

Implementing ANNs with TensorFlow

Session 01 - Introduction

Agenda

1. Introduction

- A. What are ANNs?
- B. Why do we study ANNs?
- C. Applications of ANNs (Teaser)
- D. Further Research on ANNs

2. Organizational Issues

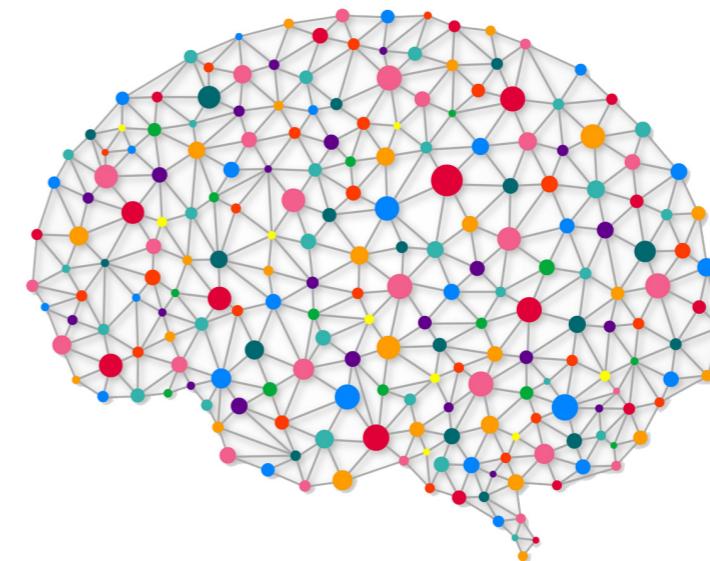
Part I

Introduction

What are ANNs?

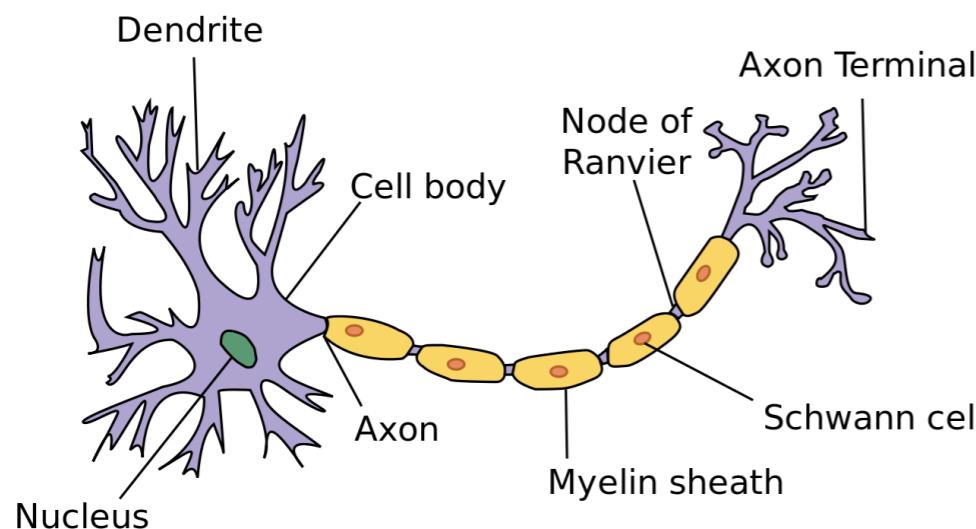
What are ANNs?

- ANN is short for Artificial Neural Network.
- Networks of artificial neurons - in contrast to networks of biological neurons (brains!).



What is an artificial neuron?

- It is **not** about building “real” neurons out of silicon.
- It is about mathematical/computational models of neurons.



$$I = C_m \frac{dV_m}{dt} + \bar{g}_K n^4 (V_m - V_K) + \bar{g}_{Na} m^3 h (V_m - V_{Na}) + \bar{g}_l (V_m - V_l),$$

$$\frac{dn}{dt} = \alpha_n(V_m)(1-n) - \beta_n(V_m)n$$

$$\frac{dm}{dt} = \alpha_m(V_m)(1-m) - \beta_m(V_m)m$$

$$\frac{dh}{dt} = \alpha_h(V_m)(1-h) - \beta_h(V_m)h$$



Computational Models of Neurons

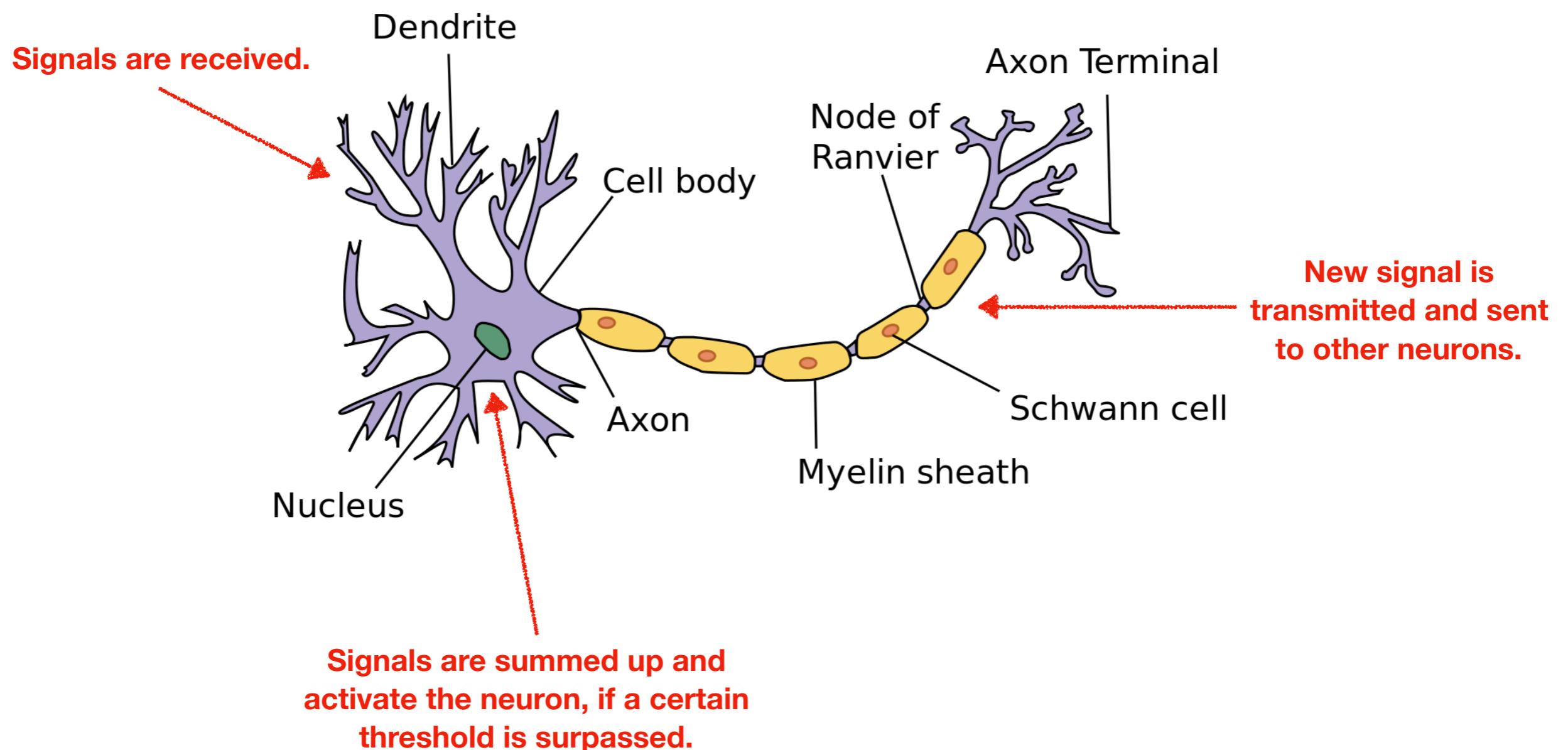
- Building any kind of model the big question is: Which aspects of the real thing do you want to model?
- There are many different computational models of neurons out there that were built for different purposes!
- e.g. building models to understand how neurons behave in a dynamic system requires quite detailed models of neurons (-> Lecture #####: Neurodynamics)
- In this lecture the focus is on how networks of neurons can process information!

