UCL

Advanced Machine Learning in Finance

Paolo Barucca
Tomaso Aste

WEEK 1

- Lecture Plan
- Datasets
- Assessment
- Introduction to Tensorflow

Lecture Plan

- WEEK 1 (W1): Introduction to the module
- CASE STUDY (CS) / Downloading data

- W2: Logistic regression and traditional machine learning
- CS: Credit crisis prediction

- W3: Feedforward neural networks and convolutional neural networks
- CS: Time-series classification

- W4: Recurrent neural networks
- CS: Return time-series prediction

- W5: Natural Language Processing
- CS: Sentiment analysis in finance

Lecture Plan

- W6: Reinforcement learning and deep reinforcement learning
- CS: Order placement optimisation

- W7: Reinforcement learning and deep reinforcement learning II
- CS: Order placement optimisation II

- W8: Overfitting and statistical testing
- CS: Payment networks classification

- W9: Variational autoencoders, generative adversarial networks and more
- CS: GRUVAE approach to time-series prediction

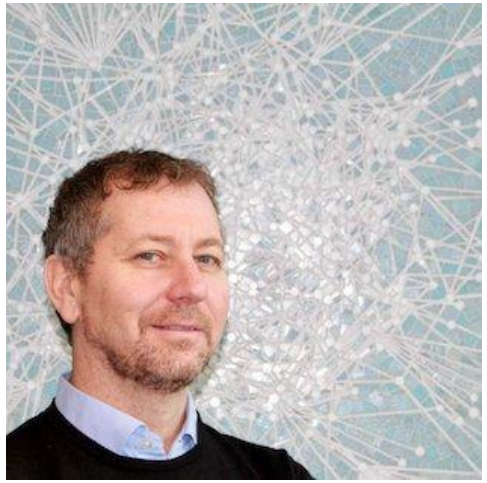
- W10: Research perspectives and project instructions
- Q&A

Office hour

- Room 4.08, Gower Street Building, 66-72 Gower Street
- Email: p.barucca@ucl.ac.uk

Academic Team

- Module Leaders: Paolo Barucca and Tomaso Aste
- Teaching Assistants: Kentaro Hoshisashi



Datasets

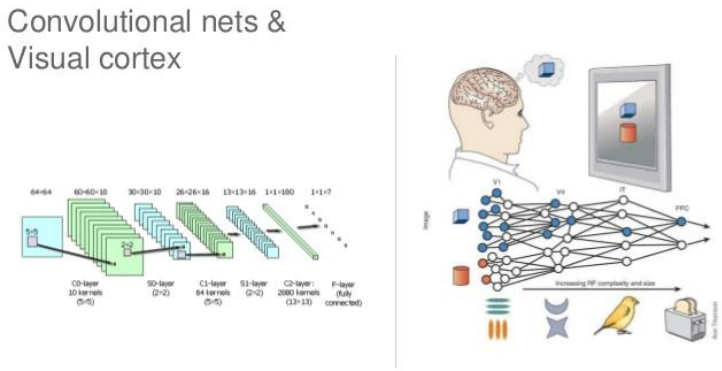
- Stocks Data
- FOREX Data
- Credit Data
- Non-Financial Data
- Online Data Sources

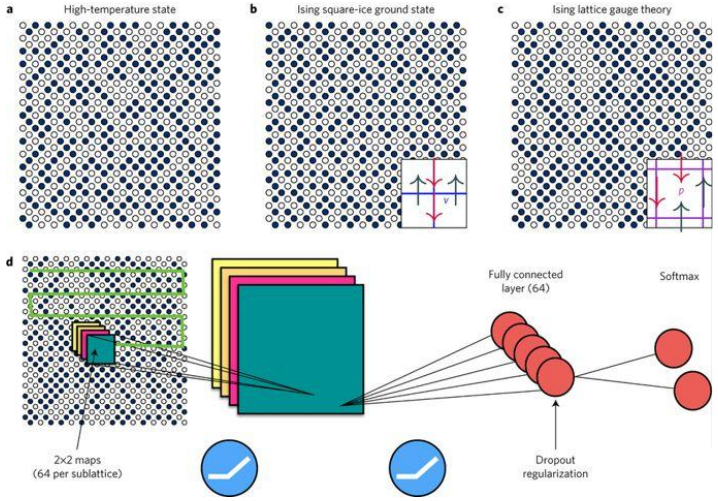
Project writing

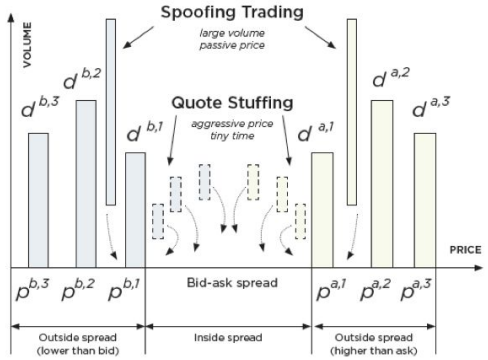
- 100% Assessment
- Individual Project
- Project Structure
- Marking Criteria

Applications of neural networks

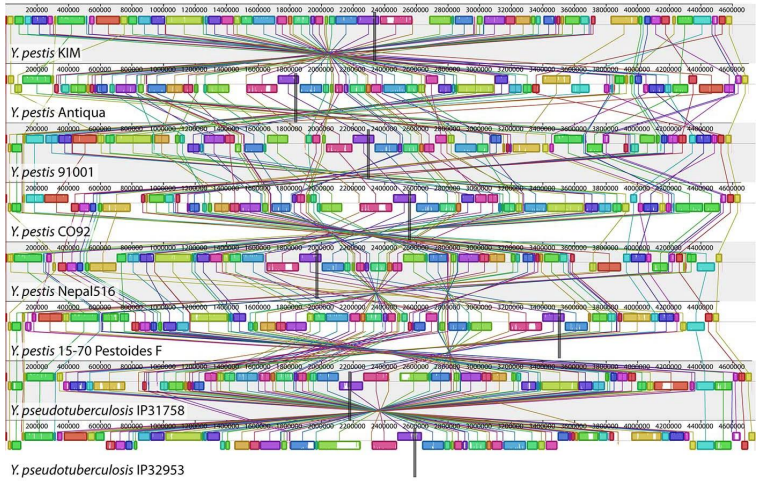
- Vision
- Physics
- Biology
- Medicine
- Finance

