Tsvi Achler, MD/PhD

POSTDOC EXPERIENCE

IBM Research, Almaden, SYNAPSE Project (2012 - present)
Cognitive Computing on Neuromorphic Hardware, Advisors: Dr. Dharmendra Modha

Los Alamos National Labs, Synthetic Cognition Group (2010 - 2012)
Cognitive & Theoretical Neuroscience, Advisors: Dr. Luis Bettencourt, Dr. Garrett Kenyon

University of Illinois at Urbana-Champaign (2006 - 2010)
Computer Science, Advisor: Dr. Eyal Amir

EDUCATIONAL BACKGROUND

University of Illinois at Urbana-Champaign (1997 - 2006)
M.D. (Neurology rotations at UIUC, UCSF and Harvard).
Ph.D. Neuroscience: *Peripheral Processing and the Role of Feedback,* Advisor: Dr. Rhanor Gillette

University of California at Berkeley (1989 -1996)
E.E. Electrical Engineering and Computer Science (Bio-Electronics emphasis)
B.S. Molecular & Cell Biology (Neurobiology emphasis)

EXPERIENCE

Computer Science *Postdoc*: Classifier theories, neural networks, machine learning, algorithm comparisons, spiking neurons, binding problem, combinatorial explosion, cognitive and neuroscience simulations.

Neuroscience/Neurology *PhD*: role of feedback processes in information processing of behaviorally characterized stimuli using multicellular nerve recordings. Research techniques: suction electrode recording, backfills, dissections, surgery, electrophysiology, multiple channel recording, filtering, spike & data analysis. MD: clinical tests, reading MRI/CT, EEG, medical reports.

Cognitive Psychology *Postdoc* (Los Alamos): Backwards masking, speed-of-sight, reaction time analysis, and search experiments. *PhD*: (Logan Lab) visual attention models, eye tracking. Data analysis and computer modeling.

REVIEWED PUBLICATIONS AND PROCEEDING PAPERS

Achler T., *Towards Bridging the Gap between Pattern Recognition and Symbolic Representation Within Neural Networks*, Neural-Symbolic Learning and Reasoning, AAAI-2012 (In press)

Achler T., *Artificial General Intelligence Begins with Perception*, Invited Chapter in *Theoretical Foundations of Artificial General Intelligence*, Eds: Pei W, Goertzel B, (2012 in press)

Achler T., *Non-Oscillatory Dynamics to Disambiguate Pattern Mixtures,* Chapter 4 in *Relevance of the Time Domain to Neural Network Models*, Eds: Rao R, Cecchi G A, Springer 2011

Achler T., Bettencourt L., *Evaluating the Contribution of Top-Down Feedback and Post-Learning Reconstruction*, Biologically Inspired Cognitive Architectures AAAI Proceedings 2011

Achler T., *A Genetic Classifier Account for the Regulation of Expression,* Eds: Chaovalitwongse, Pardalos, Xanthopoulos. Computational Neuroscience, Springer, 2010, ISBN 987-0-38788629-9.

Achler, T., Vural C., Amir, E., *Counting with Biologically Inspired Regulatory Feedback Networks*, Neural Networks IJCNN IEEE Proceedings, 2009, pp.36-40.

Achler, T., *Using Non-Oscillatory Dynamics to Disambiguate Simultaneous Patterns*, Neural Networks IJCNN IEEE Proceedings, 2009, pp.41-48.

Achler, T., Amir, E., *Neuroscience and AI Share the Same Elegant Mathematical Trap,* Artificial General Intelligence, V2, IOS 2009.

Achler, T., Omar C., Amir, E., *Shedding Weights: More With Less*, Neural Networks IJCNN IEEE Proceedings, 2008 pp.3020-3027.

Achler, T., Amir, E., *Input Feedback Networks: Classification and Inference Based on Network Structure*, Artificial General Intelligence, V1: 15-26, IOS 2008.

Achler, T., Amir, E., *Hybrid Classification and Symbolic-Like Manipulation Using Self-Regulatory Feedback Networks*, Workshop on Neural-Symbolic Learning and Reasoning, IJCAI 2008.

Achler, T., *Object Classification with Recurrent Feedback Neural Networks*, Proc. SPIE, Evolutionary and Bio-inspired Computation: Theory and Applications, Vol. 6563, 2007.

Achler, T., *Input Shunt Networks*, Neurocomputing, 44-46c: 249-255 Jul 2002.