Information Processing with Neurons

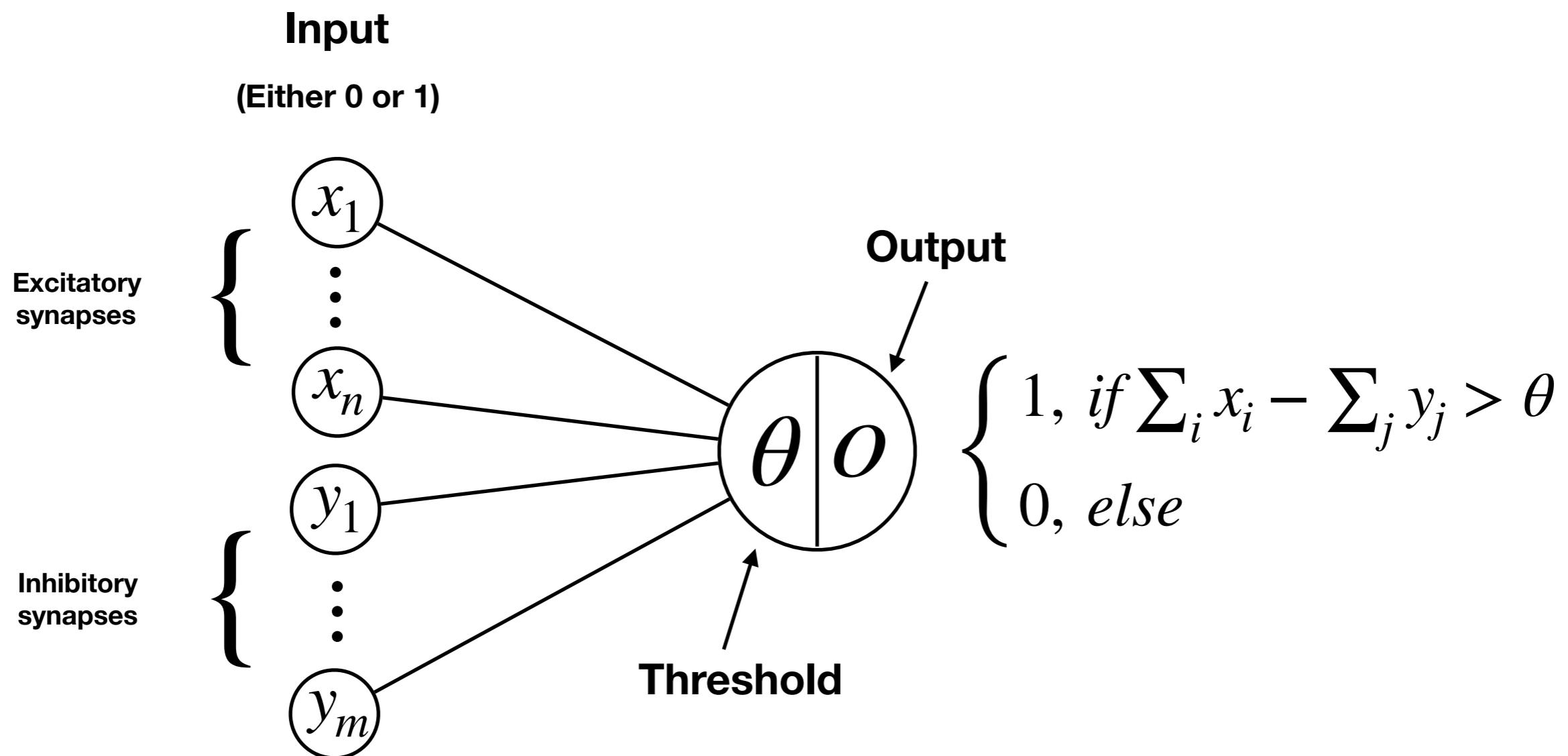
- Which properties of neurons do we need to model the information processing abilities of biological neural networks?
- **Up to date this question is not answered!**
- But a very simple (maybe the easiest) model, the **McCulloch-Pitts neuron**, can be quite effective and is the base for the current machine learning hype around **deep learning**.

McCulloch-Pitts Neuron

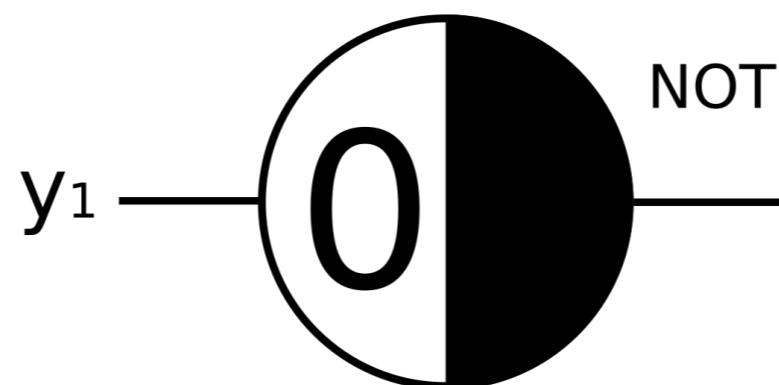
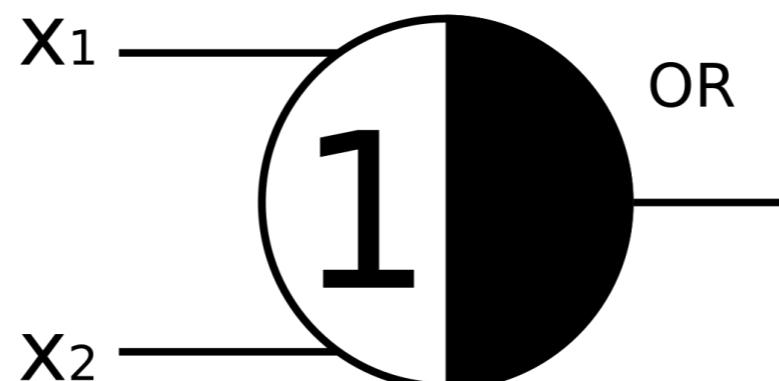
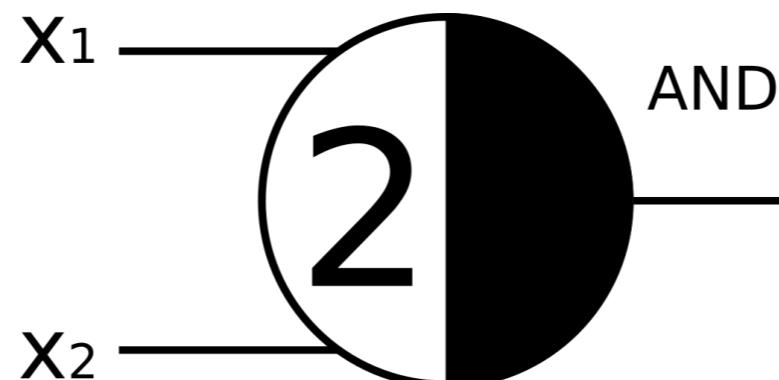
- The model makes the following (severe) simplifications.



McCulloch-Pitts Neuron



Example: Logical Gates



Why do we study ANNs?

Why do we study ANNs?

Cognitive (Neuro)Science

ANNs can help in explaining how the brain achieves certain tasks on a neural level.

Artificial neural network models from AI are used to test computational hypothesis about the brain.



Results from cognitive (neuro)science help in building better models for AI.

Artificial Intelligence/ Machine Learning

ANNs are a successful machine learning model for certain kinds of tasks.

ANNs for CogSci

- This field of research was quite active in the beginning.
- It was interesting to explore how the brain might be able to process information on the neural level.

Paper
Hinton

Die slide vielleicht einfach
weglassen?

- As artificial neural networks started to decline, research declined.
- But it is coming up again lately.

Papers of
CCN

ANNs for Artificial Intelligence

- This is the focus of this course!
- To understand why we use ANNs in AI and machine learning we have to make a quick detour into AI history.

What does it mean to build an intelligent system?

AI has a long history of choosing tasks that are assumed to require a certain level of intelligence.

Example: Chess

- One classic example is the game **chess**.
- As only intelligent people are very good at it, that seems like a good task to start.

**Once we built a machine that
will beat the greatest chess
masters...**

DeepBlue beating Kasparov in 1997!