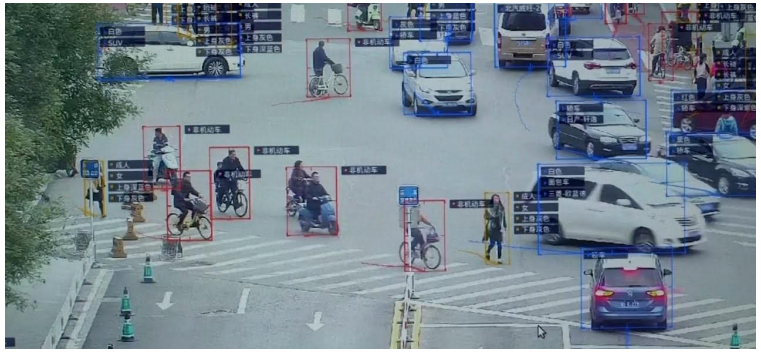






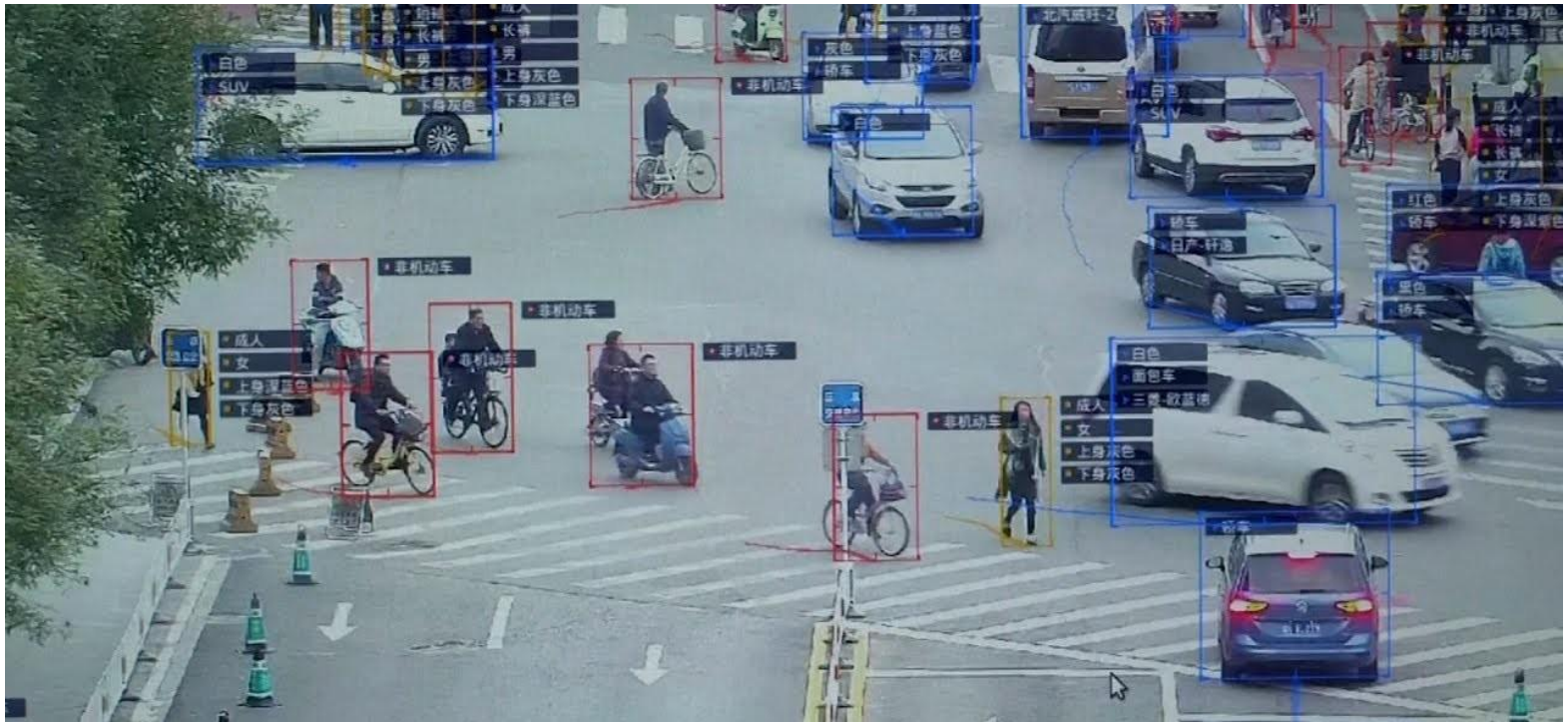
An illustration of spoofing trading and quote stuffing strategies in a L3 order book.





