Neural Networks for Robots, Signal Processing and Control Theory - Random, stray thoughts

Bill Howell, 13Oct2013

Here is a quick overview of some of the neural network [concepts, themes] that interest me in relation to control theory, with some mention of robotics and signal processing. The intent is to have something on hand for occasional discussions with friends, and perhaps more importantly as a "conceptual snapshot" for my own use. The snapshot will be a reminder of key themes I may want to revisit in several years, and as a benchmark of changes in my own thinking and progress with time, and whether or not I had "focused on the right things" (for me).

The document is perhaps too long, lacks depth, and wanders all over the place, and no doubt there are gaps and omissions in the writing. I suggest that you merely look at the Table of Contents of the document, and if you see anything of immediate interest glance through it. Probably less than a fifth of the content of this note, and perhaps none, will be of interest to graduate students in control theory and robotics, and those who are interested probably know more about the themes than I do. Still it sometimes helps to see a different perspective on a familiar subject, and to be occasionally reminded about "fringe" ideas that get lost with our priorities and deadlines...

Also, note that I've only scratched the surface of neural network based controls. There are many papers each year at IJCNN and other conferences,and of course in the journals. I only attended a few control-related presentations at IJCNN 2013 last August, as my main focus was to learn much more about models of cognition, spiking neural networks, and the results of NN competitions. Still I've used IJCNN 2013 material as examples in several places.

Status :

- 15Oct2013 first draft, email

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1. Introduction

Robotics isn't an area that I follow directly, not because it isn't of at least some interest to me, but because :

- I am already spread far too thinly across too many areas of "hobby interests"
- Many of my core interests are, for me, at a more fundamental level of understanding information processing and analysis, for machines and ultimately for biology.

However, robotics is one of the key areas that challenges and drives advances in those "fundamental areas" I refer to above, as well as forcing the development of new fundamental concept areas, and robotics will continue to do so for some time. Given the huge difficulties with tackling the "holy grails" of biology (in particular brain function as with [senses, recognition, planning, motor actions, cognition, behaviours, consciousness, personalities, etc]), perhaps robotics will be an easier domain for [testing, developing, advancing], but it's very important to keep in mind that [biology, neuroscience, psychology, sociology, etc] have long been the basis for many if not most of the advanced concepts of today. This is something that is not always well-appreciated, but more and more engineers are picking up on it. Actually, I'm probably out of date- is this a common or dominant awareness among engineering students today? I'm so used to "wandering in the wilderness on the fringes" that it's hard to forget that yesterday's lunacy (eg neural networks up to the mid-to-late 1980's) are not only recognised as being (sometimes) useful, they are even applied now.

As Goran Anderson, who I met in the "Mining Automation Program" (MAP) said :

> *"... We always over-estimate the potential of new research projects on the short term, and drastically under-estimate its potential and implications on the long-term. ..."*

I like to forrce myself into a mentality of :

> *"Multiple conflicting hypothesis, Multiple conflicting communities"*

It helps to keep me from being myopically focused on dead-ends, and from being restricted in my thinking to what is familiar to me. It also helps to reduce my chances of becoming a tool or disciple of a theory and its community of worshipers, rather than the theory being simply a tool that I may or may not want to trust or use.

Although neural networks has only been a hobby for me,it's a very serious hobby. Only occasionally have I "done anything", but a lot of conference assistance, paper reviews, and a couple of formal publications :

> *D. Prokhorov, D. Levine, F. Ham and W. Howell, guest editors "IJCNN2005", Neural Networks, Volume 18, Issues 5-6, Pages 457-860 (July-August 2005)*
>
> *William Neil Howell 2006 "Genetic specification of recurrent neural networks: Initial thoughts", Proceedings of WCCI 2006, World Congress on Computational Intelligence. Vancouver, paper#2074, pp 9370-9379, 16-21 July 2006*

2. Key themes that come to mind for really advanced control theory

The list of items below is somewhat arbitrary,and is mostly related to what has excited ME over the years, with an emphasis on recent items (not the least because my memory is bad, so things tend to drift off into a fog after several years). The literature on neural network applications to control is huge, and the results SEEM (to me anyways) to be getting hugely better with time.

Possibly because friends at the IJCNN conferences have been hitting me over the head for more than 20 years, my sense is that Approximate Dynamic Programming (ADP) is certainly one of the top themes in this area, so I have put it first in the list, and if you aren't aware of it, and only have time to look at one item, my recommendation is to look closely at this one!

I've attached a few early papers on ADP and its variants. It took some time and sweat to get the ideas up and running...

2.1 Approximate Dynamic Programming (ADP) : Self-[Adapting & Optimizing] systems

As a very short description, ADP is an approximate means of solving optimal control theory for non-linear systems, using the Hamilton-Jacobi-Bellman equations for optimal control, and empowered by recurrent neural networks, often arranged according to - you guessed it - actor-critic concepts taken psychology! I've attached a few early papers on the subject (out of many!).

I'll start off just by mentioning a few of the scientists I've met over the years at the IJCNN conferences, and who have been pioneers in the ADP area. They all have interesting and inspiring stories besides the few points that I mention. Of course, there are far many more great researchers in this area that I don't mention.

Paul Werbos, National Science Foundation (NSF-USA), Director or something **-** Paul Werbos is the "visionary"who most developed the conceptual basis for ADP and its variants, but he also is the person that established the mathematical basis for "ordered derivatives" in his PhD thesis of ~1974, now called "back-propagation" following it's re-discovery in a much more restricted and limited form by 3 separate groups circa 1986. In one of the ironies of neural network history, the second professor that Werbos eventually approached to supervise his PhD thesis was Marvin Minsky of MIT, sort of the "godfather of Artificial Intelligence". But in a ?1967? paper, Papert and Minsky "mathematically proved" that a two-layer neural network could not do anything substantive" (as needed in advanced AI), so he turned Werbos down. Perhaps Minsky could have been the godfather of AI and CI if he had decided otherwise, but then perhaps that was not a good fit anyways?

Anyways, a key thing to keep in mind is that both back-propagation and ADP were inspired by a desire to explain and model the brain, and these concepts were developed from theories in psychology, notably Freudian (if I remember correctly). That was a BIG lesson for me, as I had never been comfortable with psychology in general, and Freud in particular. So I had to shut up and listen, and learn. (I'm still not keen on Freud and Carl Jung, but at least I can appreciate them better).

Donald Wunsch, Missouri Uof Science and Technology - Don's a great leader and teacher, as well as being open-minded and fearless in attacking tough problems. One very interesting, long-standing projectof his is to develop the first effective (expert or grandmaster level, I assume, but just decent would be an accomplishment apparently) automated Go system.

Lee Feldkamp, retired from Ford Motor Research (kind of a skunk works group) , Danil Prokorov (I think he did some PhD or post-doc work under Don Wunsch, now he's Manager off CI research at Toyota) - I've attached a number of Prokhorov's papers, which are early summaries of the concepts (George Lendaris of Portland State also produced early papers describing ADP and it's challenges). Lee and Danil also focused (among other things) on the use of Unscented Kalman Filters to train Recurrent Neural Networks (RNNs). At IJCNN 2007 Orlando, it was interesting to see the stunned reaction by experts in advanced control theory who came from several automobile company labs, when they saw Prokhorov's efficiency gains with the already-very-efficient Toyota Prius hybrid car.

