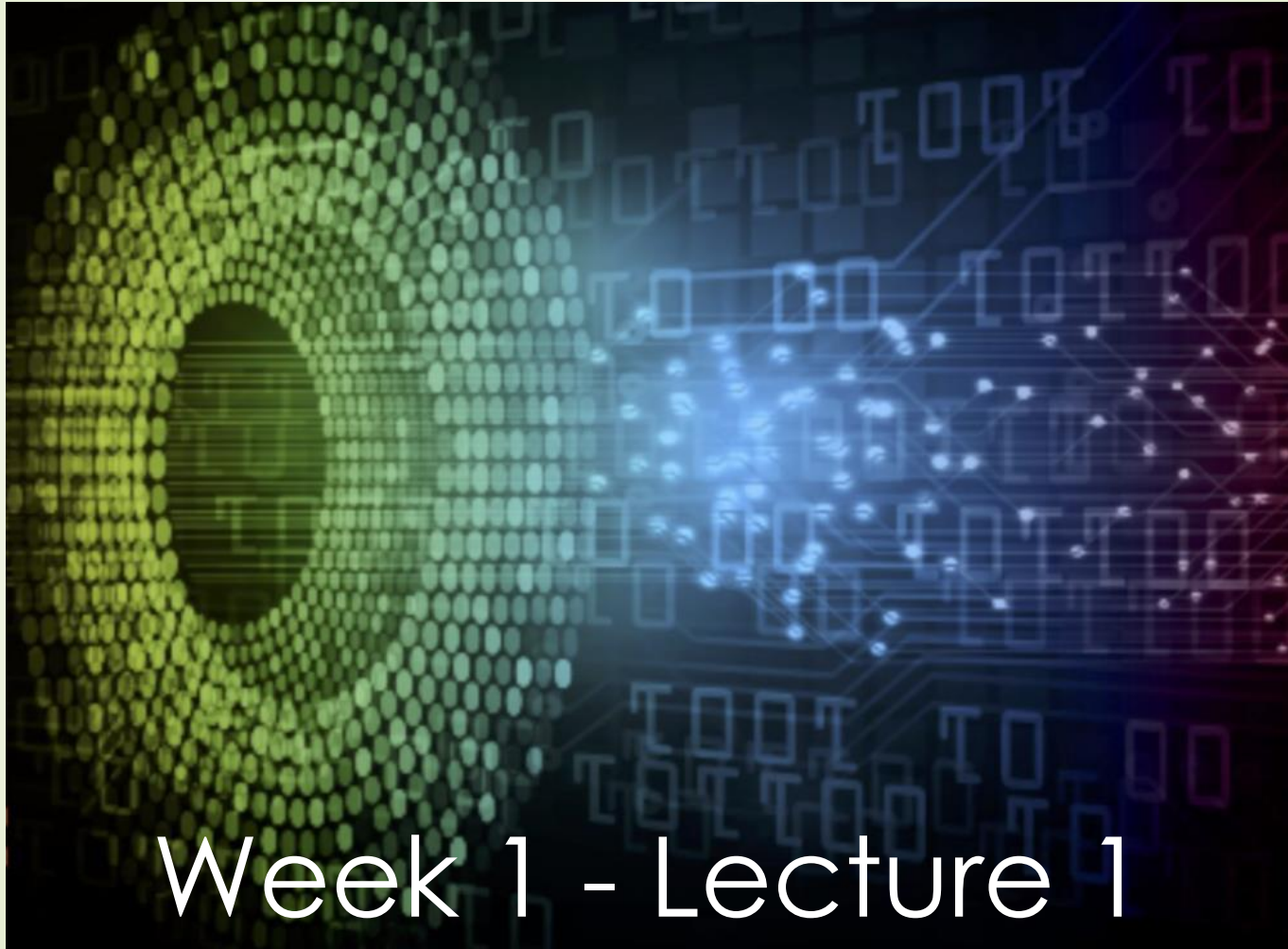


Neural Network Methods for Signals in Engineering and Physical Sciences



Week 1 - Lecture 1



Introduction

Model

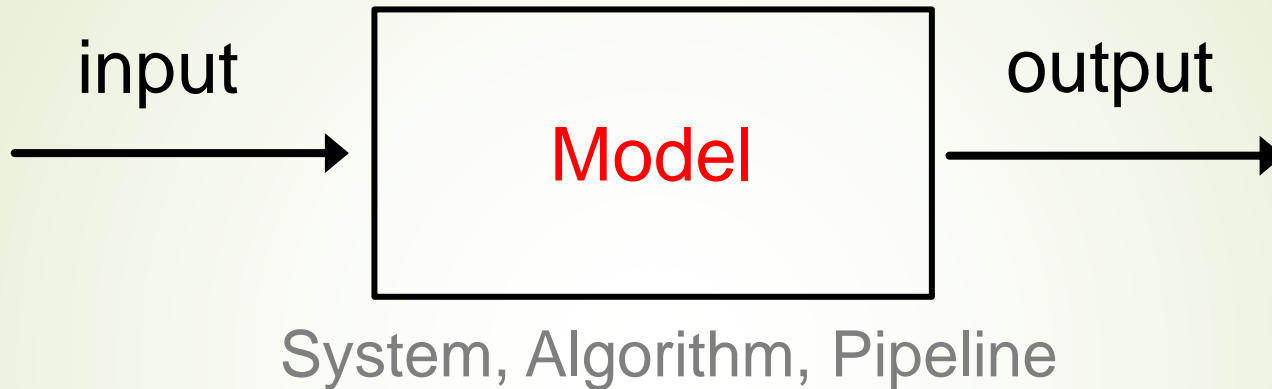
Neural Network Methods

for

Data

Signals in Engineering and Physical
Sciences

Introduction - Model



Input: signal, multiple signals, time-dependent, stationary

Model: function of the input