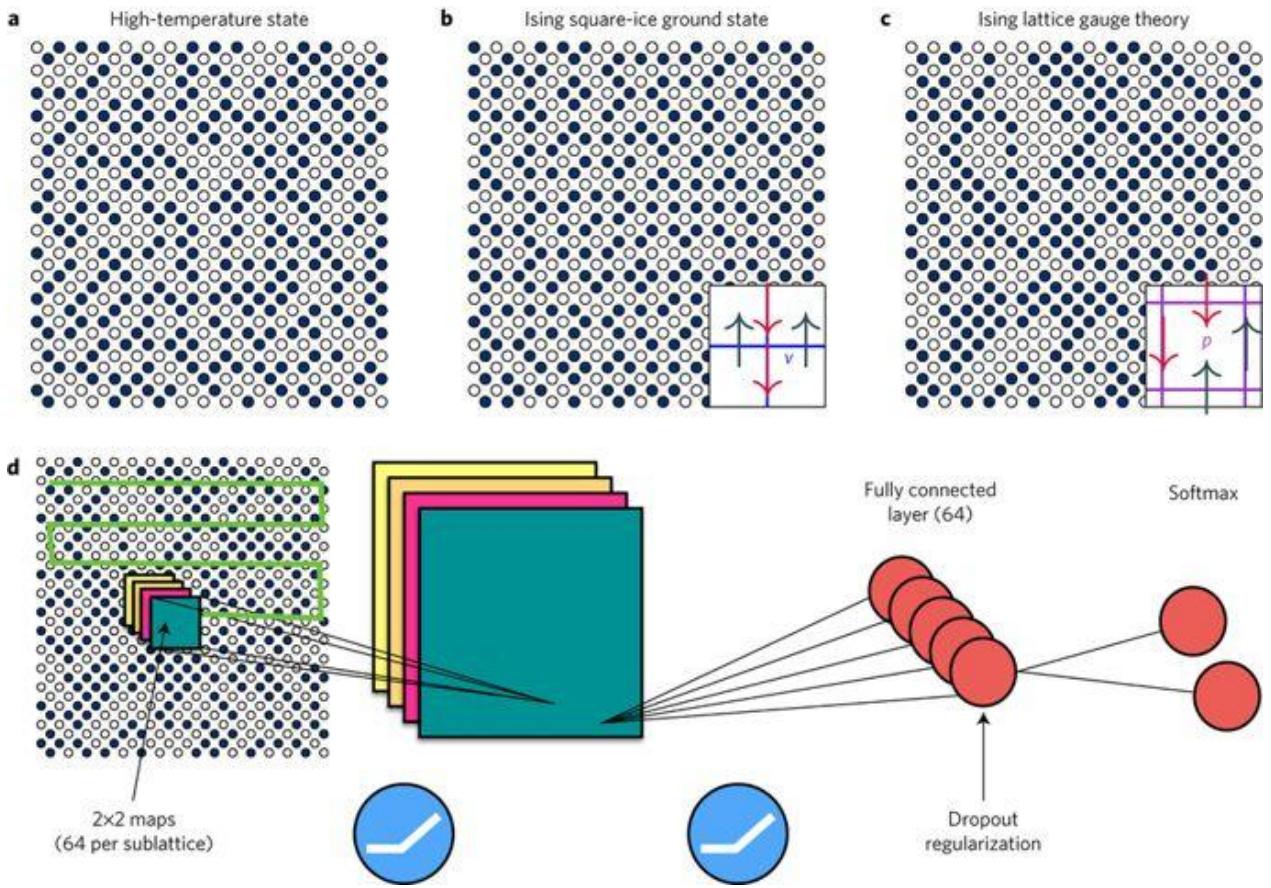
Vision

- Object detection
- Image classification
- Image captioning
- Image generation
- Automated driving



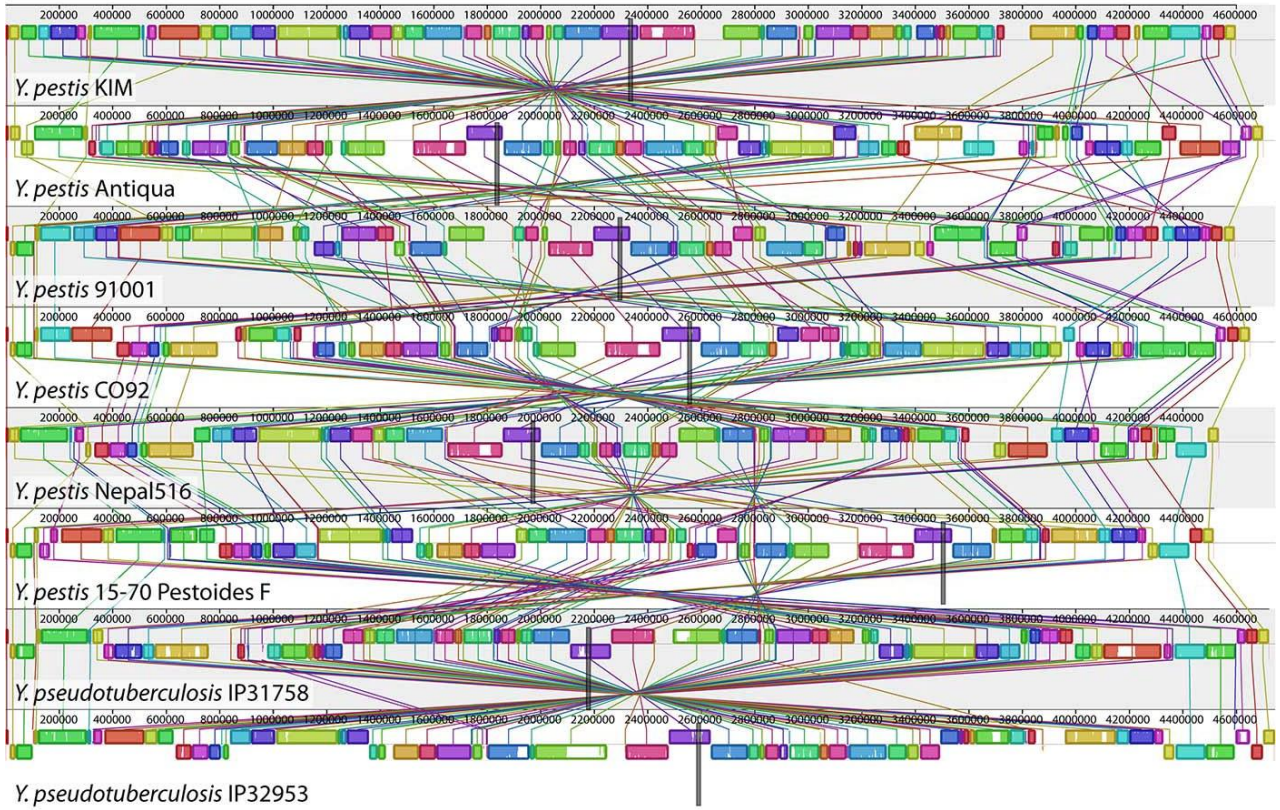
Physics

- Phase classification
- Particle tracking
- Event detection
- Complex systems modeling



Biology

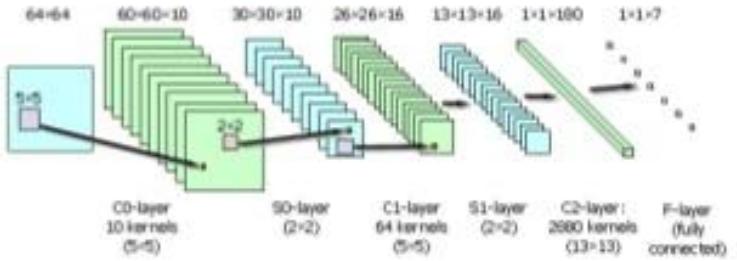
- Genome biology
- Protein folding
- Molecule prediction
- Microscopic image processing