> *D. Prokhorov, Prius HEV neurocontrol and diagnostics, Neural Networks, 21 (2008), pp. 458-465. (An early version of this paper received IJCNN 2007 Best Paper Award, Orlando, FL, August 2007.)*

Kumar Venayagamoorthy, Memphis U - If I remember correctly, Kumar did his PhD under Don Wunsch, and won several major grants and awards as a young scientist in this area. He now heads a new group at the University of Memphis, with a special emphasis on the "Intelligent Electrical Grid".

He mentioned in August that, after many years of trying, they now have a regional grid that is willing to test the concepts.

Jennie Si - Jenny was General Chair for IJCNN 2007 Orlando FL (and my boss for that particular summer vacation, as I was Publicity Chair). Perhaps 5 years ago, she branched out from advanced engineering controls for hardware (like Apache helicopters) to including “wet work” - the interpretation of single-neuron electrode studies, for applications such as Brain-Machine Interfaces (BMIs).

Derong Liu - Although I've worked indirectly with Derong on IJCNN organisation, and met him many times, I'm less familiar with his hugely productive work. He is the General Chair for IJCNN 2014 Beijing, and Jenni Si is Technical Chair. More indication that not only is the ADP concept proving out, but that most of the early leaders in the is area are also leaders in the neural network community at large!

Frank Lewis - A unification of the Adaptive AND Optimal control communities

I've attached my mid- August draft comments on Lewis' Plenary in Appendix 1, so here in the main body of the document I will only post the abstract that appeared in the conference program, which is self-explanatory :

> **Abstract for Frank Lewis' Plenary Talk at IJCNN 2013 Dallas Texas**
>
> “Neural Network Reinforcement Learning Structures for Real-Time Optimal Feedback Control and Games” Frank L. Lewis, University of Texas at Arlington
>
> This talk will discuss some new neural network (NN) structures for the design of automatic feedback controllers for continuous-time dynamical systems. Optimal feedback control design has been responsible for much of the successful performance of engineered systems in aerospace, industrial processes, vehicles, ships, robotics, and elsewhere since the 1960s. Optimal feedback control design is performed offline by solving optimal design equations such as the algebraic Riccati equation. It is difficult to perform optimal designs for nonlinear dynamical systems since they rely on solutions to complicated Hamilton-Jacobi-Bellman or HJI equations. Finally, optimal design generally requires that the full system dynamics be known. Methods known as adaptive control have provided powerful techniques for online learning of effective controllers for unknown nonlinear systems. However, optimal control design and adaptive control design have traditionally represented two different philosophies that have not been unified:
>
> *Optimal Adaptive Control Using NN***.** In this talk we unify adaptive control and optimal control using NN and reinforcement learning (RL) ideas. We show how neural network structures can be used to design a novel class of adaptive controllers that learn the solutions to optimal feedback control problems in real time without knowing a full dynamical model of the controlled system. In the linear quadratic case, these algorithms learn the solution to the ARE by

adaptation along the system motion trajectories. In the case of nonlinear systems with general performance measures, the algorithms learn the (approximate smooth local) solutions of HJ or HJI equations.
Reinforcement Learning has traditionally been applied for feedback control design only for discrete-time systems. A novel approach known as Integral Reinforcement Learning allows applications of RL to continuous-time linear and nonlinear dynamical systems. IRL leads to a new form of Bellman equation that can be used to design adaptive controllers based on actor-critic mechanisms that converge in real time to optimal control and game theoretic solutions.

Multi-Player Differential Games. New algorithms will be presented for solving online non zero-sum multi-player differential games for continuous-time systems. We use an adaptive control structure motivated by reinforcement learning policy iteration and implemented using NN. The result is an adaptive control system with multiple tuned control loops that learns based on the interplay of agents in a game, to deliver true online gaming behavior.

2.2 Lydia Kavricki - Robotics for Proteomics

I just saw this at IJCNN 2013Dallas TX, and it caught me completely by surprise. What a beautiful example of “cross-over of ideas!” It also shows how working on engineering control systems has such huge, broad implications,more so with today's advanced NN-based control concepts! It's a career expanding potential.... so keep your eyes open! Rather than make uninformed comments, I simply attach Kavraki's abstract :

Abstract for Lydia Kavraki's Plenary Talk at IJCNN 2013 Dallas Texas

Over the last decade, the development of robot motion planning algorithms to solve complex geometric problems has not only contributed to advances in industrial automation and autonomous exploration, but also to a number of diverse fields such as graphics animation and computational structural biology. This talk will discuss the state of the art of sampling-based motion planning with emphasis on work for systems with increased physical realism. Recent advances in planning for hybrid systems will be described, as well as the challenges of combining formal logic and planning for creating safe and reliable robotic systems that can interact with humans. The talk will also demonstrate how the experience gained through robotics planning has led to algorithmic tools for analyzing the flexibility and interactions of molecules for the discovery of new medicine.

2.3 *Walter Freeman's "stochastic chaos", EEG, and the brain*

Walter Freeman has long developed beautiful experimental result, mathematics and theories from his EEG and olfactory work that is the penultimate of "connectionist" thinking and chaos theory for the brain. I bought the most recent book he co-authored (below), but haven't had a chance to read it yet. He has been a key contributor to Asim Roy's blog on concept cells (Brain Representation SIG, from 20Aug2013 to present), which features the perspectives of radically diverse thinking regarding the current connectionist (like Freeman) or symbolic (past but perhaps resurrecting) ways of interpreting how neurons and the brain work. Whether or not you like the idea, I think his work is fantastic, and worth being aware of.

> Walter J. Freeman, Rodrigo Quian Quiroga 2013 “Imaging brain function wth EEG: Advanced temporal and spatial analysis of electroencephalographic signals” www.Springer.com 248pp ISBN 978-1-4614-4983-6

I was held up on something or other, and came in at the very end of Walter's presentation, catching the questions that followed. However, I've attended many of his presentations at past IJCNNs, and I've gone through several papers. I can't say that I've worked with his models, nor that I have a full grasp of what he (and Robert Kozma, who was General Chair (my boss as Publicity Chair) for IJCNN 2009 Atlanta), but a key issue is that his models are able to general “near-instant” responses that seem to violate neuron delays that would result from conventional approaches.

While Freeman's thinking is not control-centric, it is of such a radically different nature from conventional science and engineering, and has perhaps (or perhaps not) great future potential, that I think it is important to be aware of it.

> **Abstract for Walter Freeman's talk at IJCNN 2013 Dallas Texas**
>
> Dynamics of Cortical Neuropil is Gas-like in Sensation, Liquid-like in Perception
> Walter Freeman, University of California at Berkeley; Robert Kozma, Memphis University; Roman Ormandy, Embody Corporation; Giuseppe Vitiello, Universita di Salerno
>
> During intentional behavior perception proceeds cyclically from predicting through sampling, sensing, categorizing, recognizing, and updating the prediction, closing an action-perception cycle. Each cycle begins with a search for sensory information in all modalities. A set of Bayesian probabilities forms by preafference, which specifies an attractor landscape in every sensory cortex that predicts the likely outcomes of impending sampling. A learned stimulus excites sensory receptors that ignite a Hebbian assembly in each modality, which generalizes over equivalent sensory neurons and abstracts to a category. The assembly guides the cortical trajectory into the basin of the appropriate attractor, and the ignition provides the transition energy required to cross the boundary between the pre-stimulus and signal basins [2].
>
> Vigorous firing of selected neurons from sparse, ‘gas-like’ random background firing signals sensing. A burst of gamma oscillation signals recognizing by generating a carrier wave that synchronizes the firing of all neurons in each cortex. Local firing rates are above or below the mean rate, giving a spatial pattern of amplitude modulation (AM) that carries the memory of the stimulus [2]. The wave packet manifests a ‘liquid-like’ state, owing to the high density of neural activity, as revealed by the probability of neural firing conditional on local electrocorticographic wave amplitudes. All sensory systems send wave packets to the entorhinal cortex, which integrates them into a gestalt, passes the gestalt through the hippocampus for labeling by time and place of formation, and returns to every cortex a sample that updates expectancy [2].