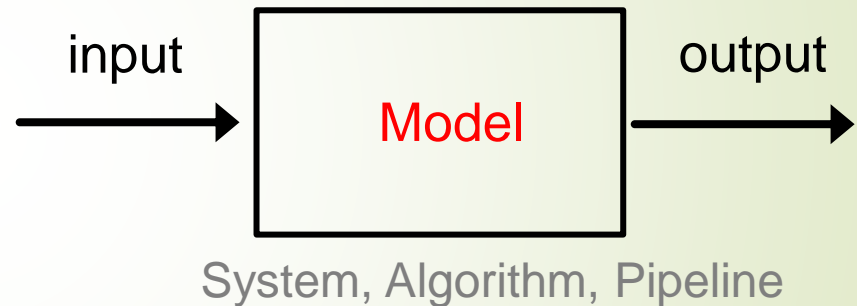
Output: signal, multiple signals, time-dependent, stationary.

Special outputs: input characteristic - class, score.

Introduction - Model

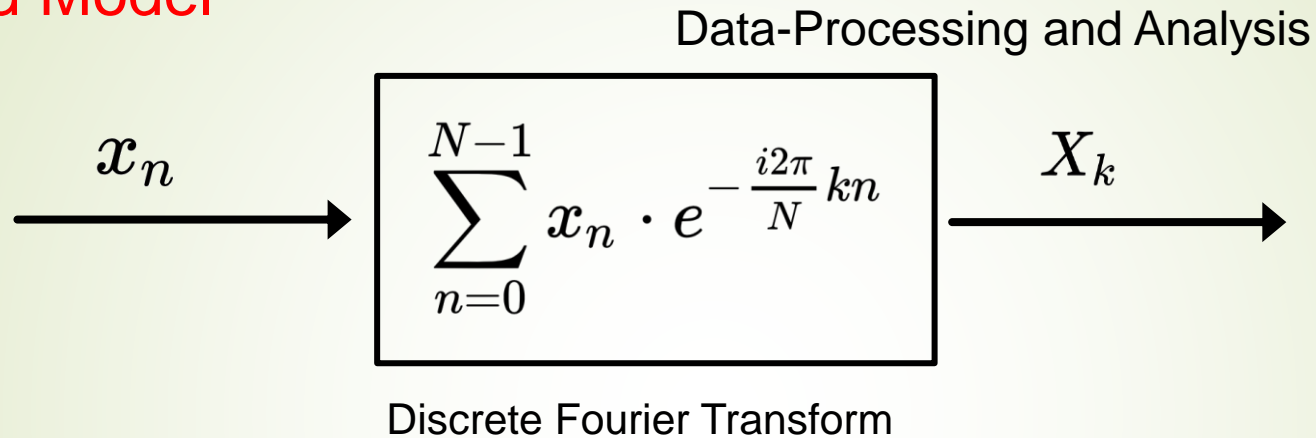
Examples of Models

- Continuous/Discrete Time Linear Time-Invariant System
 - Convolution, Transform
- Non LTI (Nonlinear Transforms)
- Fitting Data (Regression)
- Score/Class Assignment (Classification)