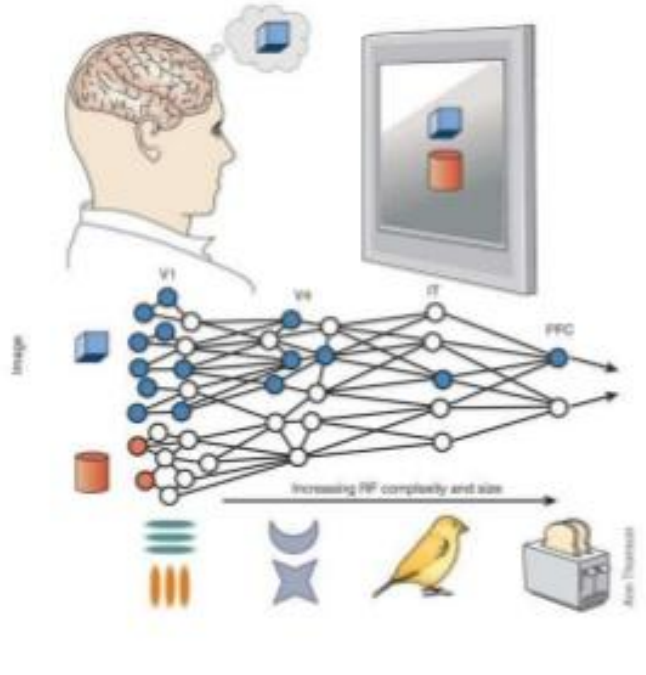


Medicine

- **Diagnostics**
- **ROI detection**
- **Neuroscience**
- **Drug discovery**

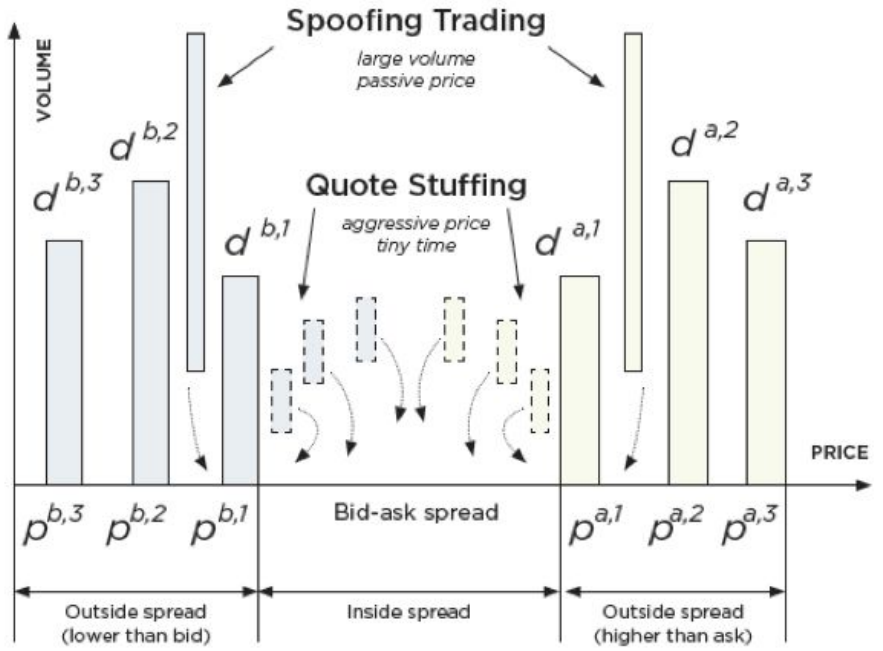
Convolutional nets &
Visual cortex





Finance

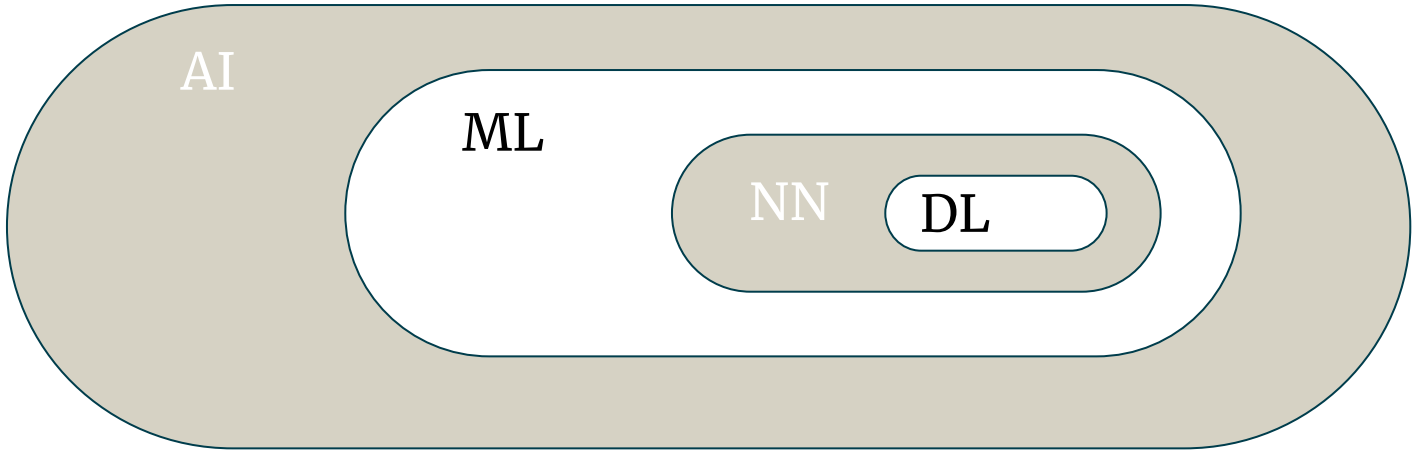
- Time-series prediction
- Automated trading design
- Portfolio optimization
- Trade activity classification
- Payments anomaly detection
- Institution classification



An illustration of spoofing trading and quote stuffing strategies in a L3 order book.

The set of AI algorithms

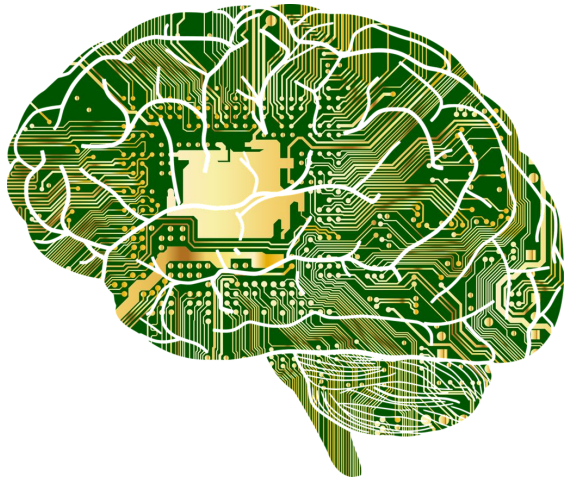
An extremely successful set of AI algorithms is the set of machine learning (ML) algorithms, within which we can find neural networks (NN), within which we can find deep learning (DL) algorithms



What is AI?