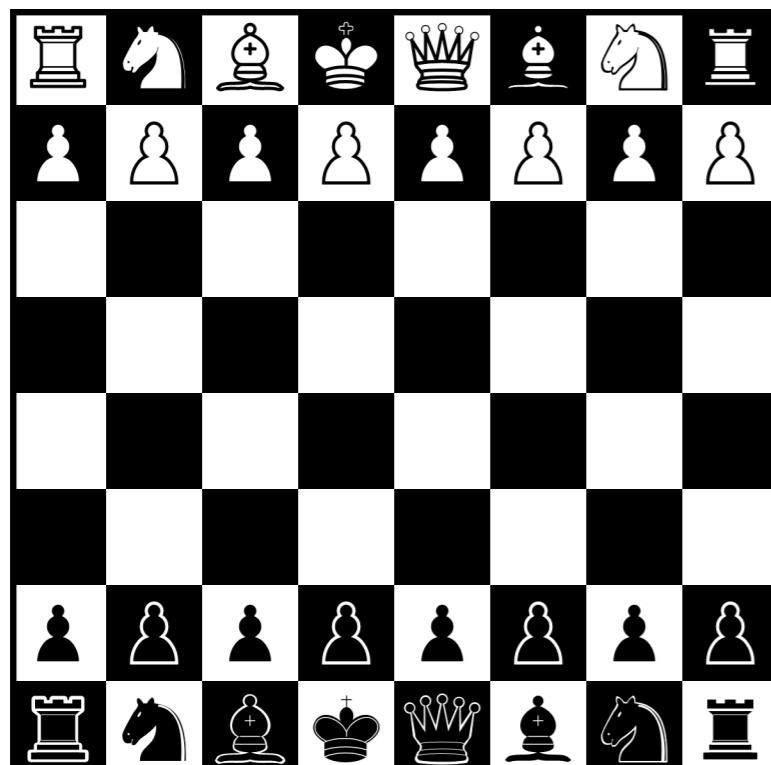


Where is AGI though?

The Symbolic Approach to AI

- Idea: Intelligence mainly arises from the ability to manipulate symbols and use logical rules.

How to build a chess AI?



- **Environment**: chess board, different figures
- **Rules**: allowed moves for different figures
- **Heuristics**: e.g. queen is more valuable than horse
- **Algorithm**: how to compute the next move

The Symbolic Approach to AI

- Can we use this approach to build AGI? **NOPE!**
- Why?
- You have to know how to solve a problem, to be able to formulate it as an algorithm.
- Turns out humans actually solve a lot of problems without knowing how!

Moravec
s
paradox



Any ideas?

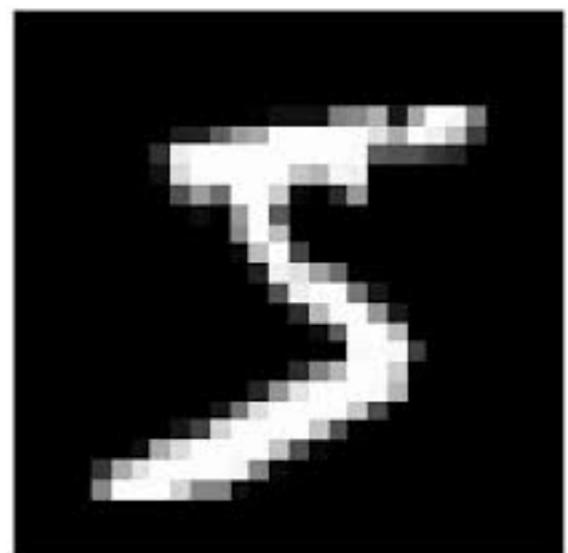
Example: Handwritten Digit Recognition

How do you know that the digit in the image is a 5?

Well there is a horizontal line and some bow attached to it.

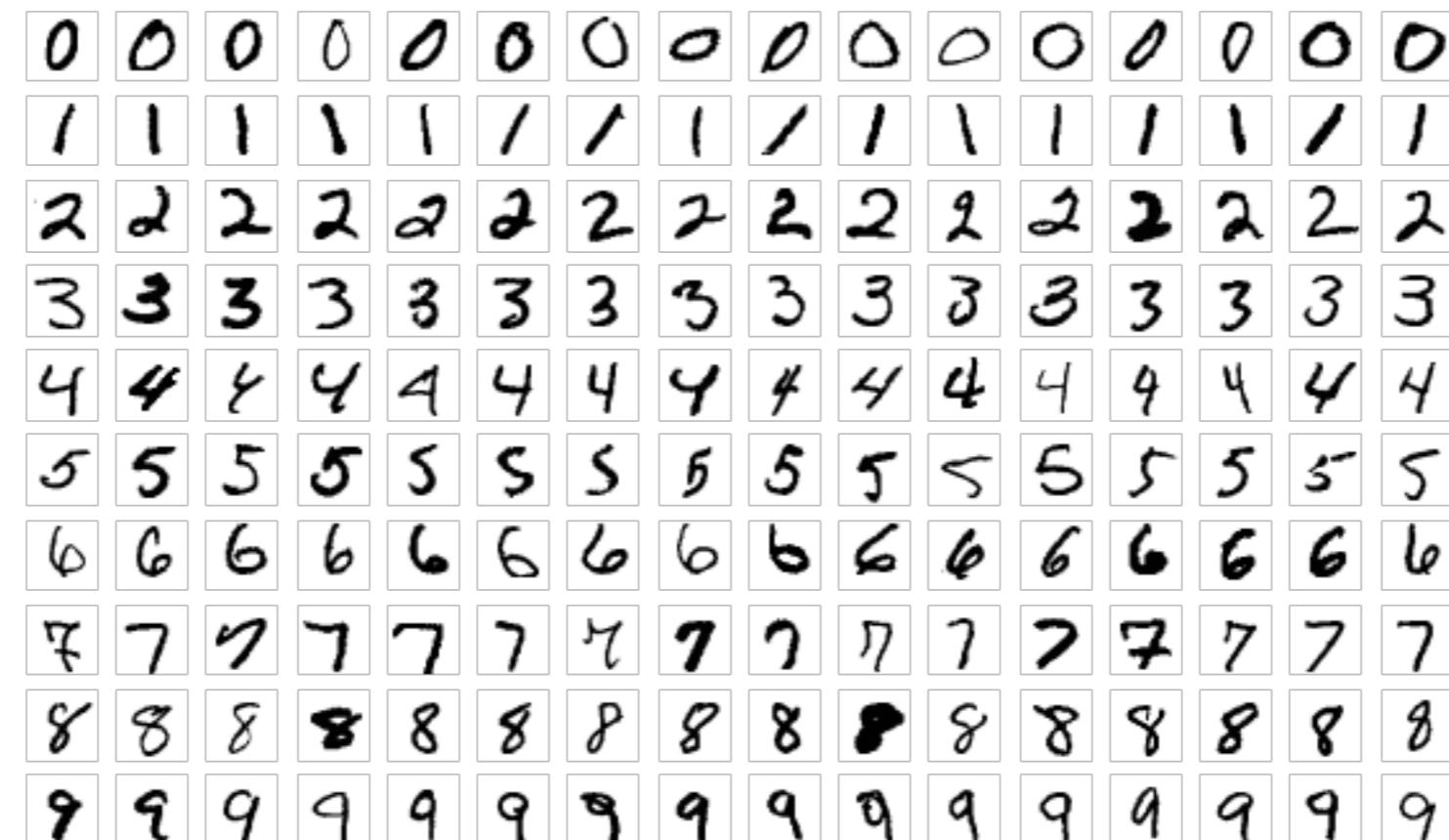
But how do you know that there is a horizontal line and a bow? And how do you know it is attached in one piece?

Well uuh...