We postulate that the crucial step from categorizing to recognizing is mediated by a cortical phase transition [3, 4], by which the electrical energy density in the neuropil rises above a threshold, such that neuronal interactions are done by ephaptic transmission [1] that then accompanies synaptic transmission. We have modeled the process by describing the liquid-like phase as a Bose-Einstein condensate [3], which synchronizes all charged particles, including the water dipoles in and between the neurons and glia. We think the two phases may conform to collective electrodynamics [5]. Our complementary model uses random graph theory [4]. Our experimental evidence includes the extreme speed phase transition; the non-locality of the categorizing information; the extreme density of energy use [1]; the power-law distributions of background activity that manifest criticality; and the null spikes of power between wave packets manifesting singularity [2] required to dissipate preceding AM patterns. We conclude that the liquid-like phase can explain the richness of memories in flashes of insight, and the high energy cost.

1. Capolupo A, Freeman WJ, Vitiello G (2013) Dissipation of ‘dark energy’ by cortex in knowledge retrieval. Phys Life Rev: in press, http://www.sciencedirect.com/
2. Freeman WJ, Quian Quiroga R (2012) Imaging Brain Function with EEG. NY: Springer.
3. Freeman WJ, Vitiello G (2006) Nonlinear brain dynamics as macroscopic manifestation of underlying many-body field dynamics. Phys Life Rev 3:93-118.
4. Kozma, Puljic M, Balister P,Bollobas B, Freeman WJ (2004) Neuropercolation: A Random Cellular Automata Approach to Spatio-Temporal Neurodynamics. LNCS 3305:435-443.
5. Mead C (2000) Collective Electrodynamics. Quantum Foundations of Electromagnetism. Cambridge MA: MIT.

Others HAVE applied chaos mathematics to robots, and you may have already through papers in that area. The one example that I remember (because I had to read and assess the paper as part of the “Best Paper of the conference” committee for IJCNN 2009 Atlanta) applied chaos to robot navigation (I hope that I have the right reference here!) :

To me, this area of chaos relates as well to the subsection below “3.2 Randomness is your friend”, with a special emphasis on echo state networks (also neural gas, liquid state machines).

2.4 Machine Consciousness

This may look way out of place in a commentary on control theory, but don't do what I did - run away from this for >10 years, not having any psychology background or confidence in the potential for the subject. It's now apparent to me that consciousness is a ROBOT REQUIREMENT for the long term!

But for now, I'll just mention two people who remind me of this :

- John F. Taylor - BIG figure in neural networks, and originator of the only theory for consciousness that I'm even half-ways comfortable with! He died in March 2013, and a whole day's tribute was paid to him at IJCNN 2013!

- Edgar Koerner, Honda Research Center, Europe - story of Asimo

2.5 MindCode

2.5.1 Howell's long-time, never-advancing hobby project

This is waaaayyy off track, but it is one of my own greatest interests in the neural network area. Simply put, instinct shows a level of "pre-programming" at all levels of [data, function, etc etc] in the brain, and the plateauing advances of NNs may reflect the emphasis on learning and evolution, without taking advantage of 570 My of evolutionary power that is already there! This is reflected in some of my comments to Asim Roy's "Brain Representation SIG". I prefer to refer to the draft version of a concept paper I did for IJCNN 2006 Vancouver. In spite of its [spelling, grammar, structure, incompleteness] as compared to the final reviewed and published version, it is broader and deeper in some key areas :

> William Neil Howell 2006 "Genetic specification of recurrent neural networks: Draft - with errors and incomplete, not peer reviewed, unpublished" http://www.billhowell.ca/Neural%20nets/Howell%202006%20-%20Genetic%20specification%20of%20neural%20networks,%20draft%20concepts%20and%20implications.pdf

I'll cut commentary off for the topics below, as I'm out of time. But these concepts really fit in well with “MindCode” :

2.5.2 Jun Wang of Chinese University of Hong Kong - Tutorial on hand-crafted neural networks for robotic control

2.5.3 Molecular memory, from Francis Crick through Bernie Widrow

I have a few great stories on this!! (John Mattick of the University of Queensland, MichaelMeanyofDouglasHospital McGill University- includigLamarckianversus Mendelian heredity, …).

2.5.4 Gary Marcus' “Kluge”

3. Basic Tools

Given that I've already spent more time than anticipated with the is note (I've been far too verbose, as usual),

3.1 Signal Processing

NRC scientists : Best language translation (5 to 10 years ago if not now), was based on a signal processing technique that treated one language as errors in the other. I never looked into it

Information Theoretics (Thermodynamics of information processing)
Jose Principe of the Uof Florida is one of many doing beautiful work in this long-standing area. His concept of "Correntropy" is of particular fascination to me!

Harold Szu's derivaton of Hebbian Learning (a foundation of neural networks and neuroscience)
Hebbian Learning is a very old, fundamental principle of psychology (neuroscience) which is still applied today in neural network theory and techniques. Harold derived this purely on the basis of information theoretics - in a sense, the "Thermodynamics of information and thought". So electrical engineers and computer scientists need thermodynamics just as much as the mechanical and chemical engineers!

3.2 Randomness is your friend

This area is hugely important, underlying many of the concepts in this paper, similar to the basic underlying importance of evolutionary theory. It deserves far more comment, but perhaps for some later day... But one quick quip of mine (see one response to this in "Particle Swarm Optimisation" below) :

> *"... Any system capable of [modeling, predicting, controlling] "sufficiently complex" systems, MUST HAVE as one of it's key components (but not the only key component) a stochastic process. Note that this arguably means the systems cannot be entirely [rational, logical, scientific]. ..."*
> [Howell - I forget which year - probably ~2005)

Reservoir Computing - Echo State Networks and Extreme Learning Machines
The stunning (but perhaps limited) results in this area are a HUGE hint for my MindCode interests. More to come in the future!....

Particle Swarm Optimization (PSO)
The surprising and strange effectiveness of PSO, as well as evolutionary computation, is a great example of the importance and effectiveness of randomness. Cheating / game theory should be as well, but I personally haven't run across papers on this. I'll look for them one day …

Russell Eberhardt and Jim Kennedy received an IEEE career achievement award at IEEE-CISDA 2012 Ottawa that I attended. He had an interesting response to my randomness quip above :

> *"... No Bill, not stochastic - chaotic. ..."*

At the time he hadn't yet published a paper on this, buthis critique is correct - stochastic is extreme. However, it'sthe penultimate andmay be necessary in some situations, as Walter Freeman believes is the case for brain operation.