What is AI?

Artificial Intelligence is the ability of a machine to mimic human tasks



What is machine learning?

What is machine learning?

Machine learning is the ability of a programmable machine to learn tasks by itself, for example by looking at samples or competing against itself

What is machine learning?

The difference between ML software and a normal piece of software:

I can TELL a normal machine how to make a sum, by telling it explicitly the function and how the bits of the sum are derived

a ML algorithm LEARNS how to make a sum, e.g. reconstructing the right function by looking at previous sums

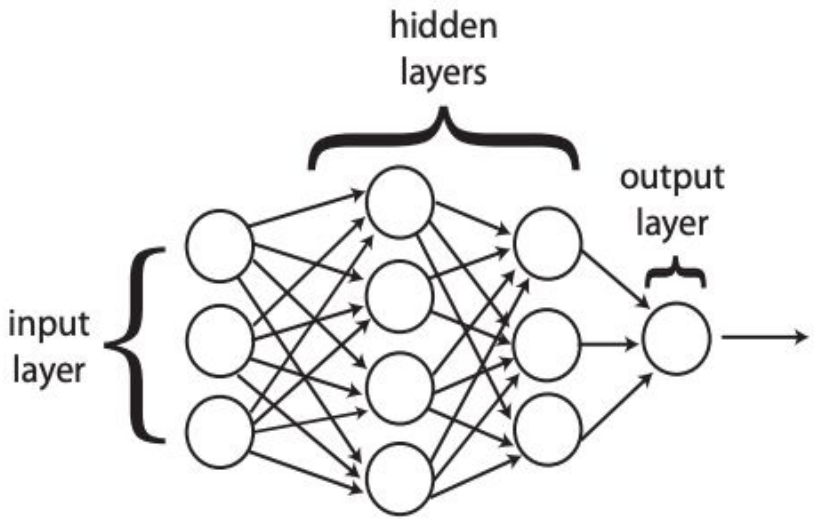
What is machine learning?

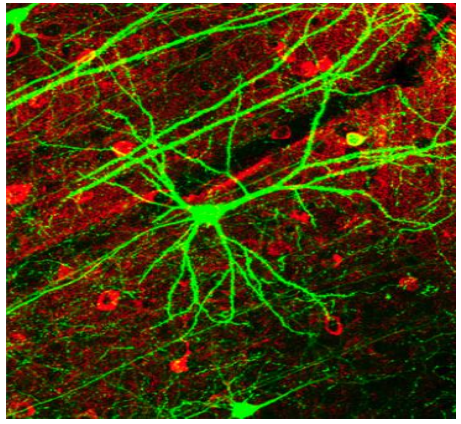
How can ML algorithms learn the function?

ML algorithms use general models that are able to represent large classes of functions.

What are neural networks?

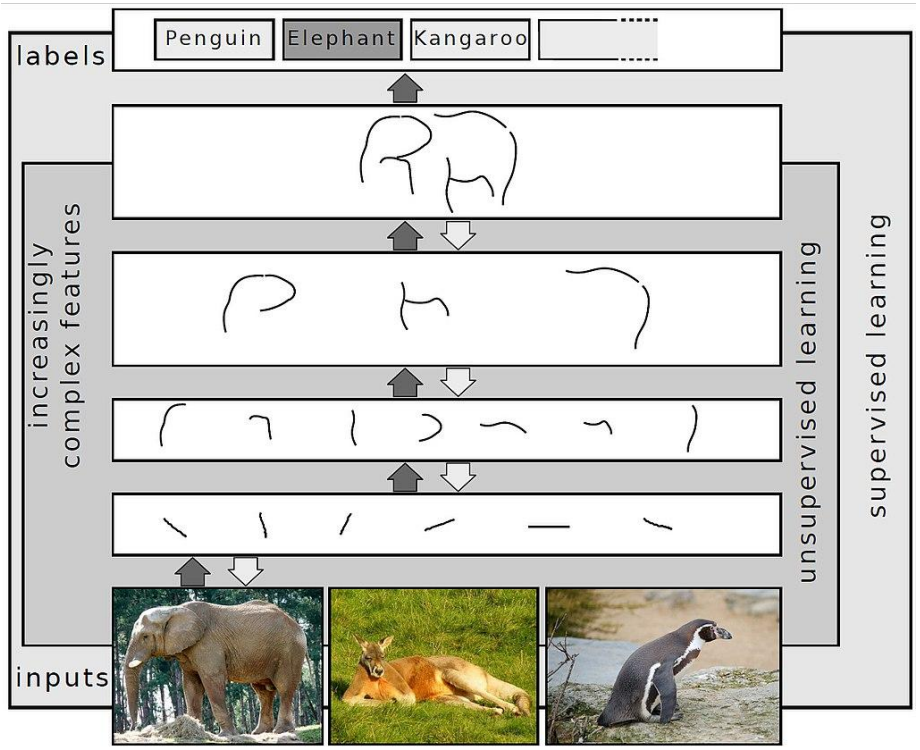
Neural networks are layered compositions of multivariable linear functions and non-linear functions which can represent almost all the existing functions of the input variables.





What is deep learning?

Deep learning is the learning carried out by neural networks with many layers of neurons, i.e. **deep neural networks**. Multiple layers are able to define features of the input variables of different levels of abstraction.