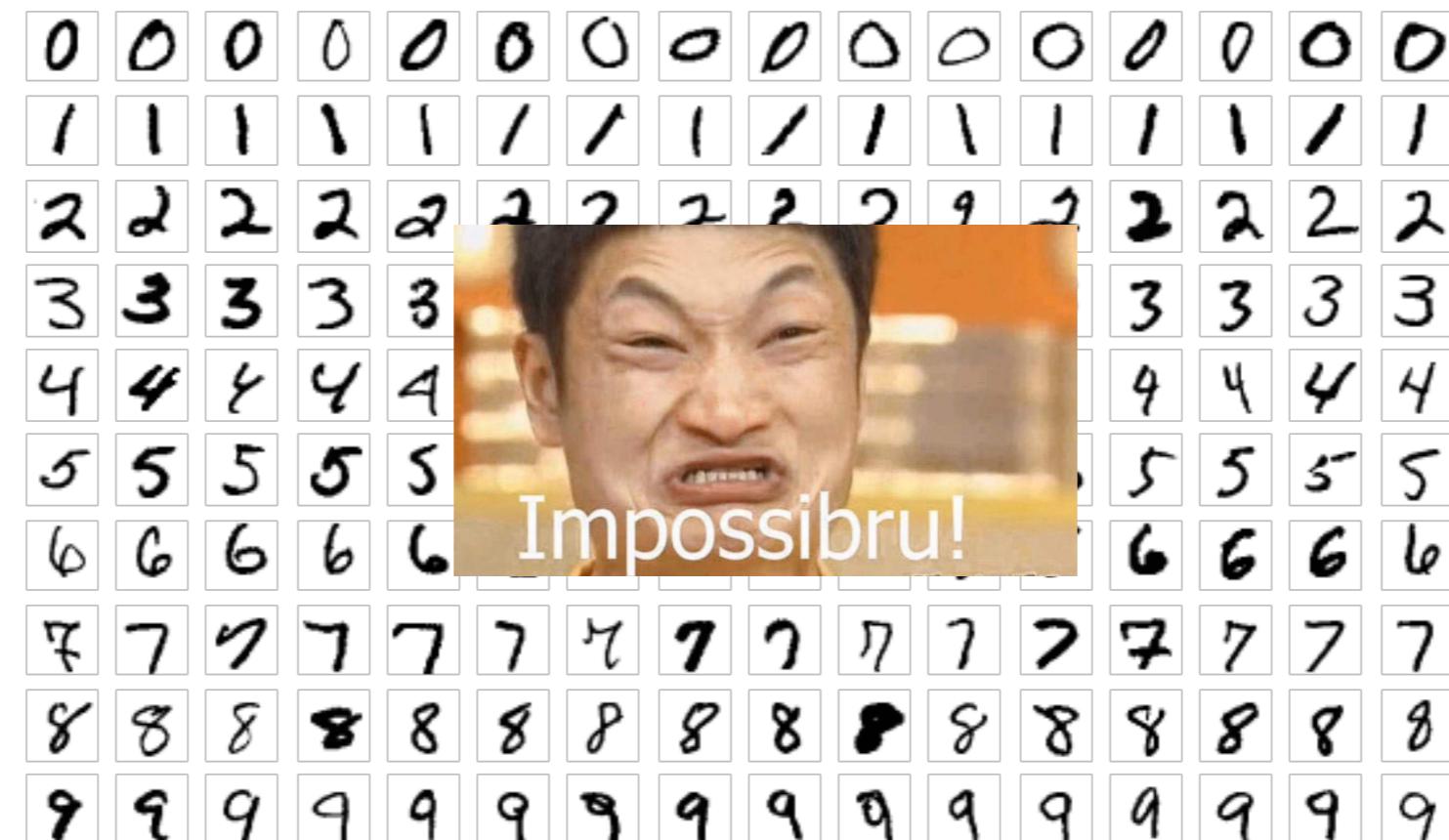
Example: Handwritten Digit Recognition

- Finally you would need to be able to provide a formal algorithm that **given the pixels of an image - returns the correct digit label.**



Example: Handwritten Digit Recognition

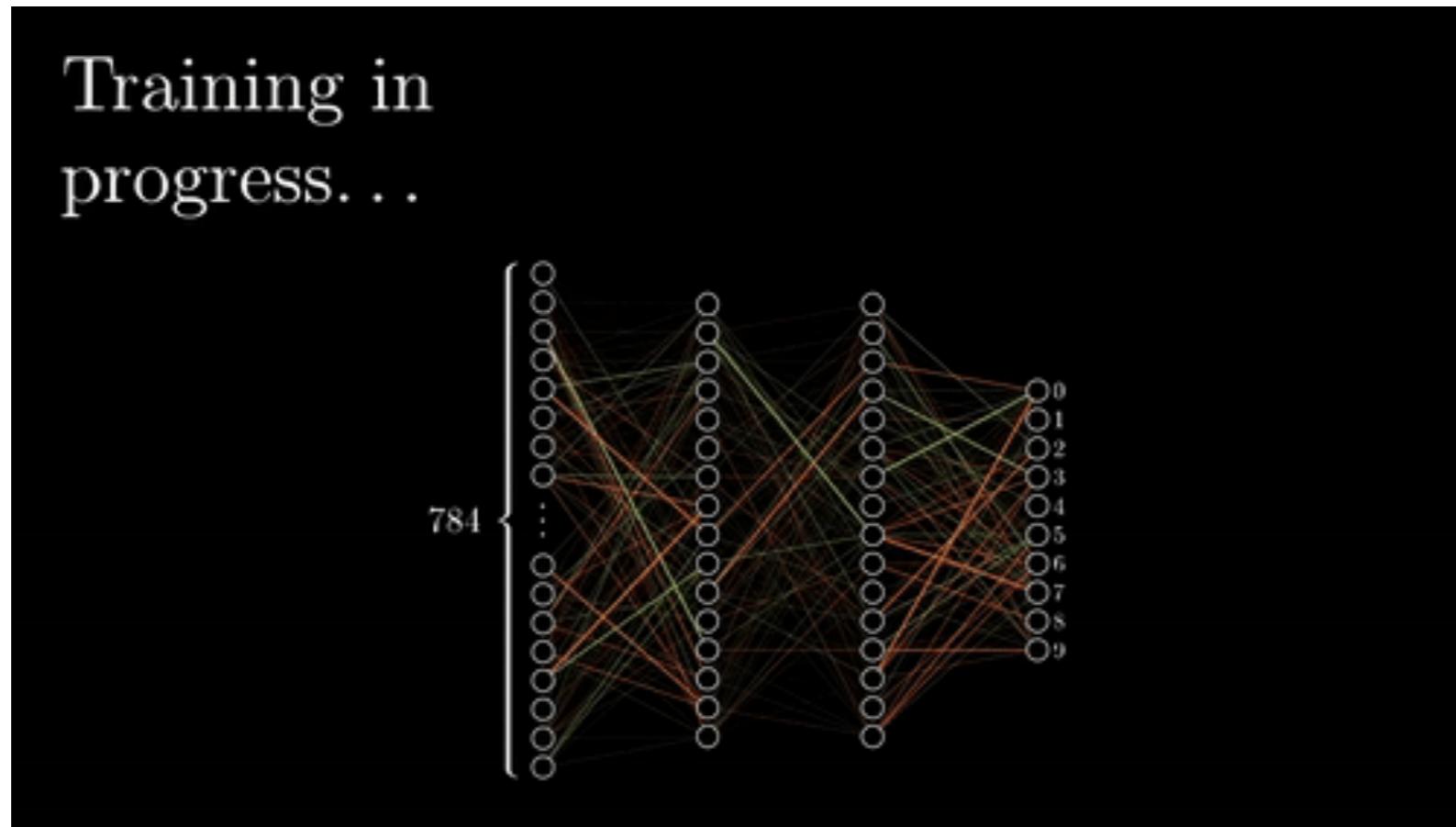
- Finally you would need to be able to provide a formal algorithm that **given the pixels of an image - returns the correct digit label.**



This turns out to be **incredibly complex/impossible!**

Sub-symbolic Approach to AI

- The intelligence to solve tasks like that is not symbolic.
- It emerges from **simple computational units** (like neurons in the brain).
- Can we built an AI that learns itself how to solve these tasks?



3Blue1Brown Series on
Neural Networks

Intermediate Conclusion

Tasks that are seemingly very simple for humans have solutions that are not trivial to formalize.

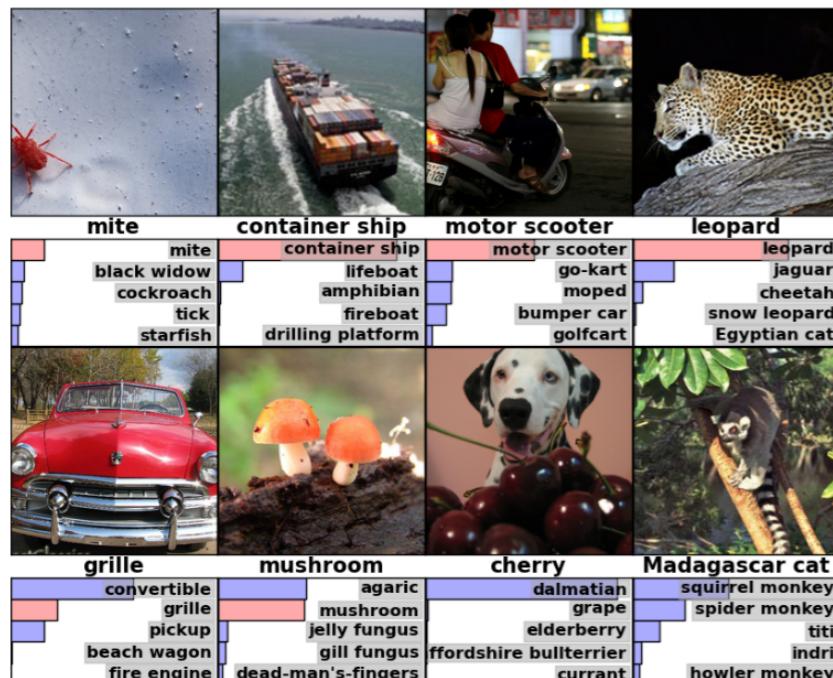
We will use Artificial Neural Networks to solve them!