CONFERENCE TALKS AND INVITED TALKS

Achler T, *Computing, Learning, and Estimating, Under the Inverse*, Information Science & Technology colloquium seminar, Los Alamos National Labs, 2011

Achler, T., Ham M., Barr S., George J., Kenyon G., Bettencourt L., *Masking Vs. Searching: Similar Underlying Mechanisms?* Psychonomics Society, St Louis MO, 2010

Achler, T., *Simultaneous Pattern Processing within Sensory Processing,* National Institute on Deafness & Communication Disorders, NIH, Bethesda, 2010

Achler, T., *Computation Through Feedback Control,* Center for Nonlinear Studies, Los Alamos National Labs, 2010

Achler, T., *Sensory Processing with Large-Scale Feedback Inhibition*, Weizmann Institute, Rehovot, Israel, 2010

Achler, T., *Simultaneous Pattern Processing; Classifier Structures & Limitations,* National Geospatial-Intelligence Agency, Academic Research Program Symposium, Washington DC 2008; 2009 respectively

Achler, T., Amir, E., *Making Sense of Simultaneous Patterns*; *Applications of Regulatory Feedback Classification*, Intelligence Community Postdoc Colloquium, Washington DC, 2008; 2009 respectively.

Achler, T., *Towards Understanding Self-Inhibition Within Sensory Processing*, Tech University of Munich, 2009

Achler, T., Amir, E., *Processing Simultaneous Patterns*, 2nd Illinois Computer Vision Workshop, Toyota Technological Institute, Chicago IL, 2009

Achler, T., *Hybrid Classification and Symbolic-Like Manipulation Using Self-Regulatory Feedback Networks*, Neuro-Symbolic Systems, Stanford University, 2009.

Achler, T., *Using Non-Oscillatory Dynamics to Disambiguate Simultaneous Patterns*, IEEE International Joint Conference on Neural Networks, Atlanta GA, 2009.

Achler, T., Amir, E., *Neuroscience and AI Share the Same Elegant Mathematical Trap,* Artificial General Intelligence, Arlington, Virginia 2009.

Achler, T., Omar C., Amir, E., *Shedding Weights: More With Less*, IEEE International Joint Conference on Neural Networks, Hong Kong, China, 2008.

Achler, T., Amir, E., *Input Feedback Networks: Classification and Inference Based on Network Structure*, Artificial General Intelligence, Memphis TN 2008.

Achler, T., *A Novel Classification Method Using Self-Regulatory Feedback Networks*, Brain Inspired Cognitive Architectures, Washington DC, 2008.

Achler, T., *Towards a Dynamic Account of Epigenetic Regulation of Expression and Classification*, DIMACS Workshop on Computational Neuroscience, Gainesville FL, 2008.

POSTERS

Achler T, George J, Brumby S, Kenyon G, Bettencourt L, *Processing Mixtures of Patterns Using Generative Model*s Los Alamos Postdoc Research Symposium 2011 **Outstanding Poster-Award**

Achler T., Ji, Z., Bettencourt L., *Generative Mechanisms During Testing: How the Brain May Recognize Mixtures of Patterns,* Neural Networks IJCNN IEEE, San Jose*, 2011*

Achler T, Ham M, Barr S, George J, Kenyon G, Bettencourt L, *Simultaneous Pattern Processing with Top-down Generative Feedback,* COSYNE, Salt Lake City, UT, 2011

Achler T, Ham M, Barr S, George J, McCarley J, Kenyon G, Bettencourt L, *Asymmetry and Similarity Phenomena in Backwards Masking Experiments Suggest Reentrant Processing,* Vision Sciences Society VSS, *33.550,* Naples, FL, 2011

Achler T, *Evaluating the Role of Feedback Regulation in Recognition Processing* Computational Neuroscience Meeting, San Antonio, Texas, 2010

Achler T, *Towards Understanding the Role of Regulatory Feedback in Simultaneous Pattern Processing*. *Front.* Comput. Neurosci. Conference Abstract: Bernstein Conference on Computational Neuroscience .doi: 10.3389, 2011

Achler T, *Processing and Plasticity Implications of Large-Scale Feedback Inhibition*, Gordon Conference on Circuits and Plasticity, Providence RI, 2009.

Achler, T., Beshers S., *Pattern Recognition with Non-Oscillatory Dynamics*, Society for Neuroscience, Chicago IL, 2009.

Achler, T., *Plasticity Without the Synapse: A Non- Hebbian Account of LTP*. Society for Neuroscience, Washington DC., 2008.