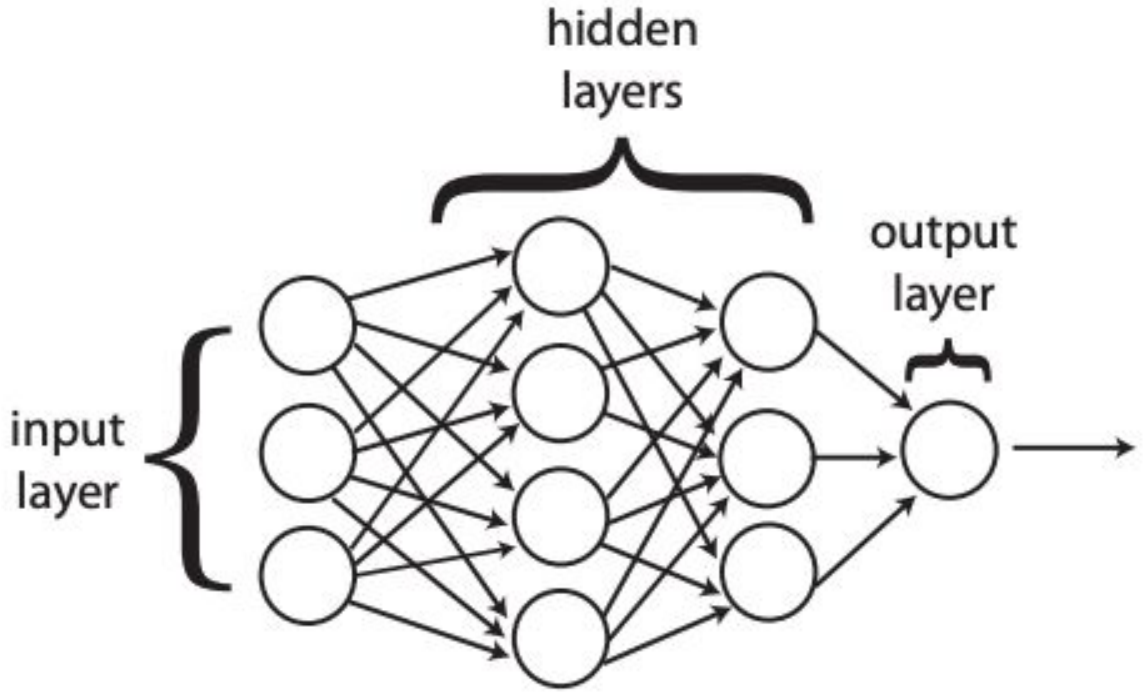


Zoology of AI

Same formalism, many architectures

- Feedforward Neural Networks
- Convolutional Neural Networks
- Variational Autoencoders
- Recurrent Neural Networks
- Transformers
- Generative Adversarial Networks
- Graph Neural Networks

Feedforward Neural Networks

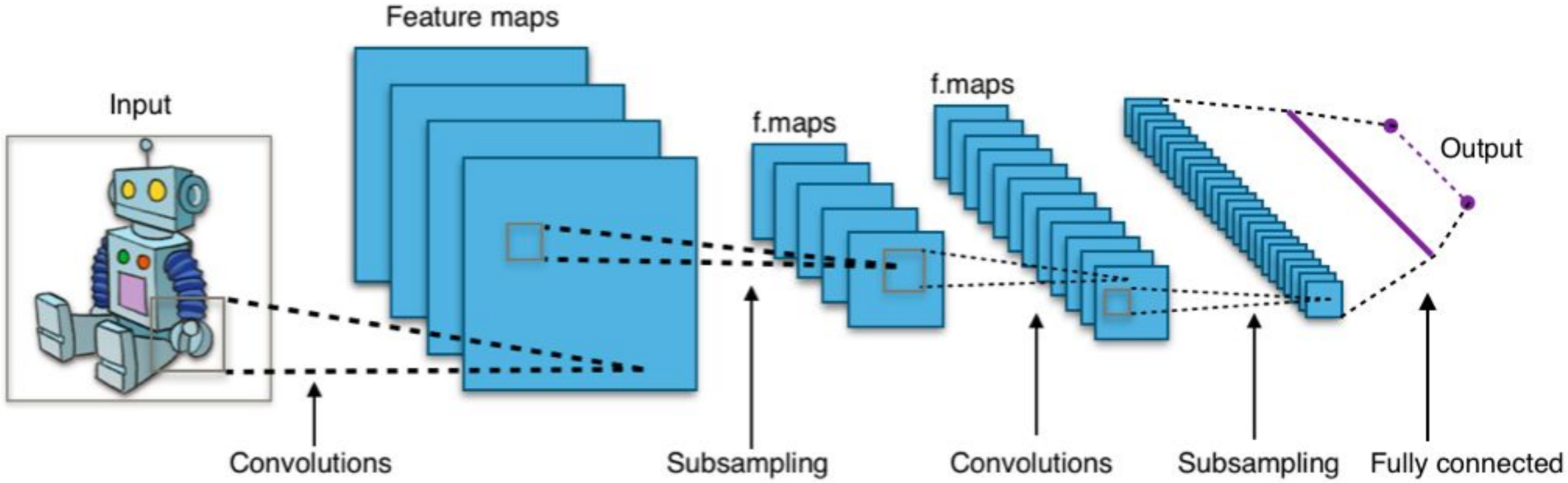


$$\hat{y} = f_L\left(\sum_{j=1}^{N_{L-1}} w_{1j}^{(L)} a_j^{(L-1)}(x) + b_1^{(L)}\right)$$

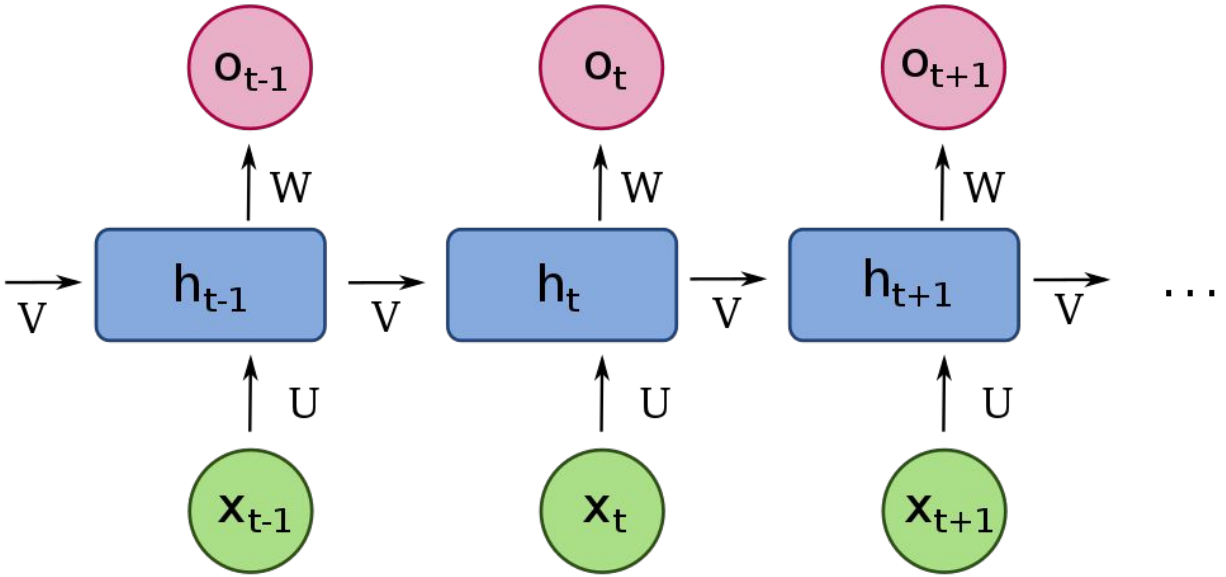
$$z_i^{(l)} = \left(w^{(l)T} a^{(l-1)} + b^{(l)}\right)_i \qquad a_i^{(l)}(x) = f_l\left(\sum_{j=1}^{N_{l-1}} w_{ij}^{(l)} a_j^{(l-1)} + b_i^{(l)}\right) = f_l(z_i^{(l)})$$

