Deep Learning beyond the hype

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Overview

A bit of history

Some of the remaining challenges

Conclusion

Deep Learning: unrealistic expectations?

Figure: Gartner Hype Circle for Emerging Technologies, 2015

Deep Learning: unrealistic expectations?

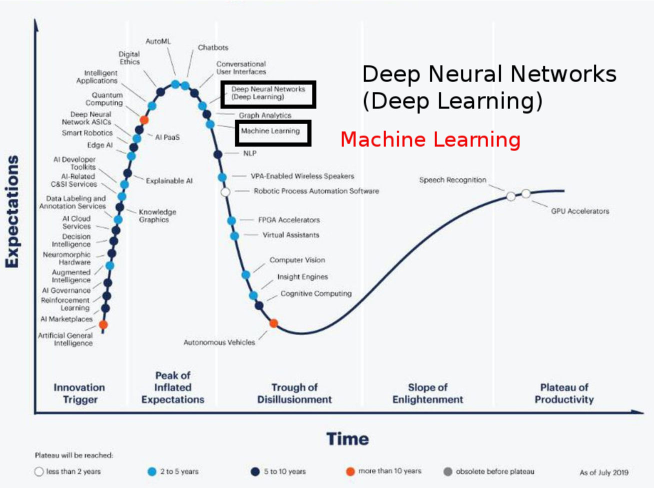
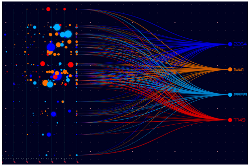


Figure: Gartner Hype Circle for AI, 2019

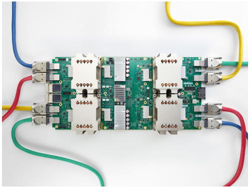
The birth of Artifical Neural Networks

- Formal Model of the Neuron: 1943 (McCulloch - Pitts)
- Perceptron: 1958 (Rosenblatt)
- Adaline - Adaptive Linear Element: 1963 (Widrow - Hoff) `https://youtu.be/IEFRtz68m-8?t=561`
- Supervised multilayer perceptrons: 1965 (Ivakhnenko - Lapa)
- Neocognitron: 1980 (Fukushima)
- First practial demonstration of backpropagation: 1989 (LeCun)

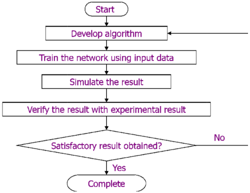
Since 1989



Data



Hardware



Algorithms

Some of the remaining challenges

"Mathematical models of physical phenomena should have the properties that:

1. a solution exists,
2. the solution is unique,
3. the solution's behavior changes continuously with the initial conditions."

— Jacques Hadamard [Hadamard, 1902]

Is a deep neural network a well-posed model?

- Adversarial attacks
- Convergence properties (non-convex optimization)

Some of the remaining challenges

Is a deep neural network (DNN) a proper model?

- Adversarial attacks
- Convergence properties (non-convex optimization)

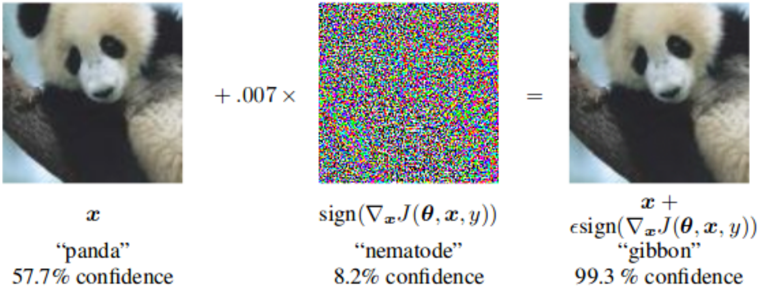
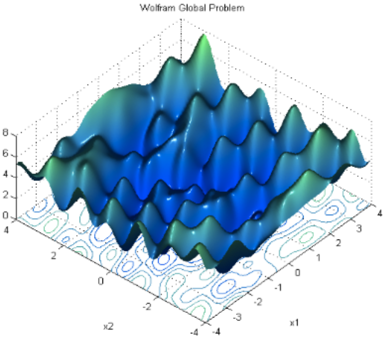


Figure: A demonstration of fast adversarial example generation applied to GoogLeNet on ImageNet. [Goodfellow, 2014]

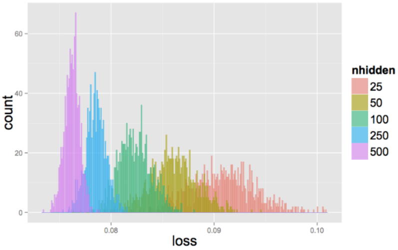
Some of the remaining challenges

Is a deep neural network a proper model?

- Adversarial attacks
- Convergence properties (non-convex optimization)



Typical objective function



Distribution of critical points

[Bengio, 2015]

My research topic: DNN and dynamical systems

Basic Idea:
A very popular type of DNN (ResNet) is a discretization at order 1 (Euler discretization) of a dynamical system (e.g. associated with an ODE).

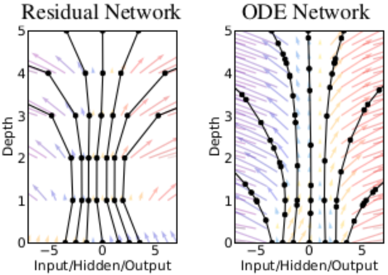
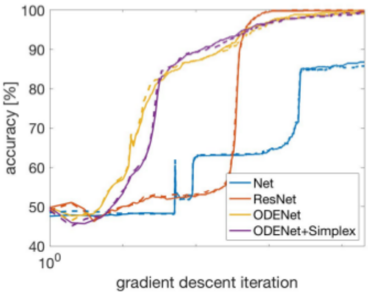


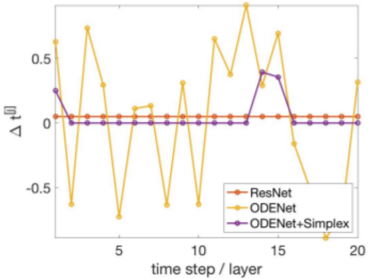
Figure 1: *Left:* A Residual network defines a discrete sequence of finite transformations. *Right:* A ODE network defines a vector field, which continuously transforms the state. *Both:* Circles represent evaluation locations.

[Chen, 2018]

My research topic: DNN and dynamical systems



Classification accuracy over the course of the gradient descent iterations



Estimated time steps. ODENet+simplex consistently picks two to three time steps and set the rest to zero.

[Benning, 2019]

Take-home messages

Predicting future research breakthroughs is hard

Cf. the controversy on Artifical General Intelligence

Without maths, you don't go far

Free products and not life-or-death applications

There is a gap to be filled between 'traditional' Applied Mathematics and Deep Learning

References

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Questions?