Chaos theory - eg Walter Freeman
There is much more to chaos theory and it's implications than I mention in my comments on Walter Freeman's work above.

Other
At IJCNN 2013Dallas TX, I took two 2-hour tutorials centered on neural networks with built-in concepts of randomness, albeit Gelenbe (from quite a few years back) used probability in a more general sense rather than have it as a basis for neuron function. This is just to show that there are many different ways in which researchers keep coming back to randomness.

Richard Windecker tutorial "Stochastic artificial neurons and neural networks"
Erol Gelenbe tutorial "Random Neural Network and applications in engineering and biology"

4. Fun topics

As with other sections,I'm out of time and will cut this short - simply listing some ideas.

4.1 Cheating theory, Game theory

There are important AND spooky lessons here, but I'm out of time!

Examples :

- Deep Blue versus Kasparov
- Blondie24 versus Checkers Player
- Chinese game of Go Donald Wunsch

4.2 Social Media

You might think this topic has nothing to do with control theory, but although you might be correct "for now", I think you would be dead wrong for the long term, and for ANY of the most powerful concepts and future capabilities in that area. his will likely go beyond the science fiction writers (not the dark stories, the fun ones). Emergent machine intelligence (like computer viruses as the first great examples of artificial life) is also an expectation I have for this area. Anyways, here is a set of reports I did for a project at work on social media :

Howell 2011 – Social graphs, social sets, and social media (63pp ~25% finished), http://www.gcpedia.gc.ca/gcwiki/images/9/90/Howell_2011_%E2%80%93_Social_graphs%2C_social_sets%2C_and_social_media.doc - Social graphs and social sets, including dynamics - Nothing has been done yet on this paper, which is far more challenging and advanced than any of the others. It does, however, tackle issues at the heart of the "new" social media (Facebook, Twitter like systems), as well as elaborating more advanced concepts *(some of which have "placeholders" in the "Semantics beyond search" paper).*

Howell 2011 – Semantics beyond search (version 110905 Howell, 30pp ~25-30% finished), http://www.gcpedia.gc.ca/gcwiki/images/a/a6/Howell_2011_%E2%80%93_Semantics_beyond_search.doc - the intent here is to force open everyone's thinking on the potential impacts and applications of semantics. (posted 06Sep2011, authored by Howell)

Howell 2011 - How to set up & use data mining with Social media.doc (15pp ~20% finished), http://www.gcpedia.gc.ca/gcwiki/images/c/ca/Howell_2011_-_How_to_set_up_%26_use_data_mining_with_Social_media.doc - A very large and diverse set of data-mining tools and systems are available for a wide range of needs, and it is not the intent of this document to overview the toolsets for data-mining. Instead, several "under-the-hood" capabilities (HOW) are discussed as are WHAT we might be seeking to achieve with Data-mining and Social Media.

Howell 2011 – Systems design issues for social media (version 110902 Howell, 18pp ~20% finished) , http://www.gcpedia.gc.ca/gcwiki/images/c/c6/SPINE_%E2%80%93_Systems_design_issues_for_social_media_110902_Howell.doc - Although a framework and a fair amount of comment has been produced for this paper, I do not have sufficient breadth to complete this on my own. However, I will be looking for others to either input or produce their own work, and I can raise a lot of issues and "provocations" that I hope to get others to respond to.

4.3 Telerobotics

Medicine is a great example of tele-robotics and haptic controls. Once effective "basic systems" are in place, look for great opportunities to augment these systems with much more aggressive "controls", such as ADP approaches! We may have to wait for the "old dogs to die" for that to happen, though.

Mining Automation Program (MAP)
I was the Secretary for the latter half of this project. INCO (nickel mining), Sandvik Tamrock (mining vehicles), Dyno Nobel (explosives), and Natural Resources Canada (Canadian government lab) collaborated from ~1995 through 2000 in a major initiative to advance the potential for automated-teleremote underground equipment for the "drill-blast-muck" cycle. Productivity and safety advances were the target. Greg Baiden of INCO(now at Laurentian U in SudburyON) was the visionary for this project. Mining is an extremely tough environment for equipment, and the challenges underground are huge. But it made for an extremely interesting challenge for automation technologies,even though nothing like ADP was applied. It's interesting to note that many challenges for space exploration are similar to mining, so Baiden helped with NSF-USA reviews of projects they funded. For example, serious latency drives the need for great autonomy of the remote system.

4.4 Anti-Engineering and Anti-Murphy's Law

Put very briefly, the implantation of arrays of electrodes in the brain (rats, monkeys etc) leads to systems that control robot arms etc to a degree not possible with current control theory. This occurs when all of the brain systems are poorly understood (in spite of many claims to the contrary), and even the interfaces are a shot in the dark. Every engineer knows that Murphy's Law kicks in, and that to get a complex system to work, you really have to understand and model it well!

The initial successes with electrodes exhibits "anti-engineering", in the same way that life might seem to violate thermodynamics - especially the third law (entropy)!

4.5 Confabulation versus Baysian Statistics

Robert Hecht-Nielson's "Confabulation theory" still fascinates me, although most scientists in neural networks that I've talked to don't like it and don't think it's anything new (just statistics). They may be wrong (even if it's more likely that I am). Hecht-Nielsen sure had a rallying cry :

> *"... Our advice to you, is to drop what you are doing, to start your research (in this area) immediately, and never look back. In a few short months, you will hear the starter's pistol far behind you, unleashing the greatest intellectual land rush in history. ..."*

That hasn't happened yet, several years later, but who knows? But one fascinating aspect of his work is the statement that much, if not most, Bayesian statistics ISN'T Bayesian, it's confabulation! This led me to call to friends and colleagues :

> *"... Who wants to join me in a rebel, intellectual-suicide attack on Bayesian statistics? ..."*

No takers so far, and I don't know why.

> *Howell 2011 - Confabulation Theory, Plausible next sentence survey (version 110903 Howell, 31pp 100% finished), http://www.gcpedia.gc.ca/gcwiki/images/9/95/Howell_2011_-_Confabulation_Theory%2C_Plausible_next_sentence_survey.doc - Confabulation Theory: next plausible sentence - This is my home project from 2007-08, which I think is a wonderful example to "blow the lid off thinking" on semantics. Note that this is also posted on my home website, having been the last small part of a home project, albeit with "cleanup" of the document here at NRCan. If you are interested in this type of thing - try this out on your colleagues, friends or family… Even if you don't want to do the exercise through your friends, the concept of Confabulation itself is advanced enough to get you thinking. (I circulated this to several SPINE team members).*

4.6 Throwing out the foundations of 20th Century Physics?

Although this is way off topic, I though it appropriate to mention, for Electrical Engineers, my interest in crazy-but-not-crazy alternative theories for fundamental theoretical physics, which could result in the rejection of key foundations of 20th century physics, notably Relativity theory and quantum mechanics (but potentially anything else as well). The latter I haven't looked at in detail, but a starting point for serious work for me will be to critically go through William Charles Lucas' "Universal Electrodynamic Force" concept and its derivatives. In essence, the theme is that the 4-vector Heaviside formulation that well call "Maxwell's equations" is an incomplete simplification and approximation of Maxwell's full 20 equation collection from other scientists, and is missing one or two conceptual cornerstones. I still have to do my own work on this, but I have a limited set of comments on this and other physics topics on my website at the following link :

> 17Jul11 Natural Philosophy Alliance conference, College Park Maryland 05-08Jul11
> - As I could not afford to go to my annual IJCNN neural network confernece this year, I went to the NPA conference, which this year accomodated the "Electric universe" community, which I have beeen looking at for both Historical modeling and Solar system - Earth Sciences modeling (especially climate). Many (not all) in the NPA are critical of Secial Relativity (SR) and General Relativity (GR), as I am, and hosts a great diversity of concepts on gravity, structural physics, and other topics. This documents summarizes many key points that interested me, and is dedicated to my mother and father's 60th wedding anniversary in September 2011.