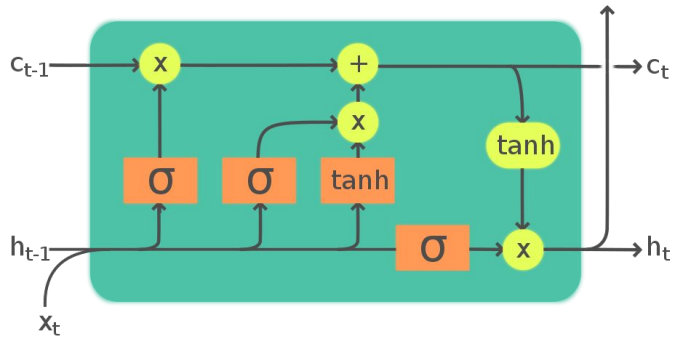
Figures from A high-bias, low-variance introduction to Machine Learning for physicists. arXiv:1803.08823. Pankaj Mehta, Marin Bukov, Ching-Hao Wang, Alexandre Day, Clint Richardson, Charles Fisher, David Schwab.

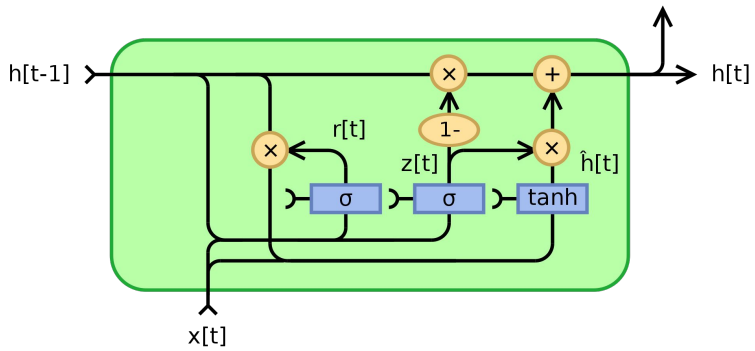
Convolutional Neural Networks



Recurrent Neural Networks







(Variational) Autoencoder

– A general framework for unsupervised learning of efficient representation of a dataset

ORIGINAL DATA (x)

↓ ENCODER

REPRESENTATION (h)

↓ DECODER

RECONSTRUCTED DATA ($\hat{x}$)

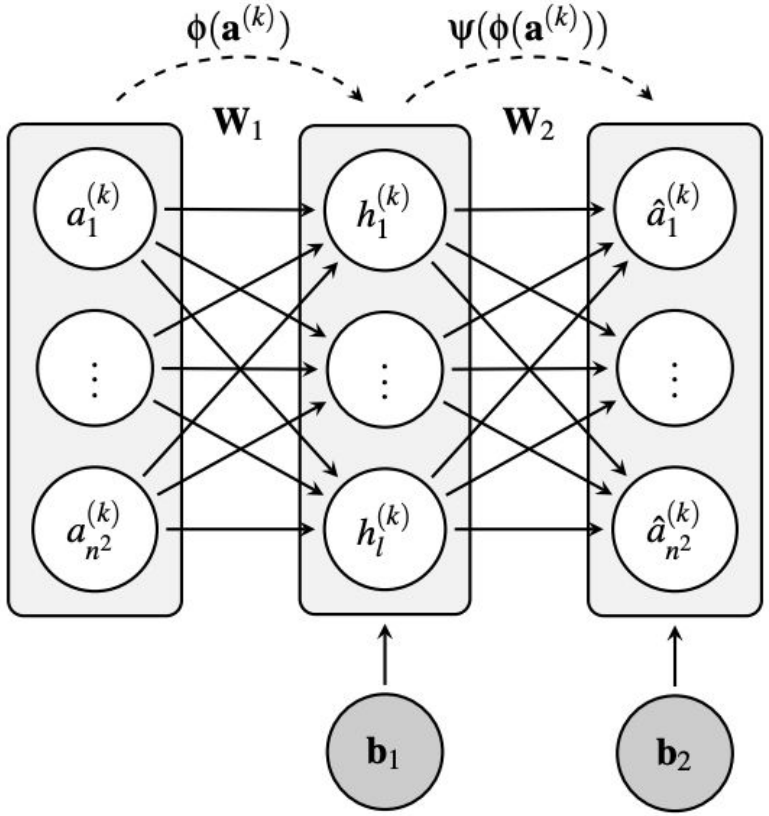


Figure from Triepels, Ron, Hennie Daniels, and Ronald Heijmans. "Anomaly Detection in Real-Time Gross Settlement Systems." *ICEIS (1)*. 2017.