Achler, T., Amir, E., *A Novel Classification Method Using Self-Regulatory Feedback Networks*, Brain Inspired Cognitive Architectures, Washington DC, 2008.

Achler, T., *Object Classification with Recurrent Loop Networks*, 10th Tamagawa-Riken Dynamic Brain Forum, Hakuba, Japan, 2007

Achler T., Torralbo A., *Recurrent Loop Model of Cognitive Effects on Recognition*, Proceedings of 16th Annual Cognitive Neuroscience Meeting, New York, NY, 2007.

Achler T., *Input Shunt Networks and Biased Competition*, Proceedings of 10th Annual Computational Neuroscience Meeting (CNS), San Francisco and Pacific Grove, California, 2001.

Achler T., *Input Shunt Networks, Biased Competition and the Search Task* Proceedings of 5th International Conference of Cognitive and Neural Systems (ICCNS), Boston, 2001

FELLOWSHIPS/AWARDS

Outstanding Poster Award to Synthetic Cognition Research Group, Laboratory Directed Research and Development (LDRD), Los Alamos, Sept 2011

Outstanding Poster Award, Los Alamos Postdoc Research Symposium, June 2011

Postdoctoral Research Fellowship Award, National Geospatial-Intelligence Agency, *Feedback-Network Based Recognition Model*, 2006-2009, **$360,000**.

Conference Funding Awards: Discrete Mathematics and Theoretical Computer Science Conference, 2008; Dynamic Brain Forum, 2007; Neuromorphic Engineering Workshop, 2002; 5th International Conference Cognitive & Neural Systems, 2001; 10th Computational Neuroscience Meeting, 2001.

PROFESSIONAL ORGANIZATION ACTIVITIES

Program Committee (2011) Biologically Inspired Cognitive Architectures Conf; **Demonstration Chair** (2010) & **Organizing Committee** (2009, 2010), Artificial General Intelligence Conference

Editor: Journal of Artificial General Intelligence, 2007 - Present

WORKSHOPS

Metrics for 'Human Level' AI, Organized conference discussion on strategies to evaluate AI algorithms for efficiency and robustness. IEEE Joint Conference on Neural Networks IJCNN, 2009.

TUTORIALS

Plasticity Revisited: Motivating New Algorithms Based On Recent Neuroscience Research Conference tutorial**,** International Joint Conference on Neural Networks (IJCNN), 2009.

ACADEMIC EXPERIENCE

Prelim and Defense Committee Member for Computer Science PhD Student Nana Arizumi. *Emergence and stability of complex structures from stochastic neuronal networks evolving under STDP rules*, University of Illinois Urbana Champaign.

TEACHING EXPERIENCE

Multidisciplinary Perspectives on Recognition Processing *(MIP 595)* Aug - Dec 2008: Graduate seminar course reviewing neuroscience, medical, cognitive findings, practicality issues such as combinatorial explosion, superposition catastrophe and evaluation of computational algorithms.

Neurophysiology Laboratory *(Physl 416)* Aug - Dec 2002: Graduate-level invertebrate Neurophysiology. Teaching Assistant. Design and implement hands-on experiments for students and demonstrate electrophysiology techniques both intracellular and extracellular.

Computational Neuroscience *(Neuro 317)* Jan - May 2002 Advanced Undergraduate level: simulations in neurophysiology and neural networks. Teaching Assistant. Neuron: membrane RC components and channel activation, circuit dynamics. Networks: PDP, Bayesian inference, learning, genetic algorithms.

Physiology Laboratory *(Physl 105):* Aug - Dec 2001 Introductory level: human and animal physiology. Teaching Assistant.

Algorithms in Computer Science *(CS 273)***,** Jan - May 1999 Intermediate Level: Computational Theory and Algorithms. Teaching Assistant. Analysis of algorithms, finite automata, recursively enumerable sets, and computational complexity.

Computer Science *(CS 105)* Aug - Dec 1998 Introduction to Business Computing Applications. Teaching Assistant. Basic Macro Scripts, Spreadsheet and Database Applications.

Computer Science *(CS 110J)***,** Jan - May 1998 JAVA language programming. Java applets, object oriented programming.

PATENT

Feedback Systems and Methods for Recognizing Patterns – Pending.