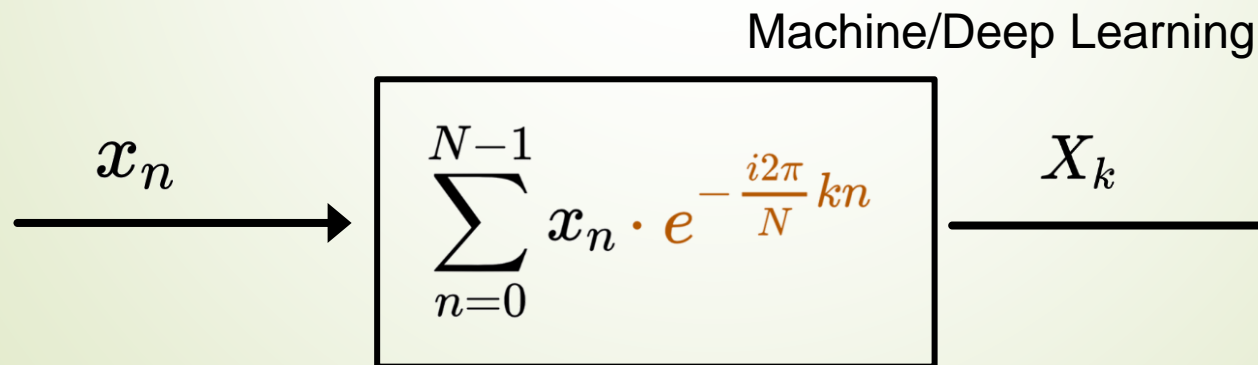


Learned vs. Fixed Model

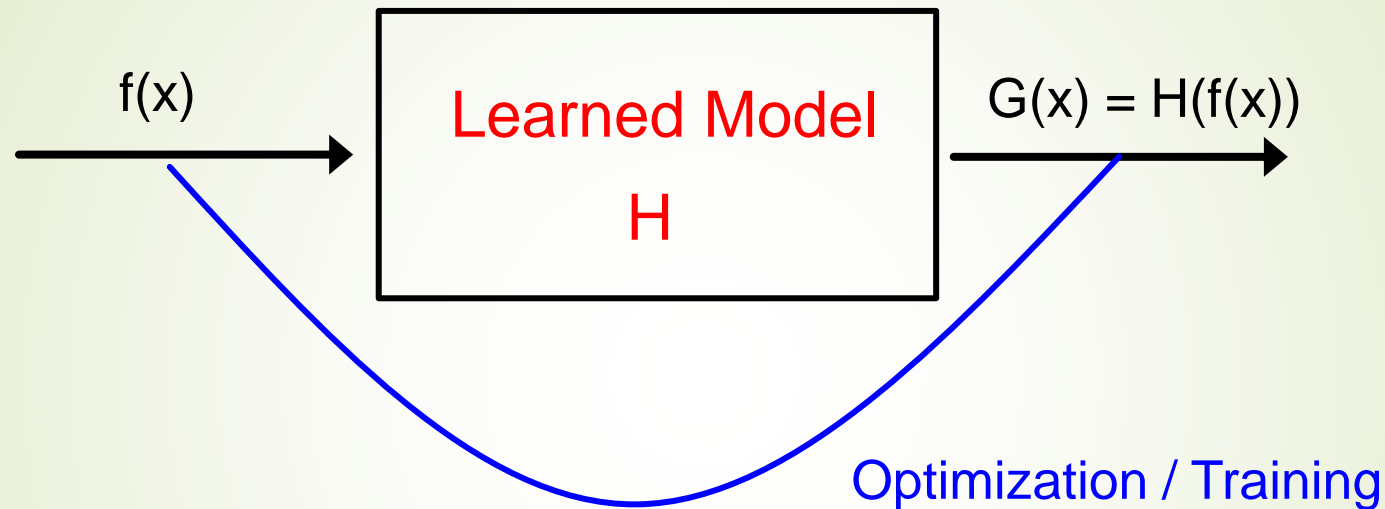
Fixed Model



Learned Model



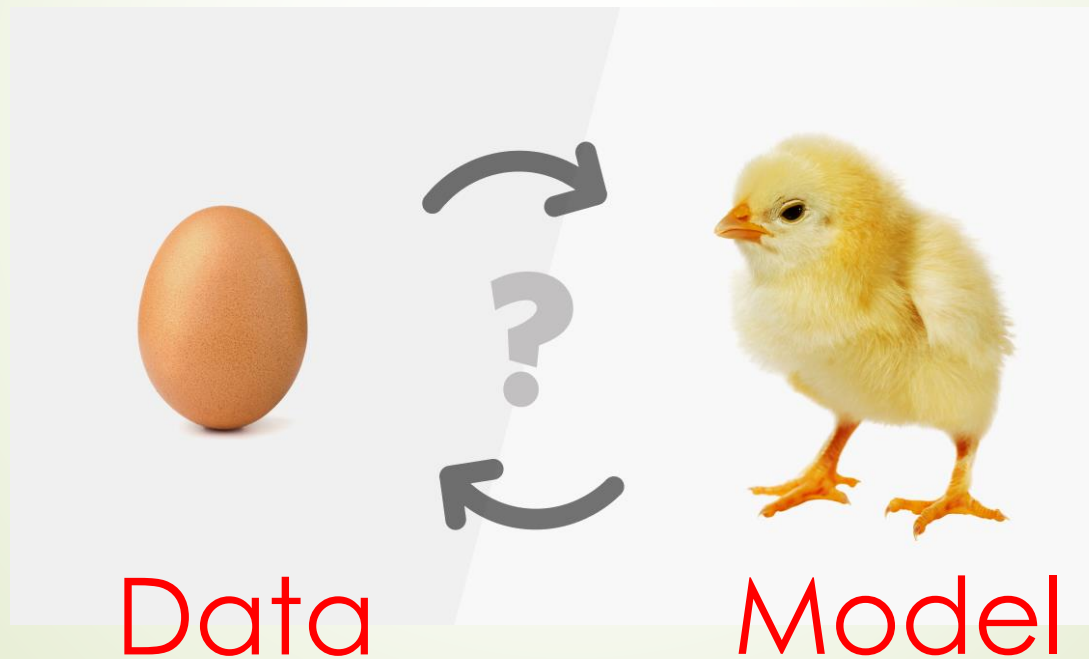
Machine Learning – Learning an Optimal Model for Data



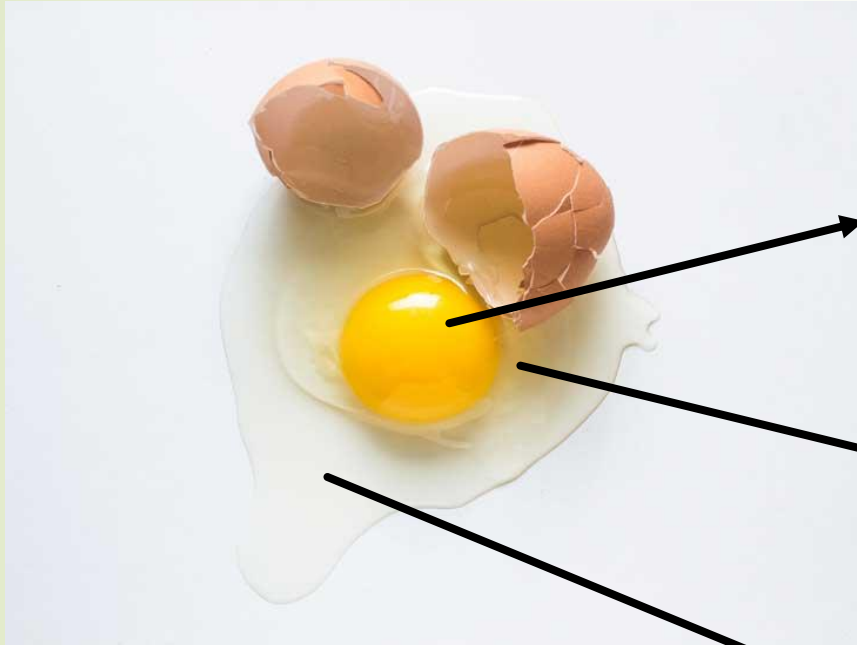
- H expression can be completely unknown (hard)
- H expression can be fixed with unknown parameters (easier)
- H can be updated through (machine) learning: optimization/ training
- Deep Learning is a subset Machine Learning

Machine Learning Main Challenge

Learn From the **Data** an
Optimal Model for the **Data**



Learning: Model Training, Validation and Testing



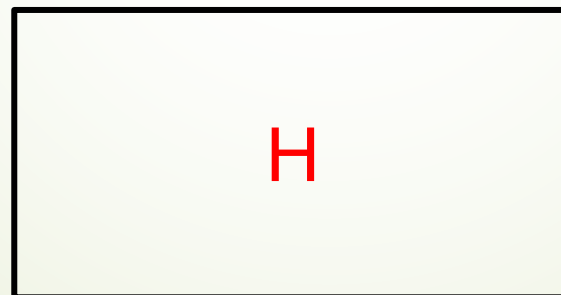
Training (Optimization)

Validation

Testing

“Classical” Machine Learning Methods

- Various Models
- Data, Task -> Model (Data and Task Dependent)
- Constraints on Data
- Transform Data to Different Signals (features)



