CRÉDIT AGRICOLE
CORPORATE & INVESTMENT BANK

AI for finance: an introduction

EUROPEAN MONEY MARKET EXPERT COMMITTEE

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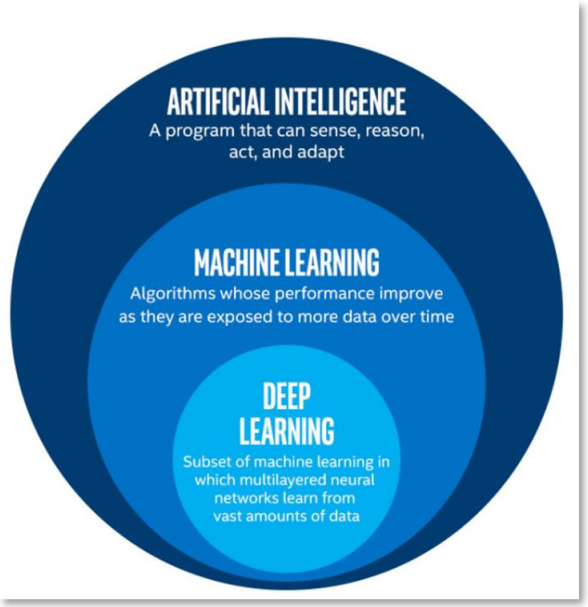
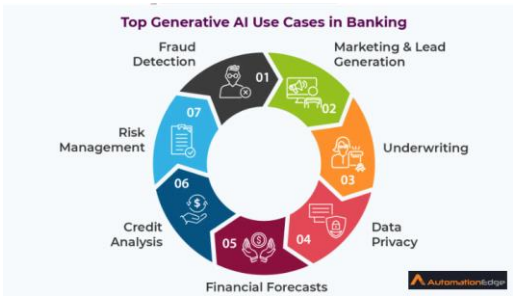
Artificial Intelligence

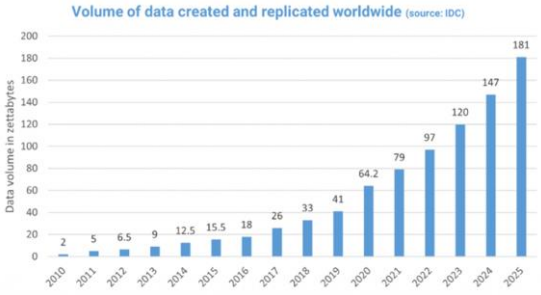
What?

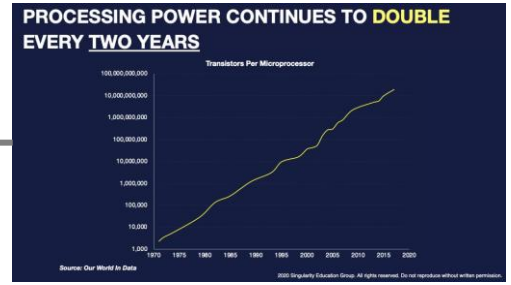
Why now?