Applications and Tasks (Teaser)

Hier noch bei den Sachen angeben die wir bearbeiten in welcher lecture das dran kommt.

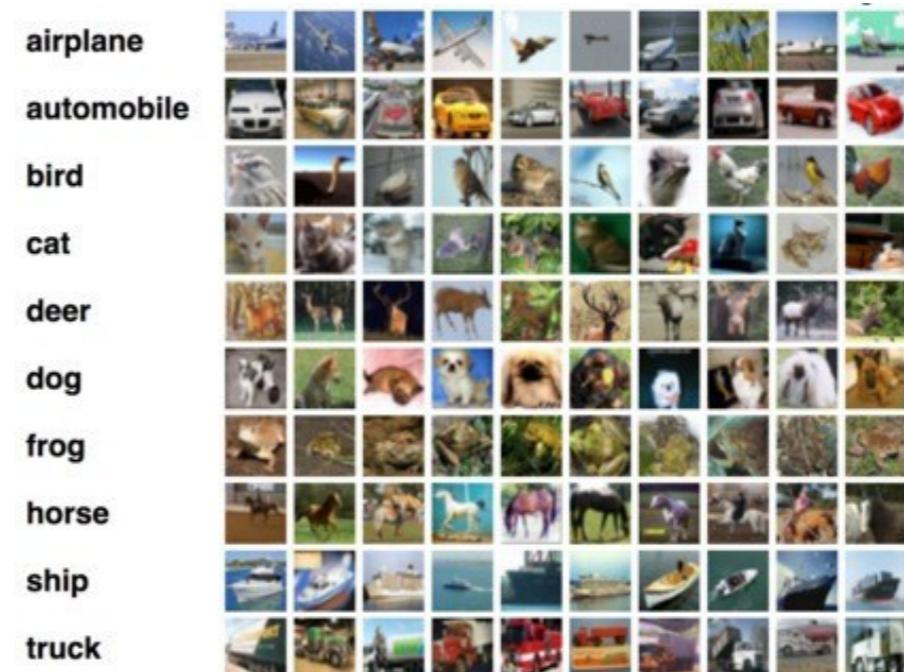
Object Recognition

- Going beyond handwritten digit recognition...

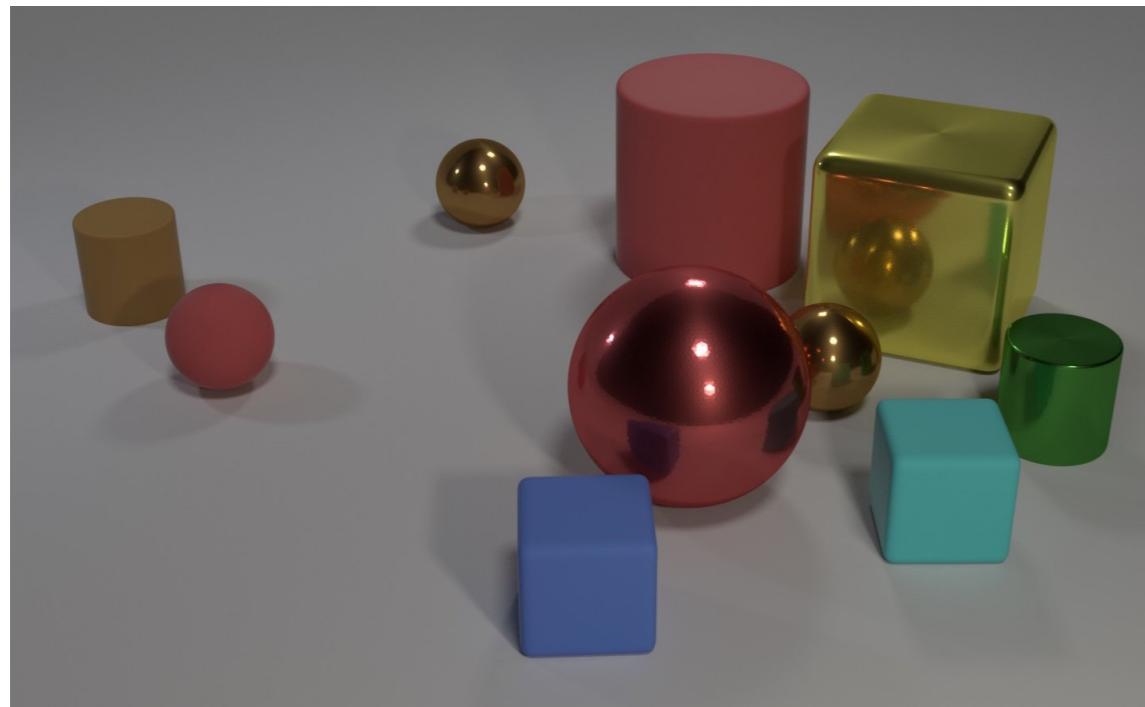


ImageNet

CIFAR10



Other Computer Vision Task



CLEVR (Visual Reasoning)

PASCAL (Semantic Segmentation)



Image Generation



Face Generator

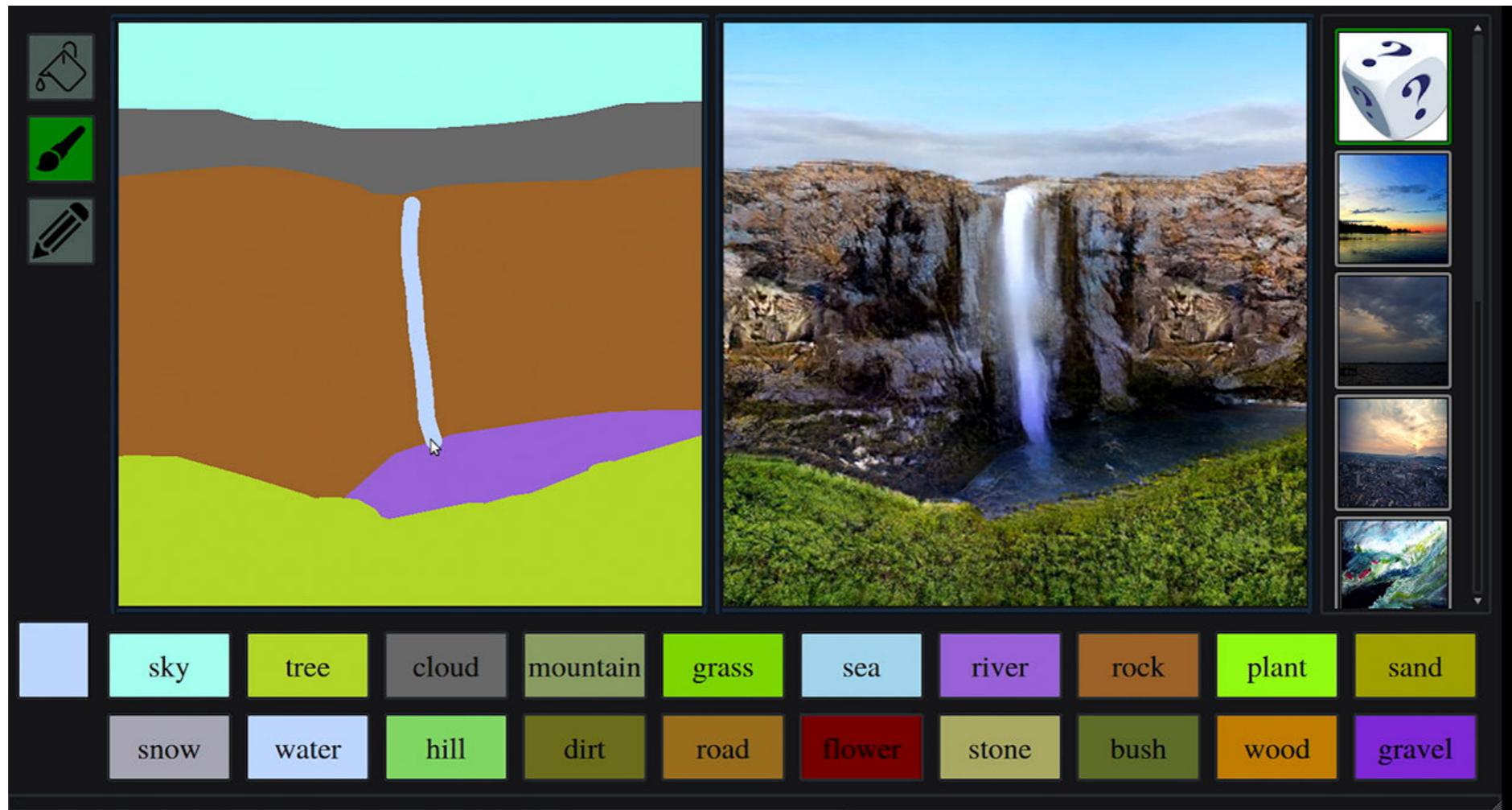
thispersondoesnotexist.com

Image Generation



Natural Image Generator

Cool Application: GauGAN



Try it yourself!