CORPORATE EXPERIENCE

Software Consultant- Catheterized Heart Blood-Flow Monitor (1996-1997) *Cardiometrics, Mountain View, CA*. Designed and programmed software to determine flow rates in real time from Doppler data, and to test and validate catheter sensors. Integrated separate machines combine Doppler and pressure measurements simultaneously. Programmed in C++

Digital Hardware Simulation (1991-1996) *InterHDL, Palo Alto, CA*. Verify Verilog language digital hardware simulator, wrote hardware simulation libraries to incorporate and ensure correct simulations, Debugged code and Provided technical support. Programming in Verilog and C++

PERSONAL

Citizenships: USA, Canada, Israel

Languages: English Hebrew

Teaching Philosophy and Statement: Tsvi Achler

In my view, student's potentials are often underappreciated. Student's minds are generally clear of bias, their hunches can be novel and during the process of studying their ideas may be original and progressive.

I like challenging students on how they would approach problems and encourage them to generate their own answers. I feel such exercises enrich the depth and breadth of understanding. After their ideas are solidified and expressed, taught material may be more intuitive and better understood. I also like to encourage students to challenge existing views. I believe it is best to teach not only the subject at hand, but also its broad aspects and pitfalls. My teaching experience draws from several perspectives: designing and teaching a seminar course, mentoring, conference workshops and tutorials, and as a teaching assistant.

I enjoy facilitating discussions from the perspectives of multiple fields. I have firsthand experience and training in medical neurology, neurophysiology experiments and cognitive perception & psychophysics studies. I have formal teaching experience in computer science, neural computation, neurophysiology (graduate-level) and physiology (both lab and discussions for each).

I designed and taught a seminar course: "Multidisciplinary Perspectives on Recognition Processing" to study and evaluate recognition processing (evidence, algorithms and constraints) based on multidisciplinary perspectives from Neuroscience, Cognitive Psychology and Computer Science/AI. I designed and organized a workshop "Metrics for 'Human Level' AI". I also designed and gave a half-day tutorial "Plasticity Revisited - Motivating New Algorithms Based on Recent Neuroscience Research" at the IEEE International Joint Conference on Neural Networks.

Advising and mentoring are important aspects of teaching. The highest reward for me is to: 1) see students teaching what I have taught, and 2) see them develop throughout the mentoring process becoming creative and perceptive. For example, I am honored to have mentored a bright undergraduate student, Cyrus Omar with whom I co-authored a paper. He received a prestigious NSF Graduate Research Fellowship. I also worked with two graduate students on projects: Dervis Vural and Vivek Srikumar. I co-authored a paper with Dervis and enjoyed learning from them as well. I served as an expert on neural computation on the thesis committee of Dr. Nana Arizumi, formerly a UIUC Biomedical Engineering student. My role was to make sure she appreciates the intricacies and pitfalls of the neuroscience studies upon which she is basing her work.

Lastly, although technically not a direct teaching interaction, I have the honor of having a thesis written by Lester Solbakken of the Norwegian University of Science and Technology based on my original findings. Thesis: "Fuzzy Oscillations a Novel Model for Solving Pattern Segmentation" 2009.

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Teaching efforts of all forms are a fundamental process for academics to organize and motivate the next generation of research.

COURSE EXPERIENCE

Advanced Graduate Seminar:

Multidisciplinary Perspectives on Recognition Processing: Graduate seminar course reviewing neuroscience, medical, cognitive findings, practicality issues such as combinatorial explosion, superposition catastrophe and evaluation of computational algorithms.

Advanced Neuroscience

Computational Neuroscience: Advanced Undergraduate level: simulations in neurophysiology and neural networks. Teaching Assistant. Neuron: membrane RC components and channel activation, circuit dynamics. Networks: PDP, Bayesian, learning, genetic algorithms.

Neurophysiology Techniques: Graduate-level Invertebrate Neurophysiology Laboratory Skills. Design and implement hands-on experiments for students and demonstrate electrophysiology techniques both intracellular and extracellular.

Computer Science: Core, Basic and Intermediate Levels

Algorithms in Computer Science Intermediate Level: Computational Theory and Algorithms. Teaching Assistant. Analysis of algorithms, finite automata, recursively enumerable sets, and computational complexity.

Introduction to Business Computing Applications Basic Macro Scripts, Spreadsheet and Database Applications.

JAVA language programming Java applets, object oriented programming.

Core Biology

Physiology Laboratory Introductory level: human and animal physiology.

GENERAL TEACHING ABILITIES

Core Computer Science, Biology, Medicine, Neuroscience

Supervised Generative Recognition In the Testing Domain

Synopsis of Research, Tsvi Achler MD/PhD

1. Background

The brain forms an unmatched recognition system using the limited resources available inside the head. Current models and algorithms have limited flexibly and do not scale well. Recognition regions of the brain (e.g. thalamus, olfactory bulb, and sensory cortex) have a massive amount of reentrant top-down feedback pathways. Pathways with large numbers of feedback connections may be difficult to analyze and the mathematics can become highly nonlinear.