Almost all ideas I work on are probably wrong, but one or two ideas among millions might be less wrong than the dogmas of mainstream, consensus science. In any case, I findthat I often learn more from theories that are wrong, as their proponents go through anomalous [data, analysis, models, theories] and point out [incoherent, misleading] aspects of the prevailing scientific religions.

5. Evolutionary Computation and Fuzzy Systems : Quick comments

This whole note is centered round a few selected neural network themes loosely related to signal processing and control theory, but I have ignored conventional control theory, and the the two other (of 3) main (classical) branches of Computational Intelligence (CI) : Evolutionary computation and Fuzzy systems. There are many other concepts in the area of CI, of course. Particle Swarm Optimization (PSO) was mentioned above, but Cultural Algorithms, Immune systems, Autonomous Mental Development, Biomimetics, natural computation, and related terms have been popular generic themes for maybe a decade or two. Many new concepts are continually being generated. But it's worthwhile making a couple of short comments on Evolutionary Computation and Fuzzy systems.

5.1 Evolutionary Computation

I do follow (occasionally) evolutionary computation, and I actually suspect that it is a fundamentally more important and powerful tool in general than neural networks, and of course it also has a strong biological [origin, foundation, application].

Of course, a great deal of work has long been dedicated to hybrid systems. A good example is :

> *Nik Kasabov, Evolving connectionist systems: Methods and applications in bioinformatics, brain study, and intelligent machines, London, UK: Springer-Verlag, 2003.*
> A second edition is available, I believe, which acknowledges comments that I had provided to Nik on his first edition.

Others are picking up (independently reinventing, as usual - and that is OK) on ideas similar to Kasabov's and the early pioneers.

From a control perspective, as an example ADP doesn't have to evolve to do an impressive job for very challenging applications. But to me, that is only because I haven't read (or looked for) creative papers on the challenges and limitations of ADP's use, especially with regards to radical changes to the [environments, systems, objectives] being modeled. I suspect that ANY approach to ANY problematic challenge for highly changing conditions has a good chance of benefiting from evolutionary concepts. As an example, in my opinion, evolutionary theory (together with [cheating&game theory, belief systems, time & subject-range limitations]) is a far better descriptor of the actual thinking and behaviour of scientists than the “scientific method” that we mostly hear about.

But this theme really comes on fire from the perspective of my “MindCode” perspective. It's unlikely that you can easily beat 570 My of biological evolution by simple learning/ adapting theories. How does one [effectively, efficiently, quickly] integrate hugely diverse [data, functionalities, operators, consciousness, behaviours, personalities] then to [recognize new challenges, strategise, plan, execute, re-define self, etc etc]? This applies control theory as well as many other contexts.

I suspect that evolutionary concepts will be one of the core, critical components of any [successful, competitive] “advanced” control system at sometime in the future, other than for very simple challenges!

5.2 Fuzzy Systems

Although I've read a bit on fuzzy systems, I rarely go through papers in this area and I don't review conference or journal papers on this subject. To me, this theme feels a bit like it is between classical [rational, logical, scientific] reasoning and [connectionist, evolutionary] reasoning. I was most interested in neural networks because of it's vastly closer connection to [biology, neuroscience, psychology]. However, it has been said that neural networks and fuzzy systems are mathematically equivalent, at least in many applications, and if I remember correctly, both are universal function approximators (like [polynomial series, Fourier series, probably quantum mechanics, etc etc].

However, at least for simpler applications, Fuzzy systems have a far more intuitive and interpretable feel to them, in spite of efforts to derive “semantics,” if I can call it that, from neural networks. Human comfort with tools should not be under-appreciated.

Furthermore, as with the discussions in Asim Roy's Brain Representation SIG, Robert Hecht-Nielson's Confabulation Theory, Gary Marcus' “Kluge”, and the need for effective human-machine teamwork, it seems to me that linguistics and communication will be more andmore important topics for robotics research. In that light, Fuzzy systems might be very amenable to the “symbolic side of connectionist and other hybrid' systems. As one example, perhaps Lofti Zahdeh's “Computing with words” may find use - I obtained his presentation from IJCNN ?2003? Portland OR following a short and shallow discussion (given my ignorance!) on that subject and others. But frankly, Hecht-Nielson's Confabulation has the best results that I've seen so far (without looking far & wide, mind you).

endpage

APPENDIX 1 : Howell's impressions : Plenary - Frank Lewis "Neural Network reinforcement learning structures for real-time optimal feedback control and games"

(OR - "A Truce at Last : A Unification of the Adaptive and Optimal Control Tribes?")

Frank Lewis went through the context and mathematical approaches to advanced optimal AND adaptive control that his group has been pursuing, putting them among a very rarified group of scientists, although this may change very rapidly in the near future once the control communities catch on and see successes. This work has formalised key components of the "Approximate Dynamic Programming" area as envisioned by Paul Werbos since ~1991 (as described in a chapter of ?Sonfield &Sorge's? book "Advanced Intelligent Control", and further explained in a 1997 paper by Wunsch & Prokorov "?title?"), and developed and advanced in work by Danil Prokorov & Lee Feldkamp, Donald Wunsch, Derong Liu, and several others.

A key concept of the various forms of ADP is to provide an adaptive approach for the approximate solution to the Bellman-Jacobi equations for optimal control. By exposure to training data, separate neural nets learn the system identification and the control requirements (in some schemes a third NN learns ???). Paul Werbos' series of approaches to ADP (depending on whether normal or differential forms of the signals are used) were inspired by Actor-Critic concepts from psychology, just as Freudian psychology was the inspiration for Paul Werbos' development of the extensive mathematics of the backpropagation algorithm for neural networks in his 1974 PhD thesis (he called it "ordered derivatives at that time, "backpropagation" was the term that arose when very simple forms were re-discovered by three independent groups in circa 1986 (LeCunn, Rummelhardt-McLeland-Hinton, and ?I forget?)). See Stephen Grossberg's comment in a later section for what happens to those who are "... too far ahead of their time ...".

As described by Frank Lewis, neural networks have really established a unique capability for adaptive AND optimal control for non-stationary environments. It is a HUGE advantage NOT to have to spend enormous engineering and scientific resources to "identify" (model) a system in excruciating detail (or perhaps, not as much time?). To me, the question also arises as to whether the "manual, constrained" detailed modeling is a constant source of errors due to :

- "belief system envelopes" that don't match reality (look up climate science for a never-ending carpet of examples of that),
- the INABILITY to spend horrendous amounts of resources to rip out flawed or sub-optimal work and redo it properly, once better analysis/ ideas arise
- the NECESSITY to use over-simplified forms of detailed models, as dictated by the limitations of scientists/engineers in the field, and the limits on maximum time that they can put into a project.
- The RARITY of finding great matches between challenges and the people available to take them on,

- the “closed doors” that always arise for young, new, better minds who threaten the established processes and assumptions.