<http://nvidia-research-mingyuliu.com/gaugan/>

Text-to-Speech

Parametric

Concatenative

WaveNet (Artificial Neural Network)

Speech generation without text

Text Comprehension: WINOGRAD

The city councilmen refused the demonstrators a permit because they [feared/advocated] violence.

“feared” → **“they” refers to “councilmen”**

“advocated” → **“they” refers to “demonstrators”**

Generate Text

SYSTEM PROMPT
(HUMAN-WRITTEN)

In a shocking finding, scientist discovered a herd of unicorns living in a remote, previously unexplored valley, in the Andes Mountains. Even more surprising to the researchers was the fact that the unicorns spoke perfect English.

MODEL COMPLETION
(MACHINE-
WRITTEN, 10 TRIES)

The scientist named the population, after their distinctive horn, Ovid's Unicorn. These four-horned, silver-white unicorns were previously unknown to science.

Now, after almost two centuries, the mystery of what sparked this odd phenomenon is finally solved.

Dr. Jorge Pérez, an evolutionary biologist from the University of La Paz, and several companions, were exploring the Andes Mountains when they found a small valley, with no other animals or humans. Pérez noticed that the valley had what appeared to be a natural fountain, surrounded by two peaks of rock and silver snow.

Pérez and the others then ventured further into the valley. "By the time we reached the top of one peak, the water looked blue, with some crystals on top," said Pérez.

Pérez and his friends were astonished to see the unicorn herd. These creatures could be seen from the air without having to move too much to see them – they were so close they could touch their horns.

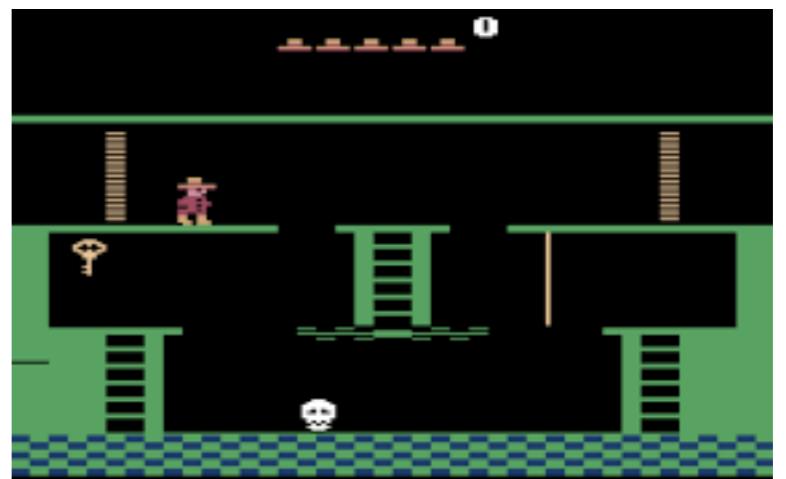
<https://talktotransformer.com>

Play Games

StarCraft



Atari Games

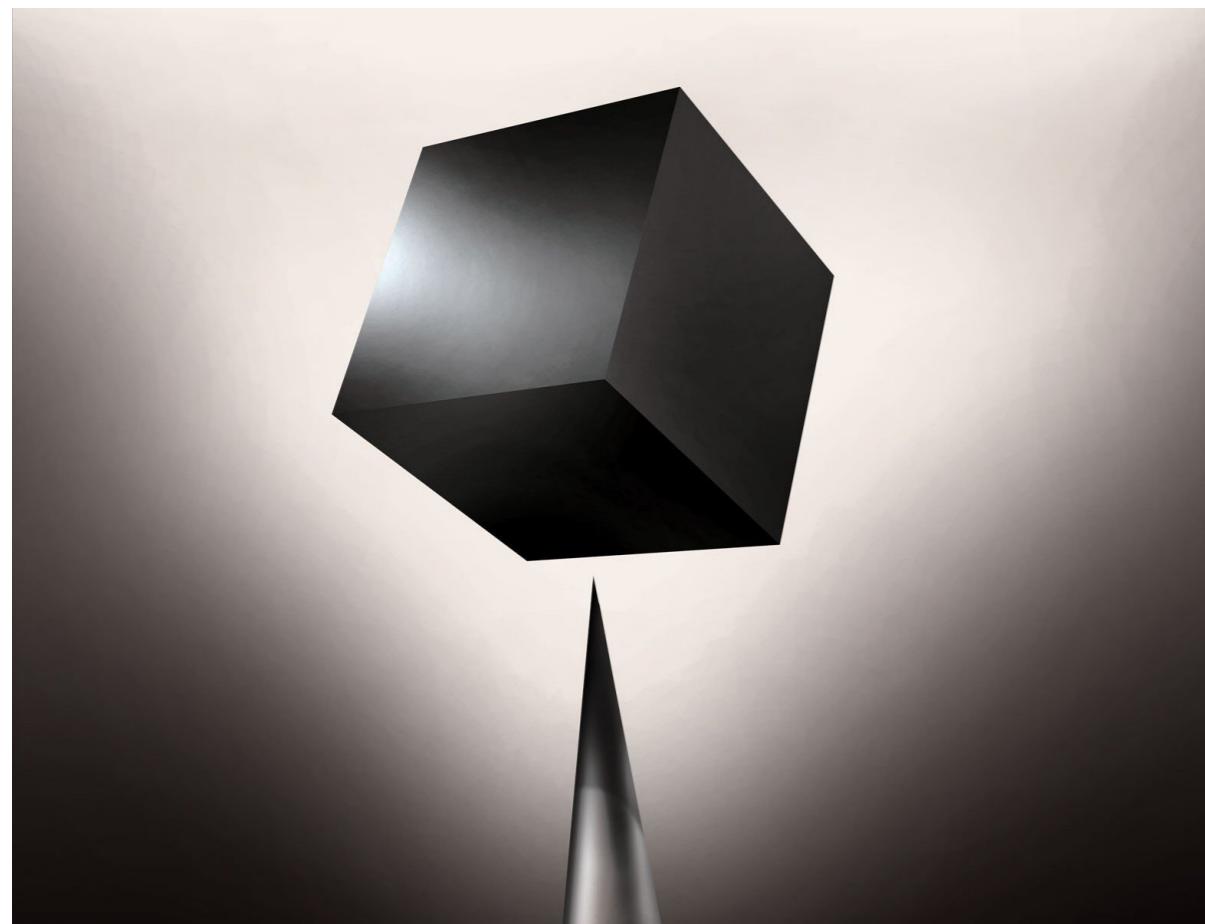


Go



Research

Black Box



Artificial Intelligence / Machine Learning

The Dark Secret at the Heart of AI

No one really knows how the most advanced algorithms do what they do. That could be a problem.

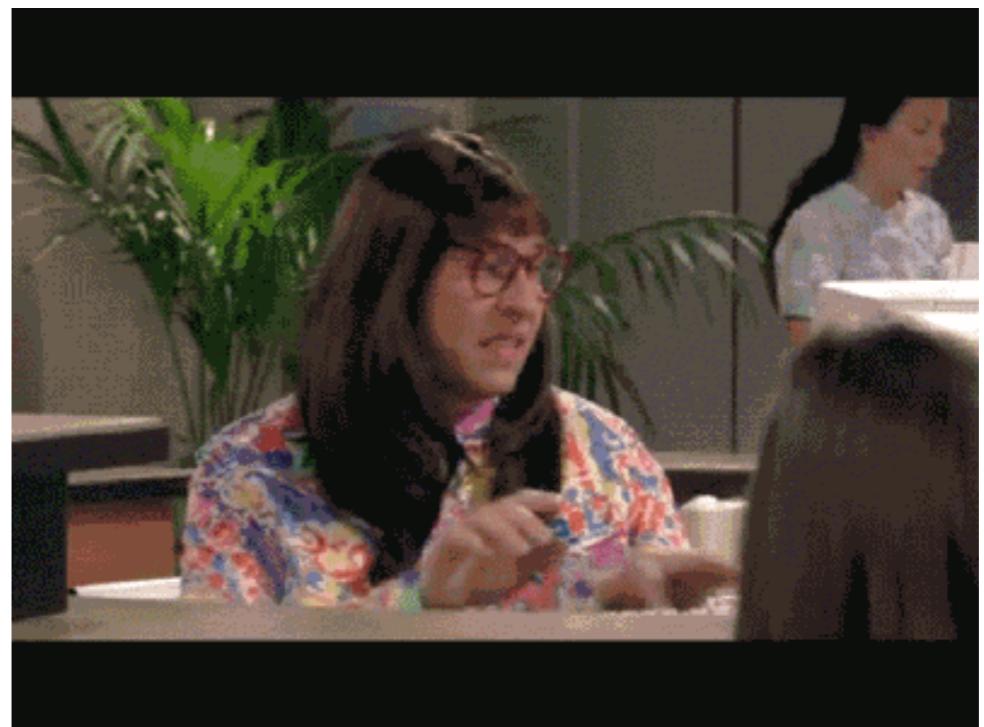
by Will Knight

Apr 11, 2017

Black Box

- If you ask a neural network **why** it did **what** it did you won't get any answer.
- A neural network is just thousands or millions of numbers. You can't extract logical rules.
- Problematic if you want to use neural networks for important decisions.