My central hypothesis that using top-down feedback, recognition centers of the brain reconstruct an internal copy of inputs using knowledge the brain has previously accumulated, in accordance with a class of models called generative models. Subsequently, it minimizes the error between the internal copy and the input from the environment. However unlike most approaches the generative model is not used to help learning e.g. (Hinton & Salakhutdinov 2006) or to generate sparse patterns within unsupervised learning e.g. (Olshausen & Field 1997). In my approach the generative function is used in the testing domain.

More concretely, let's define **X** as a vector of inputs and **Y** as a vector of supervised labels or outputs. While testing, most recognition algorithms calculate a simple feedforward relation of the form **Y=WX.** During learning most algorithms learn a matrix of weights **W** using dynamic equations. My hypothesis suggests the opposite. In the testing domain **MY-X=0** is solved using dynamic equations (the weights **M** are the pseudoinverse of **W**). During learning, weights **M** can be learned using simple Hebbian learning or averaging without complex dynamics. **M** represents expectations which are easier to learn, more intuitive, and closer to symbolic representations. This approach can be shown to have the same fixed points, but is more flexible and the network dynamics during testing inherently display cognitive-like phenomena.

2. Examples of Achievements, Work in Progress, and Goals

My research plan focuses on demonstrating flexibility, biological plausibility, scalability, cognitive properties, and using the feedback to implement more complex recognition tasks. For example:

(1) G*rouping and counting*: unsupervised generative models can show numerosity: the ability to estimate the number of patterns in a scene without individually counting each one (Stoianov & Zorzi 2012). I have previously shown that my approach can show this with supervised labeled mixtures (Achler, Vural, & Amir 2009). It is possible to combine both models to show numerosity ability from feature extraction to supervised recognition.

(2) *Cognitive phenomena*: The dynamics during testing show pop-out and similarity cognitive effects (e.g. Duncan & Humphreys 1989; Wolfe 2001) similar to signal-to-noise effects (Rosenholtz 2001). Difficulty with similarity phenomena can be shown from both a theoretical perspective and through numerical simulation (submitted). My cognitive goals are to also show that asymmetry and other cognitive phenomena may arise from this recognition mechanism.

(3) *Biological plausibility*: the network is implemented and its dynamics during testing can be demonstrated in spiking integrate-and-fire neurons (to be submitted). My goals are to further implement this in more detailed neural models.

3. Multidisciplinary Collaborations, Discussions, and Education

I believe multidisciplinary perspectives are essential to understand recognition processing. To this end I studied, worked and participate in various related disciplinary settings: Neuroscience, Neurology, Cognitive Science, Computer Science, and Applied Mathematics. At University of Illinois I designed a course "*Multidisciplinary Perspectives of Recognition Processing*", organized a conference tutorial "*Plasticity Revisited: Motivating New Algorithms*" and a conference workshop ("strategies to measure algorithm robustness "AI-IQ"). Continuing these efforts I intend to address multidisciplinary issues and encourage students with varied skills as an integral part of my lab group.

4. Summary

The overall goal of my research efforts is to attain a robust and unified understanding of recognition processing, top-down feedback, and internal reconstruction. Ultimately the goal is to use these findings to dynamically predict and interact with brain processing.

5. References

Achler T, Vural D, Amir E (2009). Counting Objects with Biologically Inspired Regulatory-Feedback Networks. *Proceedings of the 2009 IEEE International Joint Conference on Neural Networks (IJCNN'09).*

Duncan, J., Humphreys G. W. (1989) Visual-Search and Stimulus Similarity. *Psychological Review* 96(3): 433-458.

Hinton, G. E, Salakhutdinov R. R. (2006).Reducing the dimensionality of data with neural networks. *Science* 313(5786): 504-7

Olshausen B A, Field D J, (1997) Sparse coding with an overcomplete basis set: A strategy employed by V1? *Vision Research* 37:3311-3325

Rosenholtz R., (2001) "Search asymmetries? What search asymmetries?" *Perception & Psychophysics*, 63(3), 476-489,.

Stoianov I, Zorzi M (2012) Emergence of a 'visual number sense' in hierarchical generative models *Nature Neuroscience* 15, 194–196

Wolfe, J. M. (2001) Asymmetries in visual search: An introduction. *Perception & Psychophysics* 63(3): 381-389.