Principles of neural network design

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Human brains as metaphors of statistical models

Biological analogies

The visual cortex of mammals



Pyramidal cells Interneurons Machine learning instantiations

Deep convolutional neural networks

Multiple sensing channels



Memory and attention



Multimodal neural networks



LSTMs and GRUs



Neural Networks For Computer Vision

Neural Networks in Computer Vision

Neural networks for classification of handwritten digits



Fig. 2. Architecture of LeNet-5, a Convolutional Neural Network, here for digits recognition. Each plane is a feature map, i.e. a set of units whose weights are constrained to be identical.

Learning Mechanism: Correction of Mistakes

 x_1

 x_k

 x_d

Nature used a single tool to get to today's success: mistake



Modularity Is Back-Prop's Perk for Software Eng.

Back-propagation is a recursive algorithm

This module provides <u>function()</u>, commonly accessed as theano.function, the interface for compiling graphs into callable objects.

You've already seen example usage in the basic tutorial... something like this:





Image Classification



cycling track cycling road bicycle racing marathon ultramarathon

Catho demolition derby

grand prix motorcycle racing

demolition derby

monster truck

mud bogging

motocross



ultramarathon ultramarathon half marathon running marathon inline speed skating



telemark skiing snowboarding telemark skiing nordic skiing ski touring skijoring



hurdles pentathlon sprint (running)

whitewater kayaking

whitewater kayaking

adventure racing

rafting

kayaking

canocing



mushing bikejoring harness racing skijoring carting

arena football

arena football

canadian football

american football

women's lacrosse

indoor american football



freestyle scootering freeboard (skateboard) sandboarding



rodeo reining cowboy action shooting bull riding



ultimate (sport) hurling flag football association football rugby sevens



cight-ball nine-ball blackball (pool) trick shot cight-ball straight pool

Successful Architecture In Computer Vision

An example of a wide network: AlexNet



Understanding What Happens Within A Deep NN

Examining convolution filter banks



Examining activations



Determining A Neuron's Speciality

Images that triggered the highest activations of a neuron:



Another Successful Architecture For CV



ILSVRC top-5 error on ImageNet



Recurrent Architectures

Learning To Leverage Context

Memory in Recurrent Architectures: LSTM (Long Short Term Memory Network)

Input x, output y, context c (memory)



Other recurrent architectures

Gated recurrent units:



$$z_t = \sigma \left(W_z \cdot [h_{t-1}, x_t] \right)$$
$$r_t = \sigma \left(W_r \cdot [h_{t-1}, x_t] \right)$$
$$\tilde{h}_t = \tanh \left(W \cdot [r_t * h_{t-1}, x_t] \right)$$
$$h_t = (1 - z_t) * h_{t-1} + z_t * \tilde{h}_t$$

Why Is Context Important?

In language, most grammars are not context free

End-to-end translation, Alex Graves





Context Is Also Important In Control

Remembering what just happened is important for decision making





Memory is necessary for localization

Latest experiment in asynchronous deep RL: LSTMS for maze running

Memory comes at a cost: a lot of RAM or VRAM is necessary



Conclusion: the distributed brain

Interaction is crucial in enabling AI

AlphaGo Overview

based on: Silver, D. et al. Nature Vol 529, 2016 copyright: Bob van den Hoek, 2016



Playing versus computers before beating humans



Evaluating current AlphaGo against computers



Bootstrapping by interaction

Why would two androids casually chat one with another?



The distributed brain at the edge

Distributed RL is reminiscent of the philosophical omega point of knowledge





We are not human beings having a spiritual experience; we are spiritual beings having a human experience.

(Pierre Teilhard de Chardin)



Multiple Input Neural Networks

Multi Inputs For Inference

Youtube Video Auto-encoding





Multiple Input Control

Multiplexing Inputs

Softmax

Fully connected layer

Fully connected layer





Multiplexing In The Human Brain