A particular advantage of the work of Lewis's PhD student ?Druenna?, is that “proofs” of optimality for adaptive ADP-type control schemes are expressed are of the same mathematical form as fundamental theorems in each of the Optimal AND Adaptive controls areas. This should (… at least we hope!!! …) provide a painless means of bringing two long-time warring tribes together (Optimal versus Adaptive). Furthermore, there is absolutely NOTHING preventing the clever integration of conventional hand-constructed models with the ADP approach. The math of ADP has long been solid, and is now even conventionally-based, but it's always dangerous to assume that the [psychology, sociology, religious belief systems] are.

But my guess is that a big sea-change in control theory and practice is finally underway, led once again by the heretics against convention. Let the revolution begin...

APPENDIX 2 : One of Freeman's comments on the Brain Representation SIG

-------- Original Message --------
Subject: Re: [Brain-Representation-SIG] Doges of Cognitivism
Date: Mon, 14 Oct 2013 06:38:53 -0700
From: Walter J Freeman
To: roman ormandy
CC:

Dear Roman,

Thank you for your clear and robust summary of the metaphysical background of the debate in this chat room. Inter alia you have clearly enunciated two of the basic premises on which 21st century neurophysiology, neuropsychology and neurocognition must be based. As a neurphysiologist I will paraphrase you.

First is that brains are thermodynamic systems, not Turing Machines or logic choppers. They generate sequences of dynamic sttates. Some of these states we experience as perceptions, thoughts, feelings and qualia. The states are not representations; they are dynamic operators that create memories and plans and that supervise the action-perception cycle. It is convenient and perhaps necessary for modelers to attach labels to states, naming them as symbols that represent a function to the modeler, but the symbol is in reference to the modeler and not to another part of the brain. In your words the symbols and representations serve as metaphors, not as dynamic state variables.

Second, each of these operators simultaneously operates at multiple levels, so that its material constituents can be measured as pulses, dendritic currents ionic gradients, and electromagnetic fields of potential differences. Concept cells and neural networks have their places in the hierarchy of state mechanisms, especially for the janitorial functions of mindless robots, but as Wolfgang Köhler, Karl Pribram, Gerald Adelman, Joaquin Fuster, I and many other neuroscientists have states, the action-perception cycle is created by the entire brain, taking full advantage of the vast store of stored i integrated information o underwrite each moment of decision.

You mention Cartesian dualism. Descartes’ great achievement was to mathematize brain science. He provided the language scientists needed to describe operations in brains and all other matter. For example, the eye refracts. We compute the 2-E Fourier transform. This is the essence of Cartesian dualism, with or without its religious context.

BW, Walter

-------- Original Message --------

Subject: [Brain-Representation-SIG] Doges of Cognitivism
Date: Sat, 12 Oct 2013 17:12:48 -0700
From: roman ormandy
To: brain-representation-sig

In 1980, Lakoff and Johnson published Metaphors We Live By. Today “Brain is a Computer” metaphor rules the science, while nabobs of cognitivism, just like doges of Venice refuse to look through the looking glass offered to them by neural science.

I am not a scientist, I am a software designer but I was trained in computer science, AI and linguistics in Czechoslovakia before I defected to US. Here I started a 3D graphics software company which I eventually sold to Microsoft in 2008. I became interested in wearable sensors and since these are worn on our bodies I decided to study biology. Steeped in Wittgenstein’s “meaning is use” and Lakoff’s embodied semantics I quickly embraced immunology of Gerald Edelman, neural science of Walter Freeman and psychology of Esther Thelen. It became apparent to me that many cherished cognitivists metaphors are not supported by neural science. Brains are not computers, they do not use symbols, rule based logic, algorithmic computations or information processing. Above all, brains do not make representations of the world.

Soon I found that my colleagues at Microsoft Research did not share my newly found convictions. Worse, I learned that cartesian dualism is pervasive among contemporary mathematicians, physicists and computer scientists. Head of Microsoft vision research considers biology needlessly restrictive, a form of carbon chauvinism, limiting potential for silicon based vision which will surely follow in footsteps of algorithmic silicon based chess players. I admit, I was stupefied as how could this happen. To find an answer, we have to go way back in time.

350 years ago Rene Descartes formulated mind-body dualism and his famous “cogito ergo sum”. His

mathematician and physicist friends, Newton, Leibnitz, Locke and eventually Kant, carried the torch. It was not a coincidence that cartesian thinking blossomed in a world of mechanical clocks. Hot technology of the day, chess playing mechanical marionettes, were very clearly predecessors of modern day AI’s.

150 years later poet Yeats (like Blake) shot back with his famous epigram and declared that “Locke sank into a swoon” and “God took spinning jenny out of his side”. But today modern computer science resuscitated the clock and replaced mechanical brain with a silicon one. In doing so it restored cartesian dualism back to its former glory.

For evidence I want to point to George Lakoff himself. While his “embodied” semantics progressed “from Wittgenstein to Rosch”, it never progressed to neural science. Approached by Edelman and Freeman, he spurned both and embraced the objectivist semantics of static AI frames and fixed neural circuits of cognitive science instead of non-linear dynamics of continuous fields generated by vast population of cortex’s quadrillion synapses.

One would think that cognitivists would build a strong epistemic base for their central premise. Such is not the case. To my knowledge, only one computer scientist, Terry Winograd, bothered to look at modern phenomenology of Heidegger and Merleau Ponty. But you do not have to read Heidegger to realize that something is missing in cognitivists epistemology. In fact, their adherents blind faith that “it must be so” seems to be the rule, rather than exception.

Let me use quotes from Lakoff’s close collaborator Jerome Feldman and his 2008 book From Molecule to Metaphor to illustrate this. I should add that Feldman is not the worst offender by any means, he does not advocate hard AI, rather he advocates Lakoff's embodied approach.

His book starts on page 19th: “*Information processing is often useful because we have rich knowledge of computing*”. “*appropriate information processing perspective allows us to understand the neural basis of language and thought*” (p21) without presenting the evidence why this should be so. He then follows:

“*The information processing stance is extremely common in cognitive science, so much so that it rarely needs to be mentioned. It is simply implicit in much of the research done*” (p37). One can admire this honesty as well as his admission that “*binding problem is a mystery*” (p65) but should science accept a stance just because it is “*extremely common*”?

“*The general idea that mental connections are active neural connections is universally accepted” (p94) “People are generally comfortable with the idea that words or concepts and the connections among them are entities in the mind. It also seems reasonable, in an informal way, to associate each mental concept with some neural structure and imagine conceptual links being captured as active neural connections” (p105)*

“*Key insight is that, for many purposes, the brain can be viewed as an information processing system” (p106). What we need for a neural theory of language is a way to abstract away from the biochemical* *details of brain function while preserving the information processing properties of neural systems that are essential for modeling human language and thought" (p109)*

Once one convinces oneself that information processing is what the brain does it is tempting to tell neural scientist what brain should look like: "*Neurons of the visual system are laid out in the brain in maps", "The auditory cortex has maps organized by tone" (p112). "Conceptual structure is directly captured in neural structure" (p122)* I can think of a few neural scientists who would disagree with the above. Good example also is Feldman advocacy of phonemes which Lieberman disproved in his 2000 paper.