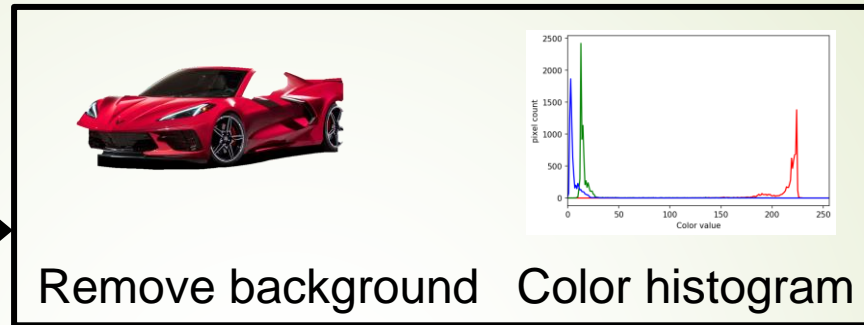
1. Color

2. # Wheels in photo

3. Tesla? Yes/ No

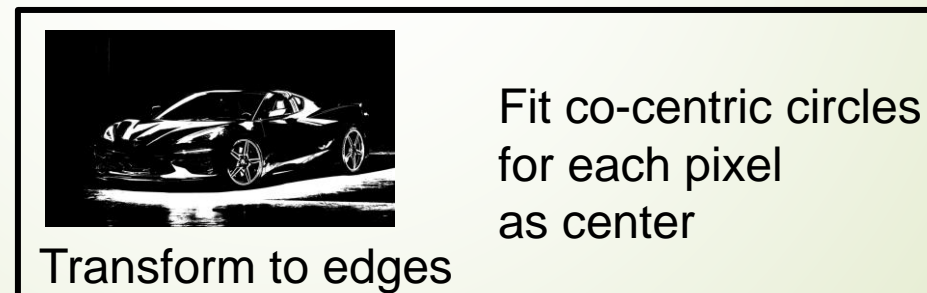
“Classical” Machine Learning Methods

• 1.



Red

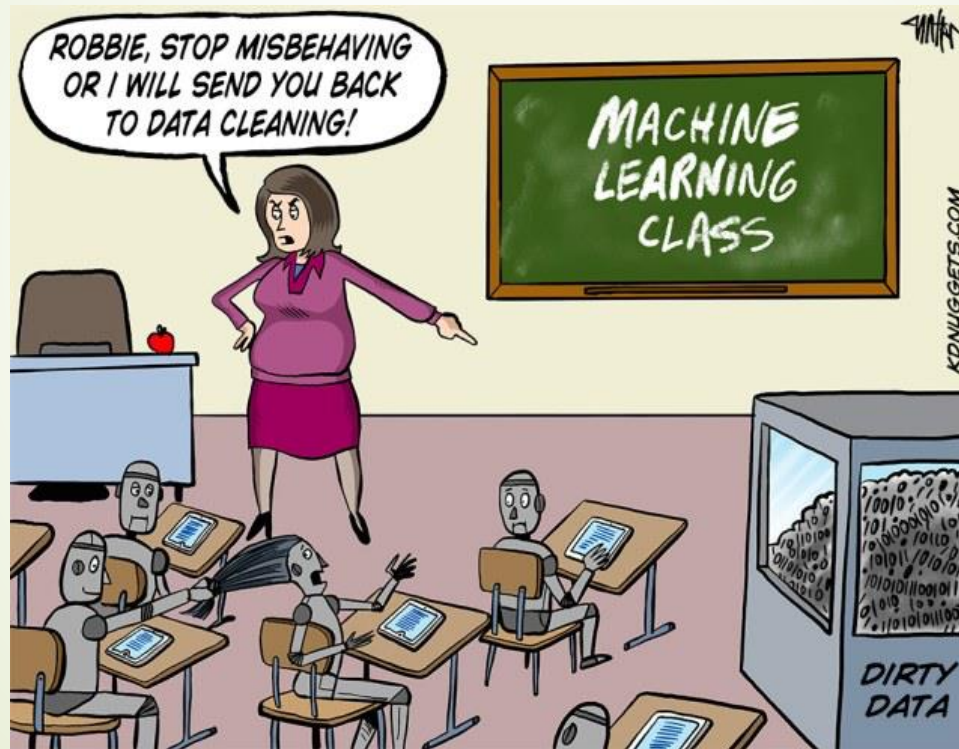
• 2.