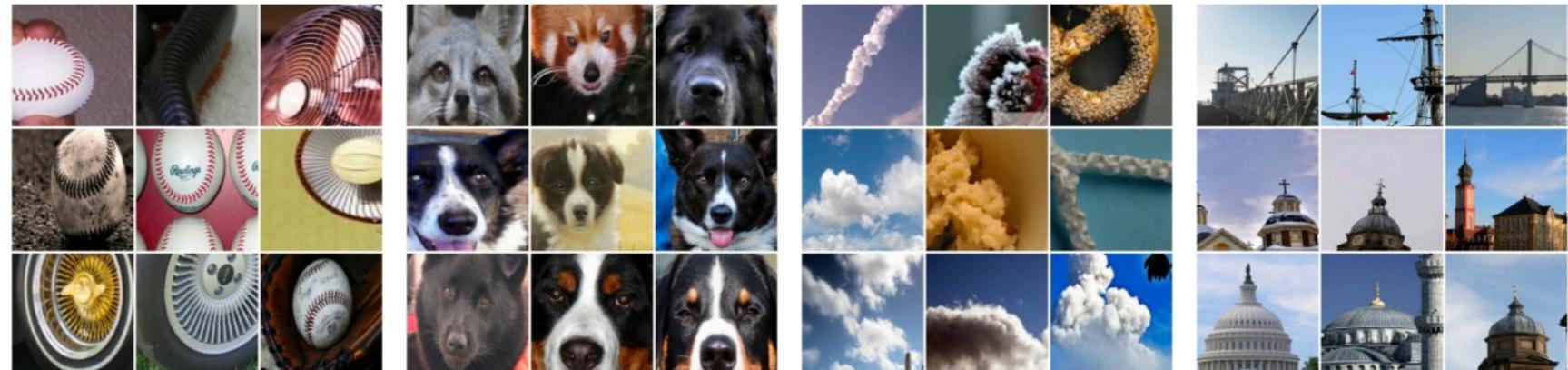
Why didn't I get that credit?!



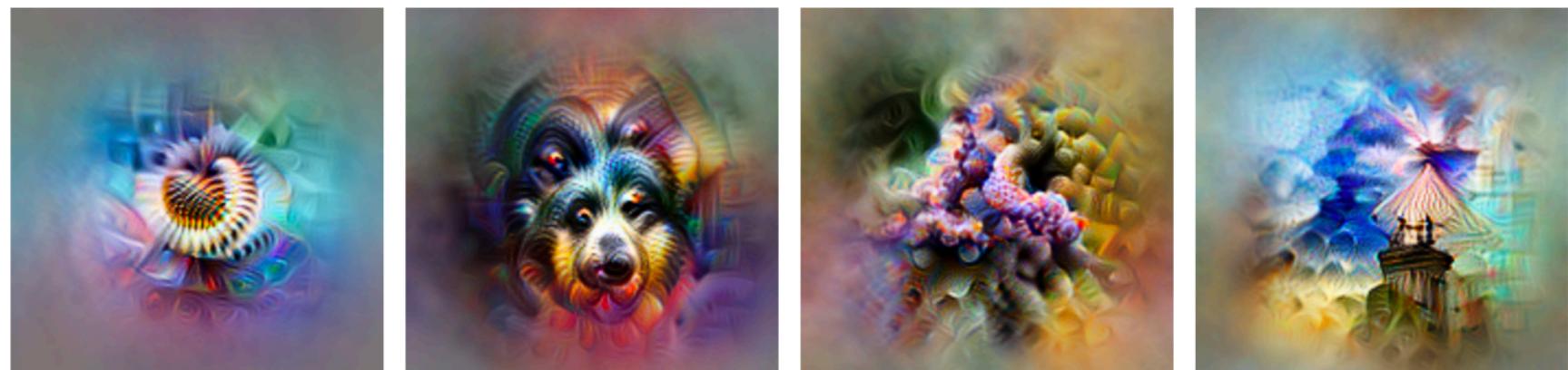
Feature Visualization

- Why do computer vision models decide for a specific category?
- What do they see?

Dataset Examples show us what neurons respond to in practice



Optimization isolates the causes of behavior from mere correlations. A neuron may not be detecting what you initially thought.



Baseball—or stripes?
mixed4a, Unit 6

Animal faces—or snouts?
mixed4a, Unit 240

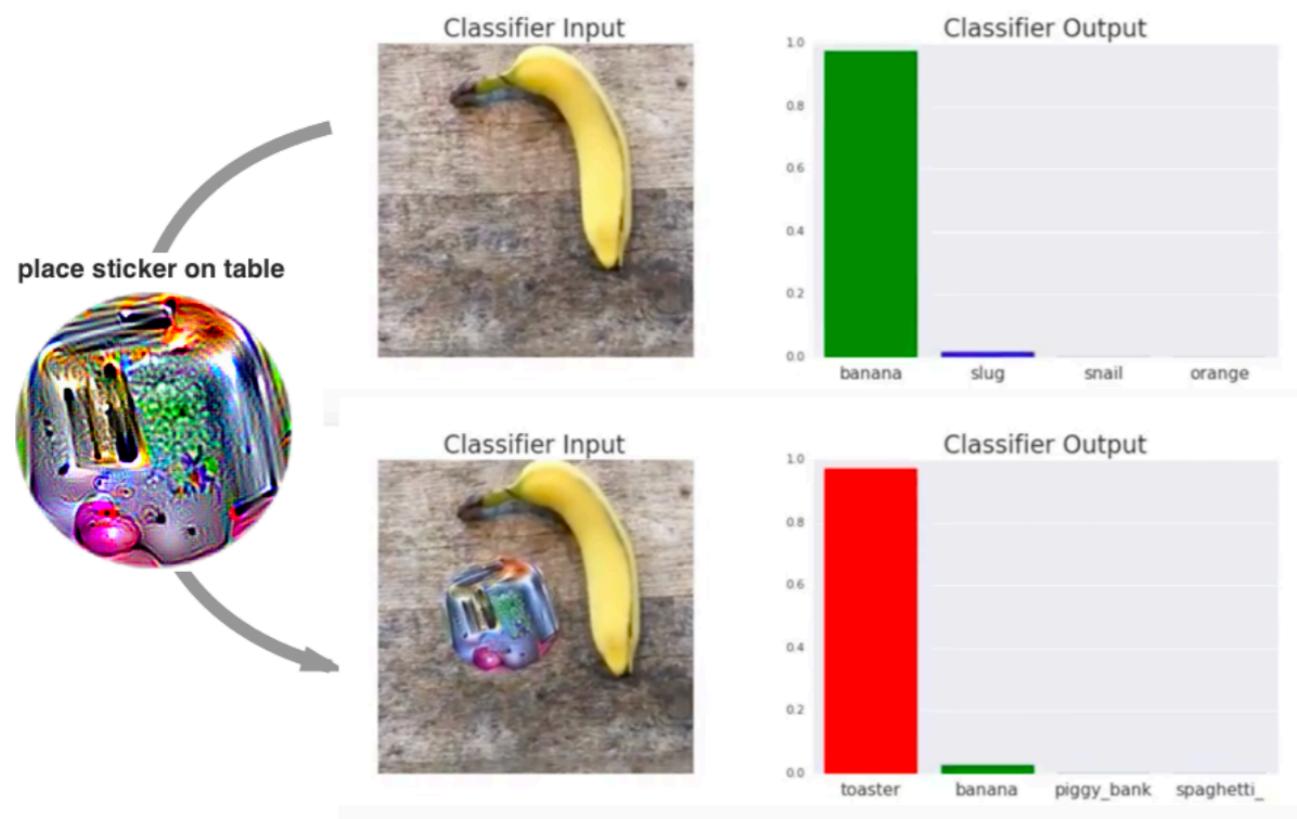
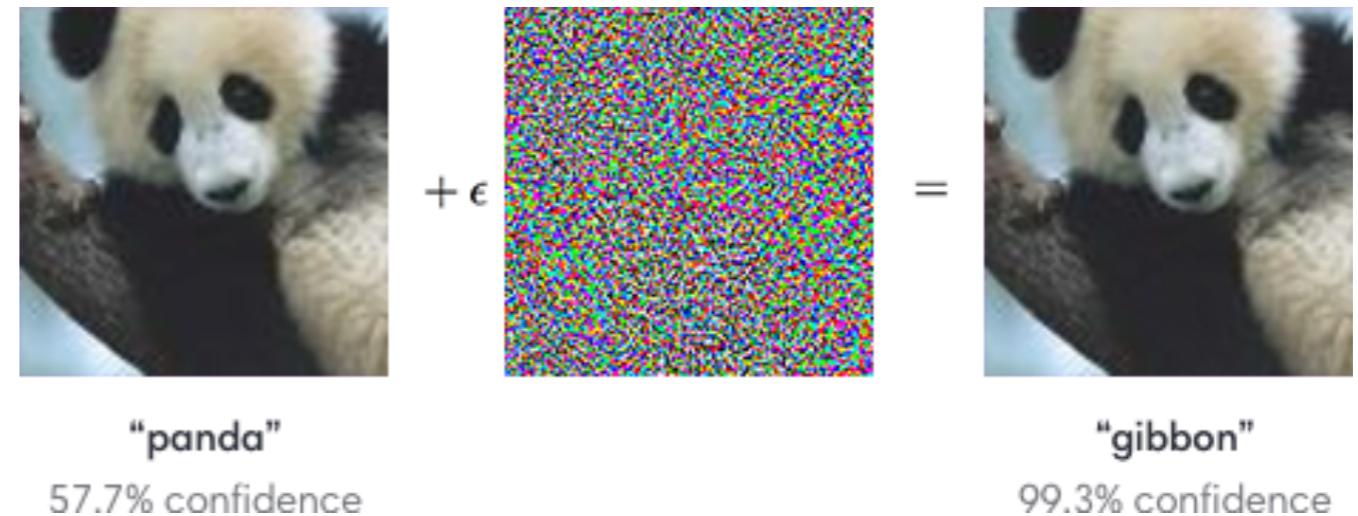
Clouds—or fluffiness?
mixed4a, Unit 453