"*For both practical and pedagogical reasons, our computational level models are based on formalism and techniques that are well established in computer and cognitive sciences. Using standard computational ideas makes it easier to communicate with colleagues pursuing different approaches"* (p141)

It would be tempting to comment on the above quotes but larger point is this: "extremely common", "universally accepted", "generally comfortable", "practical and pedagogical reasons" approach could close the door to new discoveries, particularly is they are of a disruptive nature and not conforming to cognitive dogmas.

Feldman, like majority of cognitivists seems to operate on cultural consensus rather than theories falsifiable by evidence. That is why they prefer not to look through the looking glass of empirical evidence coming from the neural science.

Roman Ormandy
Embody Corp

APPENDIX 3 : George Soros on the limits of the scientific method

"Everybody hates a short"

> 02Oct2013 George Soros "The Future of Europe: Remarks delivered at the Global Economic Symposium, 10/01/13 in Kiel, Germany"
> http://business.financialpost.com/2013/10/02/george-soros-the-euro-crisis-might-be-over-but-europes-nightmare-is-getting-worse/
> (Below is only a part of his comments...)
>
> I shall take a holistic approach to the future of Europe. I have developed a conceptual framework, which has guided me in my decisions throughout my adult life. The framework is much broader than the financial markets; it deals with the relationship between thinking and

> reality. What makes that relationship so complicated is that the thoughts and actions of participants are part of the reality they have to think about. Their thinking serves a dual function: on the one hand they try to understand the world in which they live – that is the cognitive function; on the other, they want to influence the events in which they participate – that is the manipulative function. The two functions interfere with each other – I call the interference reflexivity. The cornerstone of my conceptual framework is the human uncertainty principle, which is based on the twin pillars of fallibility and reflexivity.
>
> The human uncertainty principle has far reaching implications for scientific method. It applies only to social phenomena and thereby it separates the social sciences from the natural sciences. Economic theory has sought to imitate the natural sciences, particularly Newtonian physics. Consequently my conceptual framework is in direct conflict with mainstream economic theory.
>
> The differences are especially pronounced in dealing with financial problems in general and the euro crisis in particular. Mainstream economics has pursued timelessly and universally valid laws whose validity can be tested by reference to the facts. I contend that the facts produced by social processes do not constitute a reliable criterion for judging the validity of theories because of the human uncertainty principle. I do not deny the possibility of establishing universally and timelessly valid laws – the human uncertainty principle is one of them – but I consider such laws too vague and general to be of much use in producing specific predictions and explanations.

APPENDIX 4: Howell's comments to Asim Roy's "Brain Representation SIG"

------- Original Message --------

Subject: Learning on the order of seconds, instinct

Date: Tue, 08 Oct 2013 09:42:44 -0600
From: Bill Howell. Retired from NRCan. now in Alberta Canada <Bill@BillHowell.ca>
To: brain-representation-sig@erlars.org <brain-representation-sig@erlars.org>

Below is a re-posting of my comment from Saturday 03Oct2013. The original message was too large, so I removed most of the earlier postings from this message.

In relation to this BrainRep SIG's focus on "concept cells", a key question buried in the middle of my 03Oct2013 comment was : "... Concept cells could be one of many key features ..." related to "pre-programming" of [data, functions, operators (transformers), modules, processes, architectures, ... all the way to [multiple, conflicting & complimentary) [behaviours, personalities, strategies] (whether through

DNA, epigenetics, other molecules or structures, or whatever).   This is not to ignore powerful [growth, learning, evolution] of [neurons, ensembles, brain regions etc], and the critical importance of new environmental challenges and new concepts.

So, assuming that the concept of "concept cells" is valid, my questions are :

is the concept cell CAPABILITY built in through inheritance, and not just emergent (both could be the case!)?
are some, if not many, very specific concepts "built into" concept cells at different stages of development (pre-and-post natal, eg at adolescence) by inheritance (either specific or generic concepts)?
is it possible to identify concept cells in lower life forms for which experimentation is much easier? (eg reactions to specific smells, sounds, movements, tastes, whatever to which an organism has not yet been exposed)
do concept cells arise as-needed (say in the hippocampus, pulling material/context from other regions like the cortex)? almost-instantly (using rich prewiring prehaps) giving a capability like variable-function-operator-system? (Ben Goertzel 30Sep2013 referred to something like functional capabilities).

Bill Howell

-------- Original Message --------

Subject: Re: [Brain-Representation-SIG] Learning on the order of seconds

Date: Thu, 03 Oct 2013 23:35:19 -0600

From: Bill Howell. home email. Ottawa <Bill@BillHowell.ca>
To: Brad , Allan , "brain-representation-sig@erlars.org" <brain-representation-sig@erlars.org>

Brad, Allan,

Does quick "learning" or "representation" necessarily require biological [synaptic, neuronal, network, .. maybe regional] modification, at least initially?   It seems to me that instinct shows that there is already a huge genetic-and- nonGenetic "programming" ["chemical" (eg DNA, epigenetics) or other] source for [data, functions, operators (transformers), modules, processes, architectures, ... all the way to [multiple, conflicting & complimentary) [behaviours, personalities, strategies]. This is augmented by [fine-tuning, learning, evolution] through environmental challenge-responses, which "should" also be available.

"Novelty-reaction learning" might possibly take place "very quickly or even one-step" with what is already there, even if it is sub-optimal and relatively slow compared to a well-learned response. Perhaps the brain at this stage needs to mull over the challenge and try many possible routes - reminding me of Walter Freeman's concepts, for example. But if a "need" recurs, more and more [specific, tuned, evolved] biological modifications (synaptic changes and perhaps many others I am less familiar with) might lead to much [faster, more accurate, powerful] "semi-hard-wired" processing and results. Concept cells could be one of many key features for this. Earlier comments on this SIG did suggest that concept cells could be of great advantage to certain forms of processing. One doesn't need "either/or", both approaches may always be involved.

As simple abstract examples :

I've often thought that there must be enough DNA coding (3.2 Giga base pairs, if I remember correctly for humans, with less than 1 or 2% being "genetic", is the naive impression I have) to provide an extremely rich source of code at various levels of abstraction, to be able to "quickly [pick, assemble, architect]" almost any general purpose (Turing or super-Turing) system. Why wouldn't biology take advantage of this - one might speculate that higher-order epigenetic processes might make this possible. John Mattick's group at the university of Queensland seemed to be looking at issues like this 10 years or so ago, but more for "normal biology" as opposed to neurons and the brain (Mattick's description of non-genetic DNA and micro-RNA as being an explanation of the Cambrian explosion ~600 My ago was a nice conjecture). (Note that Gary Marcus' "The Birth of the Mind" discusses the inherent power of a relatively small number of genes to do their work with very compact, powerful coding and capabilities).

Bernie Widrow's 2009 IJCNN Atlanta plenary presentation "Memory Molecules" (and many MUCH earlier papers along this line) argued that long-term memory may require some form of stable molecular form, rather than relying on ever-changing synapsis, but even if that concept area doesn't work, instinct (greatly under-appreciated and under0discussed in my humble opinion) begs explanation. As I understand it, there really isn't an experimental basis for this, but ...