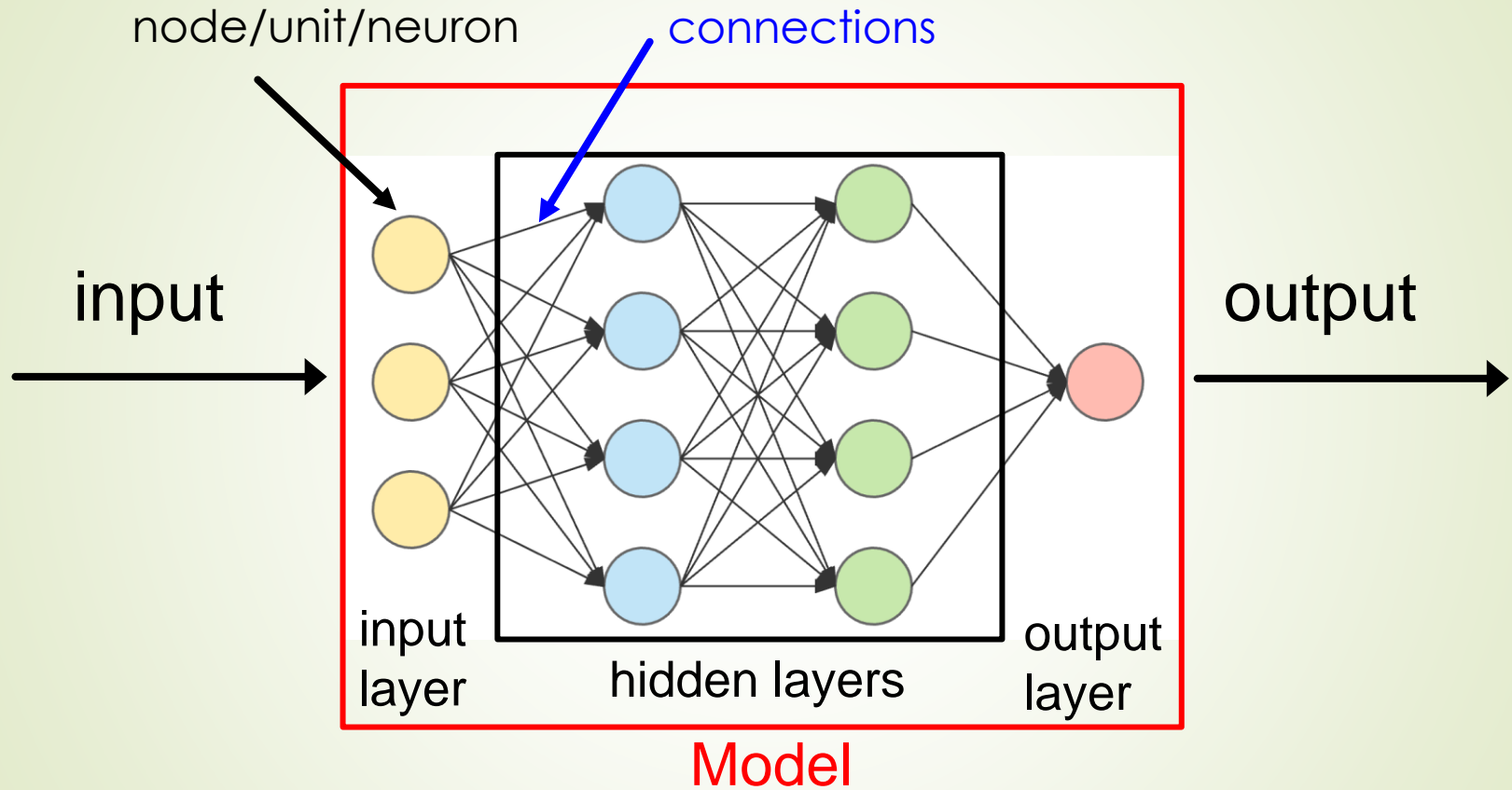
2

Additional Challenges

- **Robustness** to Imperfect Data
- **Scalable** with Data



Neural Networks (ANN/DNN)



Model: Network of nodes (neurons) and connections (weights)
Learning: Optimization of Connections (Deep Learning /Back Propagation)

