READINGS IN DEEP LEARNING

3 Sep 2014
ADMINISTRIVIA

• Lab assignment 1 to be up today
  – Due 2 weeks from now

• Still waiting to sort waitlist issues
  – We may have to change room
Next 2 Classes (Week of Sep 8)

- Monday, Sep 8
  - Organization of behavior
    - Donald Hebb
    - About the Hebbian learning rule
    - Srivats will present
  - Widrow Hoff learning rule
    - Widrow and Hoff
    - Key rule which is still applied to many learning algorithms
    - Zhiyong Chen will present
Next 2 Classes (Week of Sep 8)

- Wednesday, Sep 10
  - A Simplified Neuron Model as PCA
    - Erkki Oja
    - Shows that the Hebbian learning rule learns principal components
    - Haohan Wang will present
  - Backpropagation
    - Paul Werbos
    - The fundamental learning rule that enabled further research in neural nets and is still being used
    - Tina Liu will present
Week of Sep 15

• Monday, Sep 15
  – Kohonen Maps
    • Teuvo Kohonen
    • The first paper to show how to “chart manifolds” of data
      – Using neural networks!
    • Need a volunteer
  – Hopfield Nets
    • John Hopfield
    • Content addressable memory
      – Hypothesizing how the brain stored memories
      – Led directly to Boltzmann machines and RBMs
    • Need a volunteer
Week of Sep 15

• Wednesday, Sep 17
  – Boltzmann Machines
    • Geoff Hinton
    • Better content addressible memories
      – And how to train them
    • Suyoung Kim will present

  – Restricted Boltzmann machines
    • Paul Smolensky
    • The basic unit of deep networks of today
    • Need a volunteer
Notices

• Success of course depends on good presentations
• Please send in your slides 1-2 days before the presentations
  – So that we can ensure they are OK

• You are encouraged to discuss your papers with us/your classmates while preparing for them
  – We will have a google group at the end of this week
  – Use the google group for discussion
The story so far

• Alexander Bain proposed neural network models
  – Complete with the following ideas
    • That neurons connected to neurons
    • Neurons could have many inputs and a single output
    • The connections determined what the network would do
    • The same network could generate different outputs for different inputs
    • All by 1879!!

  – His work was forgotten..
    • Even by himself!
Today

• McCulloch and Pitts: Simranjit Kohli

• Walter Pitts
  – Homeless hobo
    • Ran away from home at 15 and never returned
  – Cybernetician, Computational Neuroscientist

• Warren Sturgis McCulloch:
  – Neurophysiologist
  – Psychologist,
  – Famous for his work on the mind
  – Founder of American Society of Cybernetics
  – Wrote poetry
  – Took in homeless hobo Pitts into his home in 42..
Today: McCullough and Pitts

• Fundamental problem – how does the physical body produce the abstract mind?
  – Hypothesis: Structure embodies propositional inference
    • Structure of the brain
  – Mind == thought, ideas, *propositions*
  – Generation, acceptance, and rejection of propositions hidden in the structure of the brain
Today: McCullough and Pitts

• “A logical calculus of ideas immanent in nervous activity”
  – Tries to model a logical calculus using a network of neurons
  – “immanent” – logical propositions are within the activity patterns of neurons(!!)

• Didn’t actually intend to explain neurons; but to show how a neuron-like structure could do things like the brain

• Proposes a model based on Boolean logic
  – Instead of more conventional continuous-valued physics
  – Inspired by Turing in this, though he doesn’t cite him.
Today: McCullough and Pitts

• Problems:
  – Given a net, explain its behavior
  – Given a behavior, design a net

• Behavior of a neuron can be defined in terms of the afferent neurons feeding input into it
  – What is the logical expression for each neuron

• Networks can be designed based on units
  – Had units for and, or, and-not, delay
    • Anything can be constructed with it

• Can explain complex percepts with nets
  – Heat-cold example

• First reference of neural networks and *computation*
• NOT Turing machines, since even with loops
  – Though McCulloch thought so
Today: Perceptron

• The perceptron: A probabilistic model for information storage and organization in the brain (presented by Volkan Cirik)

• Frank Rosenblatt
  – Psychologist!
  – Neurophysiologist
  – Cybernetist
  – Astronomer
  – “New Navy Device Learns By Doing”
Today: Perceptron

• The perceptron: A probabilistic model for information storage and organization in the brain
  – Not really about the logistic perceptron, more about the probabilistic interpretation of learning in connectionist networks
  – Sensing, storage and processing of information in the brain
  – Information stored in connections
  – Uses probabilities vs symbolic logic
Today: Perceptron

• Built on earlier works by Hebb etc
  – Neural connections unique to an individual
  – Develop from a plastic base through exposure to stimuli
    • Positive and negative stimuli
  – Is a *hypothetical* model, not claimed to be true biology
  – Rejects Boolean logic
  – Is a testable model of biological learning
Today: Perceptron

• Model
  – Learning by trial and error
    • Random initialization, learns from input and desired response
    • Verifiable via simulation/hardware
    • Proposes multiple learning rules
    • No formal proofs of any kind, though

• Thought he’d solved it all
  – Till Minsky and Papert showed the models limitations
    • And set back research in neural networks by two decades!