Jonathan Edward's examples from immunology may provide another potential example of this (I really enjoy his perspective in this SIG) - evolution with [existing, random changes, selection, iterations] allow the immune system to become very good at dealing with specific pathogens, but there is likely at least some initial capability to handle new pathogens via the "primitive, general" immune system (I forget the name for capabilities such as inflammatory responses and others response that I also forget), and the ?killer -cell? "targeted, specific" actions.

Michael Meany's work at McGill University and Douglas hospital on epigenetics and behaviour may be another potential platform for this, wherein behavioural changes in response to the environment could be reproduced by methylation of epigenetic sites.

If the brain already has systems that make for a wide range of specialized "applications" of general capabilities such as Approximate Dynamic Programming and symbolic capabilities together with concept neurons (perhaps not just objects and classes, but functions, processes etc as listed above), then these might also be quickly adapted to a new challenge with little of no requirement for "hard" biological changes.

It seems to me that incredible "brain power" is likely always available to deal with challenges.

Biological changes may not be required for a "quick and reasonable answer". Many more processes are available for the"biological" modifications to approach optimality and to provide a more-or-less permanent capability for a new challenge.

Bill Howell

+++++++++++++++++++++

01Sep2013 Howell's own posting Initial comments

I am enjoying the comments and discussions of this Brain Representation SIG, which has so far put forward ideas from electrode probe based tests, EEG results, logic and symbols, information theoretics, chaos, category theory, and other areas. I tend to look at all of the ideas discussed so far as being complimentary, and even if they conflict, it is best for me to retain ideas for future use, given the very sketchy understanding we have at present, and to avoid becoming trapped in any specific concept.

A. Robert Hecht-Nielsen's Confabulation Theory [1]

This SIG has reminded me of Hecht-Nieslen's Confabulation Theory for mammalian cognition (thought)- not for planning, executive or other functions if I remember correctly). The reminder started with respect to comments on the number of neurons required for concepts etc in this SI and Quiroga etal [2]. Hecht-Nielsen made many rough estimates along those lines, to quote from aquick note I did a couple of years ago for a social media project at work [3]:
"... As a gross overview, Confabulation Theory assumes that information is held within “attribute classes” in roughly 4,000 thalamocortical modules (~45 mm^2 each cortial patch, carrying information about “mental object attributes”) and roughly 40,000 cortical knowledge bases (establishing “meaningful co-occurrences” between thalamocortical modules). All vertebrates (and even invertebrates such as bees and octopi) are postulated to possess functionally analogous structures, albeit in smaller quantities. Confabulation is a “winner-takeall” process for coming to a conclusion (intermediate or final) , and is the only information-processing operation used in cognition. Confabulation DIFFERS from Bayes theorem in statistics, and these simple differences make confabulation a superior form of reasoning for the real world, where information is often incomplete, erroneous, or event misleading (predator – prey). It is even proposed that many supposed successes of Bayesian statistics are the result of extreme
simplifications which mean that it is actually Confabulation that is being applied, without the statisticians and scientists even being aware of this important distinction! ..."

Confabulation Theory was not well received by many when presented at WCCI 2002 Hawaii, or later at IJCNN 2007 Orlando (I hope I got the dates right). But I was intrigued, like the mathematics, and was stunned by the results of his "third plausible sentence" exercise. I have not heard anything since 2007, but I have met one or two others who are still interested in the idea. IBM Watson's defeat of the Jeopardy plyer a few years back also reminded me of confabulation, but although it seemed similar in some ways, as I understand it Watson is not based formerly on Confabulation. However, it may have heavily used the naive Bayesian technique, which is apparently closely related to Confabulation Theory rather than being a proper form of Bayes Theorem.

In any case, Confabulation Theory has been applied to several impressive problems (eg. awesome machine sentence construction without the need for formal grammar - I did an informal survey to see if people could pick out the machine from human respondents - they couldn't), requires massive inputs from much of the brain (like Walter Freeman's chaos concepts), and provides for cognition in a real-world robust and reasonable manner.

B. Questions related to the concept neuron itself:

How PERSISTENT over time is the "Jennifer Aniston" neuron? Can we check a couple of months or so later to see if the neuron or the whole
hippocampal population, has changed "duties", or is this prevented by glial cell passivation of electrodes and other difficulties of sustaining stable, long-term probes?

Can a neuron of local group of neurons rapidly "change jobs" to assume a different a completely different context (i.e forget Jennifer Aniston and instead primarily focus on making cookies or something)? If themes do "wander" or swap in and out of long term memory, how does this change the concept of a concept cell, and how fast can a local "context" (duties) change?

Consciousness and imagination - Presumably concept neurons can be used to "imagine" many possible future events and scenarios. As per John Taylor's theory of consciousness [4], a sense of self, and what the expected results of one's actions should be, are critical to learning a model of the external environment (including collaborators, competitors, etc), and to evolve/adapt behaviours and plans accordingly ("control strategies" in the terms of Paul Werbos' Approximate Dynamic Programming ideas). While I've seen models of learning (eg temporal difference learning) and control theory (Approximate Dynamic Programming (ADP) community especially) and creativity (Ali Minai), I haven't followed neural network based symbolic systems, other than Hecht-Nielson's.

C. How are concept neurons used?

Walter Freeman (Sun, August 25, 2013 4:32 pm) I like his contrasting perspectives on Freeman-K-set model as a finite state automaton using thermodynamics and random graph theory versus his complementary description using thermodynamics and quantum field theory (Note 1).

How are [functions, processes, dynamics] built and run, as distinct from how data is constructed? Are there "concept" neurons for processes? If so, do they use similar mechanisms? Several SIG comments touch on this, but I haven't listed them here.

Recurrent connections may be required for a symbolic / conceptual system - I liked this point in the SIG:
Ben Goertzel (Mon, 26 Aug 2013 07:55:08 +0900) and Michael Healy (Thursday, August 29, 2013 3:48 PM) My impression from Michael's comments in particular is that "relationships" (morphisms) between symbols are well-handled and preserved in Category Theory, and this requires back-connections (functors) between representations. "... this approach involves reciprocal pairs of connections, so feedforward networks are unlikely to be able to handle ...".
Tsvi Achler's (Fri, 30 Aug 2013 09:01:09 -0700) "functional" perspective of does NOT seem to include [functions, processes, dynamics], but instead contrasts recognition versus symbolic descriptions.

D. Structure and function:

I'm very interested in this theme, but perhaps it's too far off topic forthis SIG, although I suspect it would be come important when addressing mechanisms. Walter Freeman's concepts do provide for some ofthis, but not to the detail I hope to see some day (as he says on this SIG - a tenfold increase over current resolutions will help progress).

NOTES:
1) Although I purchased the Freeman-Quiroga book [5] in early August at IJCNN2013 Dallas, I have yet to read that or the links provided by Walter in this SIG. I have followed several of Walter's past papers, and would have to go through those again to jog my memory. I don't find the ideas easy, but they are very stimulating and powerful, as well as being fun.

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http://www.billhowell.ca/Neural%20nets/Howell%20110903%20-%20Confabulation%20Theory,%20Plausible%20next%20sentence%20survey.pdf
[4] John Taylor 2006 “The Mind: A users manual” John Wiley & Sons, Chechester, West Sussex 286pp
[5] Walter J. Freeman, Rodrigo Quian Quiroga 2013 “Imaging brain function wth EEG: Advanced temporal and spatial analysis of electroencephalographic signals” www.Springer.com 248pp ISBN 978-1-4614-4983-6

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