Deep Learning

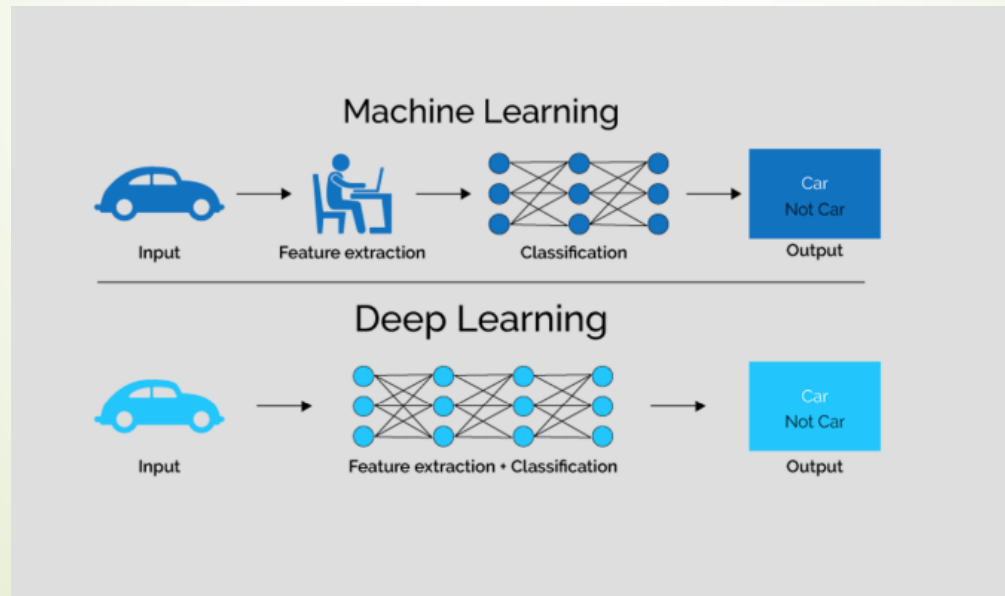


H: NN

1. Color

2. # Wheels in photo

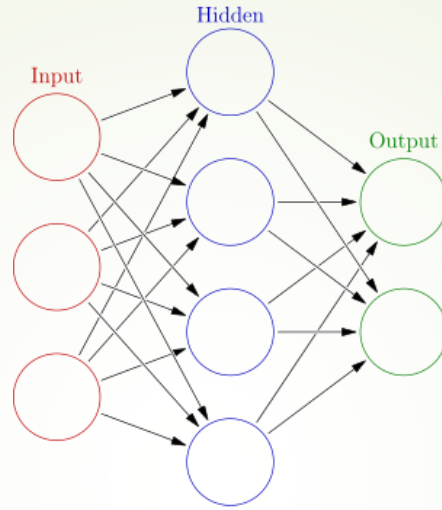
3. Tesla? Yes/ No



Artificial Neural Networks (ANN)