Buildings—or sky?
mixed4a, Unit 492

Distill.pub article

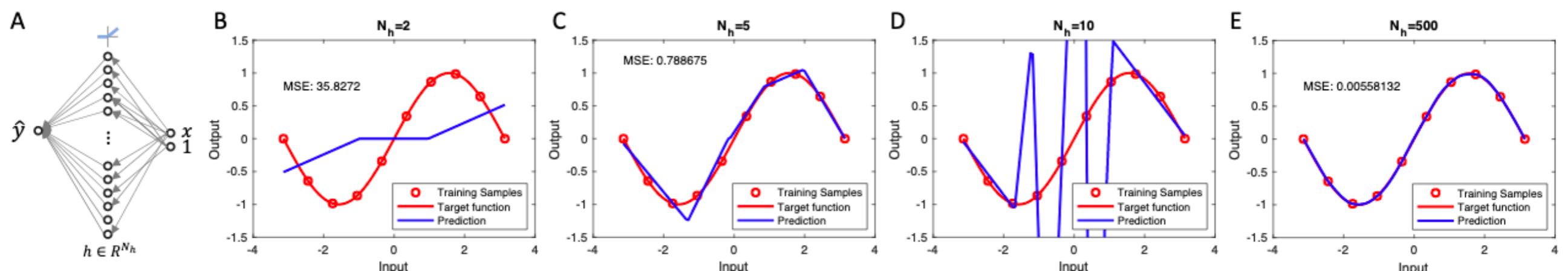
Adversarial Attacks

- And maybe these networks do not even work as we would like them to work?



Why do ANNs learn that good actually?

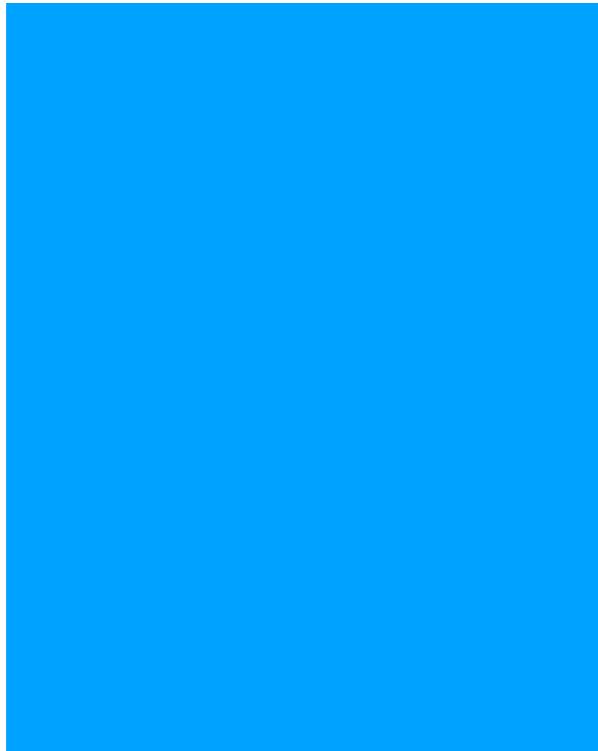
- It is also not quite clear why actually ANNs work as well as they do.
- Neural networks are heavily overparameterized, still they find good solutions.
- This also means making them better often comes from intuitions and experiments.



Part II

Organization

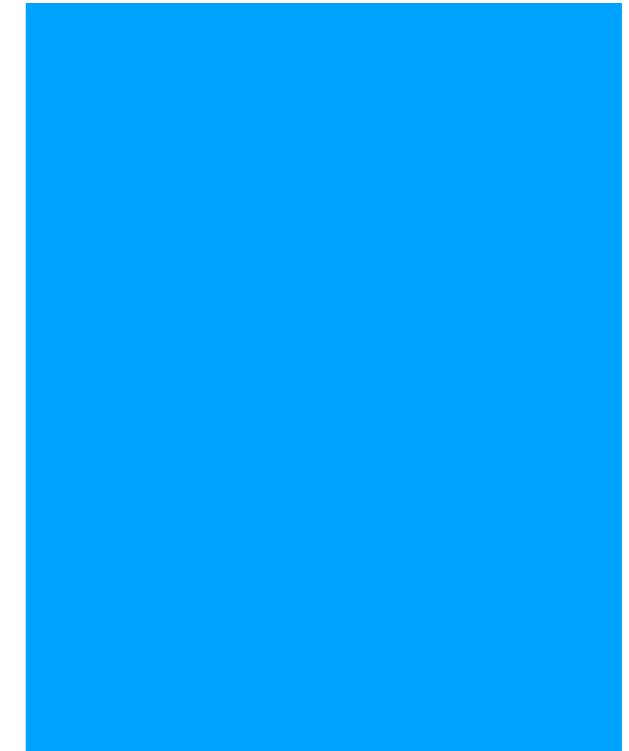
Team



Luke



Sahar



Leon

About Me

- PhD Candidate in Gordon Pipa's Neuroinformatics Lab.
- My work focuses around how to teach ANNs to learn more like humans do.
- Previously MSc in Cognitive Science here in Osnabrueck
- Before that BSc in Mathematics at HHU Duesseldorf.

Drin
lassen?

I will supervise bachelor and master theses around deep learning and artificial neural networks. If you are interested drop me a line!

Sessions

- Lecture: **TBA**

Mostly theoretical background on artificial neural networks and their applications. Sometimes implementational topics. Hold by me.

- Open Q&A Homework Session: **TBA**

Homework session to work on the current homework. Supervised by **TBA and TBA**.

- Homework Tutorial Session: **TBA**

Tutorial session to discuss the last homework. Presented by **TBA**.

Recording

- The lecture should usually be recorded.
- But do not bet on it as it often simply fails!
- Tutorial and QnA is not recorded!

Requirements

A. Homework

B. Midterm

C. Final Project

Homework

- Google colab!

Midterm Exam

Final Project