often motivated to

incorporate biological elements into their models in the hope that doing so will lead to better performance of their models (Baldassarre et al (2017); George (2017); Laszlo & Armstrong,

(2013)) Another approach incorporates biological elements into models as a way to test

hypotheses about the mechanisms underlying human vision (Tarr & Aminoff, 2016). I

emphasise that these payoffs depend on the goals of different modelling approaches and what

the approaches take to be biologically relevant for these goals. By sketching out different

approaches and their notions of biological relevance, I show that there are many important

roles that EMR can play instead of informing traditional metaphysical debates about the

reduction of mental to neural processes.

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*Fundamental Design Principles in Engineering and in the Architecture of Nature.*

Author: William C. Wimsatt

Senior Fellow, Center for Philosophy of Science, University of Pittsburgh, 2018-2019.

Universities of Chicago and Universities of Minnesota, emeritus.

Corresponding Author: William. C. Wimsatt wwim@uchicago.edu

Abstract:

I consider, illustrate, and argue for the fundamentality of several design principles that emerge

in all evolving systems, in their design and in their analysis. These include robustness or the use

of multiple means using less reliable elements to secure more reliable outcomes, near

decomposability, which can arise by different paths both top-down (securing contextdependent

quasi-independence, to facilitate evolution as first noted by Lewontin), and bottomup

(thru aggregation of relatively context-independent stable sub-assemblies, as first noted by

Simon), and differential generative entrenchment (as noted and used in different ways by

several different writers including Riedl, Wallace Arthur, Brian Arthur, Wimsatt to explain and

to predict patterns of differential evolutionary conservation and change, and inference patterns

in evolutionary developmental biology including Bauplans, and combinatorial recombinations

and entrenchments, generating adaptive radiations, families of technologies, and the

importance of history.

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*Towards an improved BioInspired Causality in Neurosciences.*

Paola Hernández-Chávez

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Abstract:

Classifying the world into general regularities is a human proclivity to optimize our

understanding of the world. Classification and categorization are recurring throughout History

of Science. Metascientific studies of how scientists allocate regularities go backward and

forwards in Physics, Biology, and recently in Neuroscience. This is not surprising provided the

impact Neuroscience has regarding technological resources, numerous results and public

attention it calls. Nonetheless, not many studies have been run regarding the use of

neuroscientific classifications and its bio-inspired causal assumptions, nor how to improve

them.

There is an old philosophical debate regarding our most basic notions of Nature’s organization

and causality, known as the Natural Kinds debate (NK). Talking about Nature’s most basic

organization will take us right there, to bind a gap going from Biology to Medicine, to

Neurology, to Technology and finally back to the Neuroscience.

This work accounts for the bio-inspired causality assumptions working in current neuroscience.

In particular, going only a few centuries backward makes possible to identify a causal agentbased

model coming mainly from the eighteen and nineteen-century classical Biology, which is

much still alive in current neuroscientific claims.

First part of this work is an account of the natural kinds debate from the perspective of

philosophy, aimed to call for awareness of our ontological assumptions and conceptualizations

deriving into technological tools for explaining brain phenomena. The second part addresses

the brain as a phenomenon of Nature. The third part is an overview of how old biology

assumptions were imported paired with an indication of an improved bio-inspired approach to

neurosciences.

Session

***AI Applications and Ethics in Industry***

**Chair: Thomson Nguyen**

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*Distributed Autonomy for Robotics*

James Edmondson

The majority of robots and cyber-physical systems developed and deployed today are stand-alone systems, and they are often controlled remotely by a human operator or even two or more operators. The useful options available for general development of multi-agent systems and swarms with collaborative intelligence and mission-focused autonomy for controlled experiments is limited. Researchers have even fewer tool and development options for pushing the state-of-the-art in trustworthy, predictable, and scalable distributed artificial intelligence for real-world, outdoor environments. In this talk, I will discuss my efforts over the past decade to bring large-scale, multi-agent systems into reality via my work in extensible middleware and algorithm development in the Group Autonomy for Mobile Systems project (GAMS: http://gams.ai) and in Unreal Engine simulation options for AR/VR integration. I will present videos of simulated systems and real world, outdoor multi-agent robotics. I will also outline the process of creating beneficial emergent good behaviors in distributed agents with techniques inspired by Dijkstra self-stabilizing system concepts in finite state machines, implemented in GAMS and another middleware I have been maintaining called the Multi-Agent Distributed Adaptive Resource Allocation project (MADARA: http://madara.ai). Finally, I will discuss determinism in distributed artificial intelligence and my work applying software model checking and statistical model checking to the autonomy development process.

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*Machine Ethics*

David Burke

Most existing attempts to formalize machine ethics have focused on two of the three main schools of thought of ethics: deontological approaches, which are rules-based and often involving concepts of obligation and permission, or utilitarian/consequentialist approaches, which attempt to calculate in some manner the greatest good for the greatest number.  We have instead been pursuing an approach based on the computationally instantiating the five principles described by Haidt in his “Moral Foundations Theory”: harm, reciprocity, authority, loyalty, and disgust.  These design primitives allow us to express moral constraints, objectives, and outcomes for machine ethics.

We measure our success in specifying and expressing ethical machine behaviors by the amount of congruence achieved between humans and machines, measured along the following dimensions:

1. Congruence in Identification - does the machine have similar abilities to a human when it comes to perceiving the salient characteristics of the scenario?  That is, can the machine identify what ethical violations or moral challenges are involved in the scenario?

2. Congruence in Assessment - is the machine able to articulate the stakes involved for both the human and the machine in resolving the potential ethical violation?  An additional question we are investigating is how to characterize and build the necessary trust between the human and the machine so that they are able and willing to share these assessments.

3. Congruence in Action - Given the machine’s decisions and/or recommendations, how do we resolve residual conflicts?  For instance, say the machine makes a decision or recommendation, and the human disagrees - does there exist an effective resolution procedure?

Session

***Nature and Games session, celebrating Bud Mishra's 60th birthday and closing Panel***

**Chair Steven Massey**