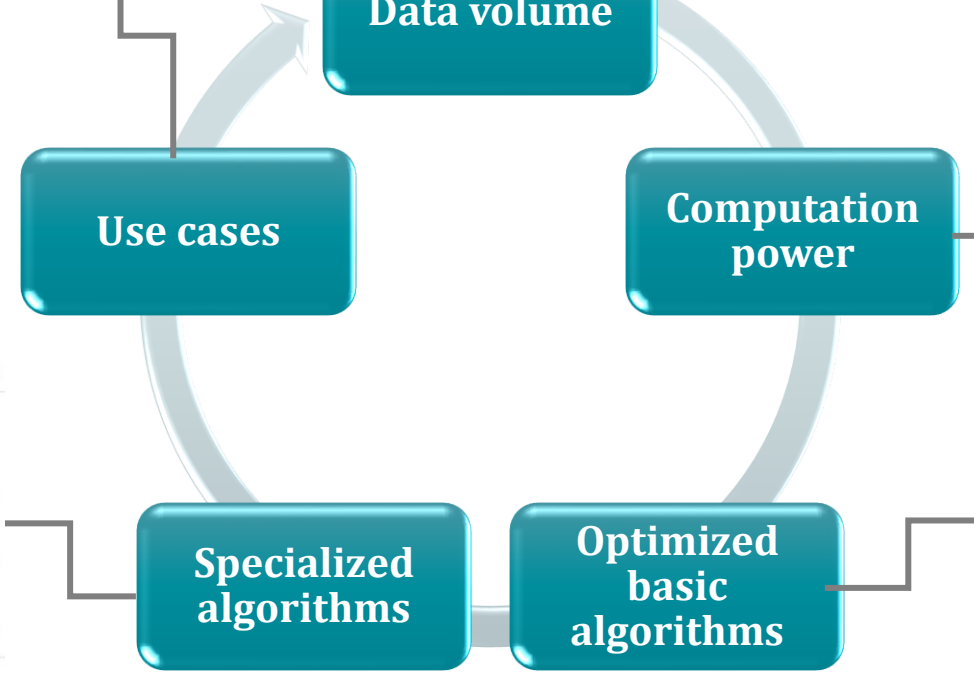


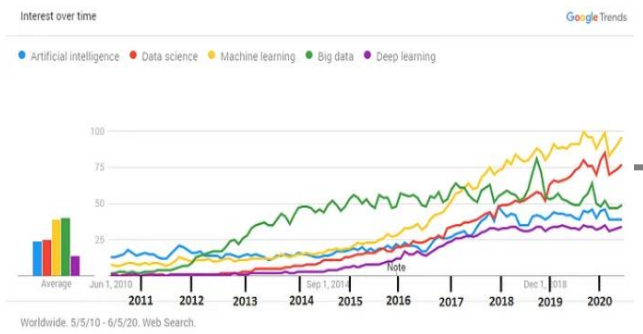
Interception from Prowesscorp website.

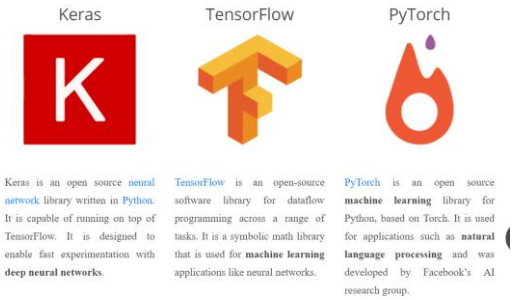












Real Intelligence

Incentivized with data visualization tools

Data visualization tools

Many tools available (Tableau, PowerBI, Sisense, Qlik, …)

The task:

- Data quality first check
- Real intelligence stimulant: data presentation, mining, links, dynamic, …
- Normalized reporting

dev3lop.com

Example of use case

APA data

- Traded product
- Traded price
- Traded volume
- Known after 15mn to 1M

RFQ data

- Our product
- Our price
- Our Client

Market data

- Historical market tick to tick
- Ability to re-compute

Data visualization questions

- **What is being traded? where? What maturities? How much?**
- **How far was our price from the done price of an RFQ?**
- **With which clients are we making or losing money?**
- **Can certain clients be predictors of market movements?**
- **How does a particular client trades? Which clients are advantageous partners?**

Machine learning questions

- **Can we predict the likelihood of winning an RFQ (and with what margin) given a market environment?**
- **Can we predict client behaviour from APA reported data?**
- **Can we then predict market breakaways/turns?**