Data Processing



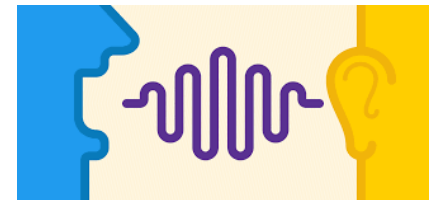
Computer Vision



Navigation

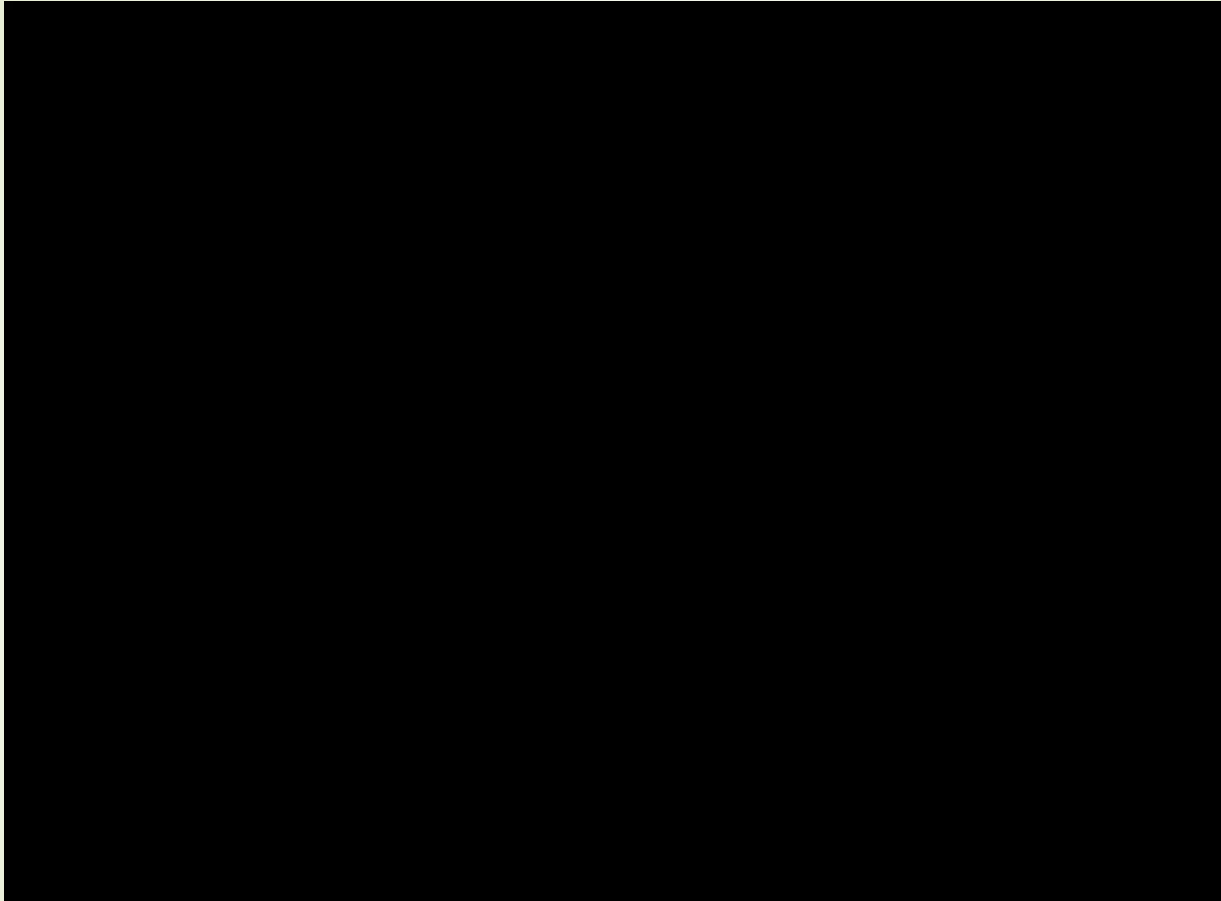


Text Processing



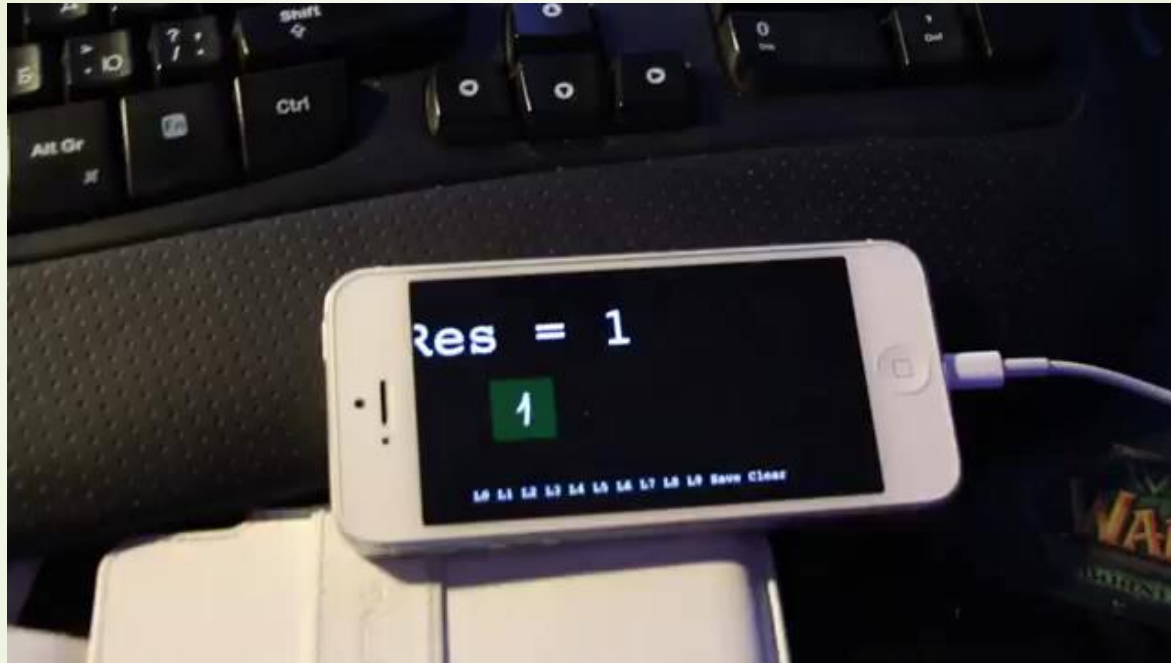
Speech Understanding

Applications and Signals



Digits Reader

Applications and Signals



Digits Reader 2013

Applications and Signals



Multi Person Detection and Tracking

Applications and Signals



Speech Understanding

Applications and Signals



Autonomous Driving



A3D3 Datasets/Tasks

- Particle Physics
- Gravitational Waves
- Multi-Messenger Astrophysics
- Recordings from Neurons

Neural Networks / DL

“Deep Learning is
the new electricity”

Andrew Ng



Next Lecture: Learning from the Brain

