Q/A CCN 9. Feb. 2016

It's not clear, for me, what does the crosstalk means from a geometric point of view. **ANS**: Orthogonality = 0 crosstalk.

Section 13.4 shows the equivalence between the Hopfield and the Perceptron models. When it should be better to use an approach based on Hopfield networks and when another one based on Perceptrons? And, in general, what could be some practical applications of Hopfield networks? **ANS**: For example face-recognition `http://iris.sel.eesc.usp.br/lavi/pdf/Fabiana_SIBGRAPI.pdf`

Are there some other benefits for asynchronous networks in comparison with synchronous networks than that they are closer to the biology? **ANS**: Think about Hopfield nerwork with 2 neurons and the weight between them equal to 1 and both thresholds are 0. You start from the states -1 and 1. If you update synchronously, you will never converge, because the network will go (-1,1) -¿ (1,-1) -¿ (-1,1) -¿ etc. But if you update asynchronously one neuron at a time, it converges quickly to (1,1) or to (-1,-1).

It was stated that: "associative memories can be implemented using networks with or without feedback, but the latter produce better results". Why is this the case?

Can you give a simple example how you store information to a Hopfield network?

What is the difference between associative memory and linear associative memory networks? Is there nonlinear associative memory networks? **ANS**: Hopfield networks are non-linear associative memory networks.

In your opinion, how could classic knowledge (e.g. Hebbian Learning, Analytical Model of Hopfield Network) in the field of computational neuroscience help today's large scale neuron network research (deep learning)? **ANS**: Hopfield and Hebbian learning are unsupervised while deep learning is so far understood only in terms of supervised learning. So maybe Hopfield and Hebbian learning can help in advance for unsupervised deep learning. Unsupervised deep learning is a major open problem. Hopfield learning is expensive, so it might not be successful. Other learning methods for Hopfield networks? Unsupervised deep learning is a difficult problem, so it is unlikely...

Is it widely accepted in the field of neural network Bolzmann machine is a better model than Hopfield networks? If it is, why ? **ANS**: Bolzmann machines are better from the point of view of probabilistic modelling, but they are computationally heavier and mathematically more difficult. So it depends on the situation which one you should use. Hopfield nets don't have much applications in AI, but are a good model for neuroscience, at least conceptually.

The basic associative network can work with m $= 0.18$n vectors where n is the dimension of the weight matrix. Is there same kind of number for Hopfield networks? **ANS**: Rojas gives 0.14n for Hopfield (p. 370).

Are there any other learning algorithms suitable for Hopfield networks, than hebbian and perceptron learning? **ANS**: Anything goes. Evolution, even backpropagation

Beginning of chp 12 (heteroassociative, associative, pattern recognition network): how did things become so linear? How can we solve the autoassociative case by solving system of linear equations?

What does it mean that "Hopfield network can also be interpreted as an asynchronous BAM in which the left and right layers of units have fused to a single layer"?

Hopfield networks are connected to Boltzmann machines (which are in turn connected to simulated annealing). This is interesting! Explain / discuss this / these relationship(s) more in bit more detail?

Rojas discusses shortly optical and electrical ("massively parallel") implementations of Hopfield model. The Rojas book was published in 1996. Any recent developments on these areas since then? Other novel implementation ideas?

What are examples of some special multilayer network architectures that can be trained in polynomial time?

Have any structures in the brain been found that are similiar to hopfield networks? Or is there any other reason to think that human memory works in a similar way to hopfield networks? **ANS**: Key words: Spike-time dependent plasticity and long-term potentiation. Are both related to Hebbian learning realizations on neural level. But note that 'Hebbian' in the original, causal

sense, not the Rojas' correlational sense.

What are the crosstalk and capacity of associative networks? How are they related? **ANS**: Crosstalk is how much different stored patterns interfere with each other. Capacity is the number of patterns one can store.

What are "first-order dynamical systems" and "stochastic dynamical systems"? **ANS**: A dynamical system is always given by a set of differential equations. First-order means that only the first derivative is involved. A stochastic one is where the PDE's are stochastic, i.e. some of the variables are stochastic processes yielding a stochastic process as a solution.