Transformers

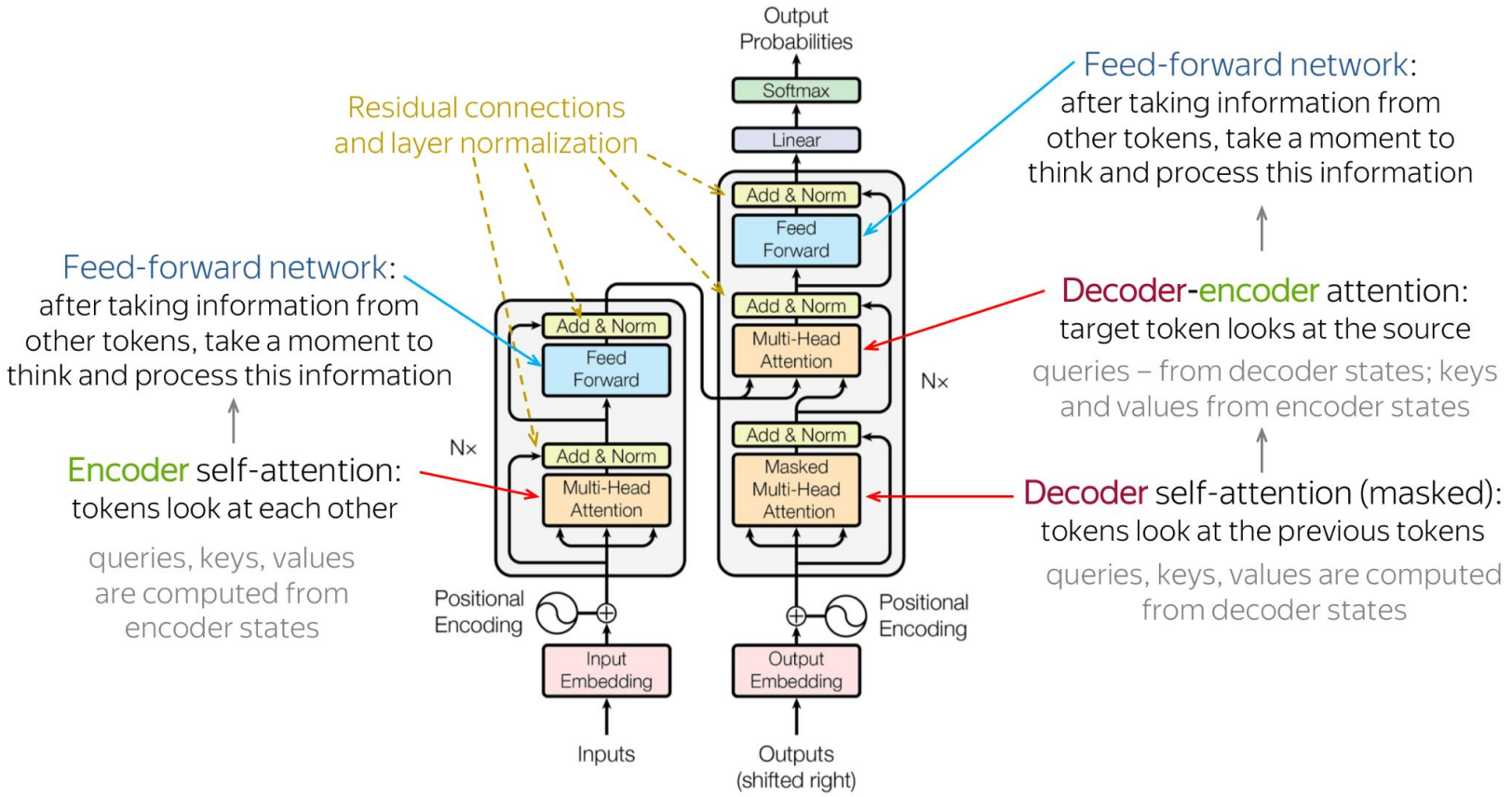


Figure from https://lena-voita.github.io/nlp_course/seq2seq_and_attention.html

Generative Adversarial Networks

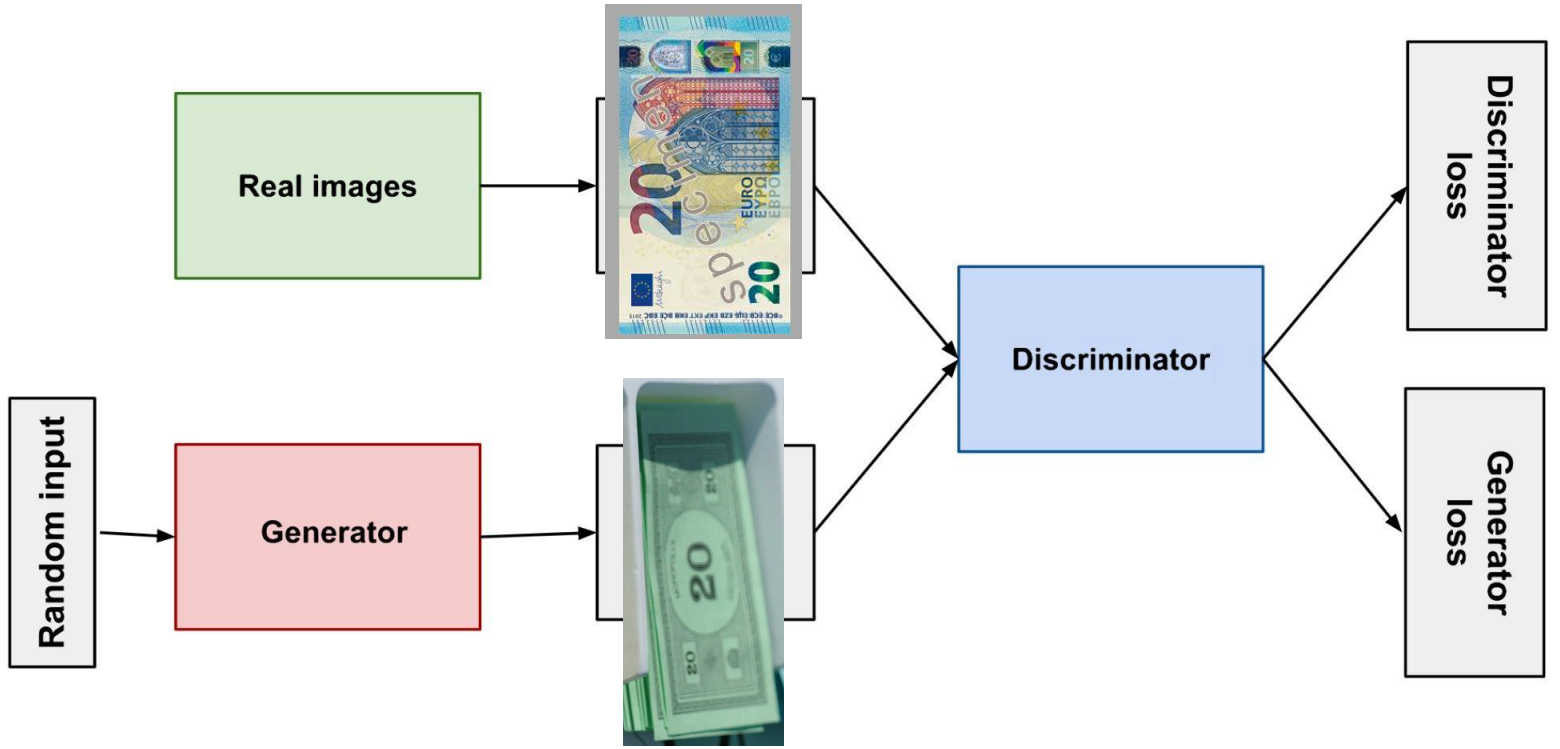


Figure from https://developers.google.com/machine-learning/gan/gan_structure

Tensorflow