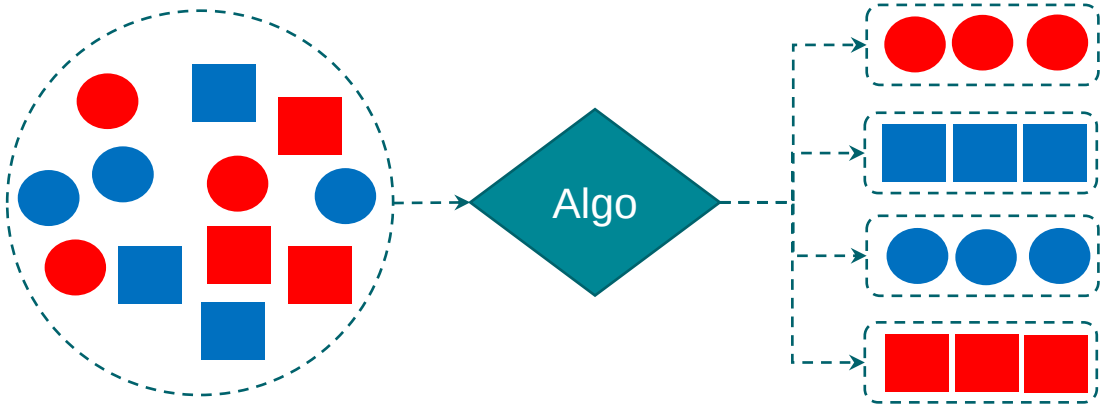
Machine Learning

Unsupervised learning

Unsupervised learning

The task:

- Detect pattern, similarities in a set of unlabelled data



- The number of clusters isn't predetermined

Standard algorithms:

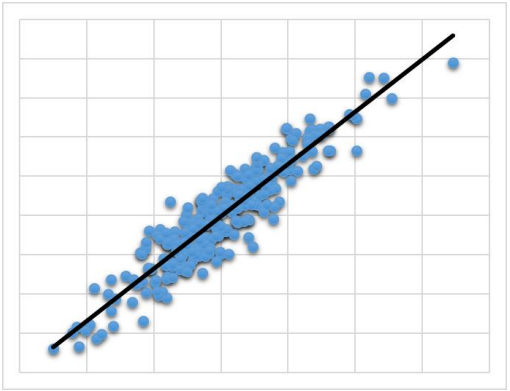
- Hierarchical clustering
- K-means clustering
- Principal Component Analysis
- Singular Value Decomposition
- Independent Component Analysis

Examples of use case

Risk management and market making:

➔ Identify and classify the main source of risk (with techniques of dimension reduction)

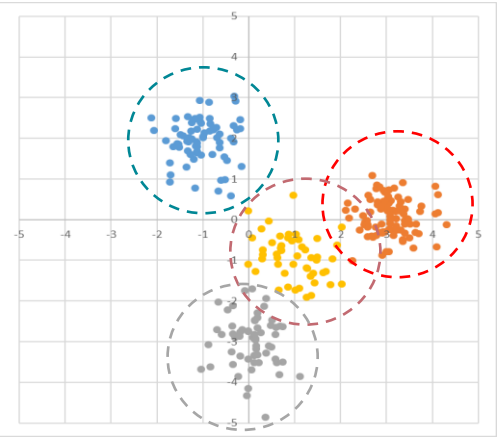
- Hedge main risks with most liquid products
- Identify main market drivers
- Define meaningful stress tests



Client avisory, behavior anticipation:

➔ Identify group of clients with similar profile, interest, risk aversion, etc.

- Dedicated marketing actions
- Those liked this use to like that…
- Specialized market feedback
- Study the dynamic intra-group and inter-groups i.e. use this cluster to enhance supervised learning (labeling)



Machine Learning

Supervised learning
Classification

Supervised learning: classification

The task:

- Classify a poputalion into predefined categories

TRUE LABEL	PREDICTED LABELS: POSITIVE	PREDICTED LABELS: NEGATIVE
POSITIVE	TRUE POSITIVE (TP)	FALSE NEGATIVE (FN)
NEGATIVE	FALSE POSITIVE (FP)	TRUE NEGATIVE (TN)

- Accuracy = $\frac{TN+TP}{TN+TP+FN+FP}$
- Precision = $\frac{TP}{TP+FP}$
- Recall = $\frac{TP}{TP+FN}$
- F1 score = $2 \times \frac{\text{Precision} \times \text{Recall}}{\text{Precision}+\text{Recall}}$

Standard algorithms:

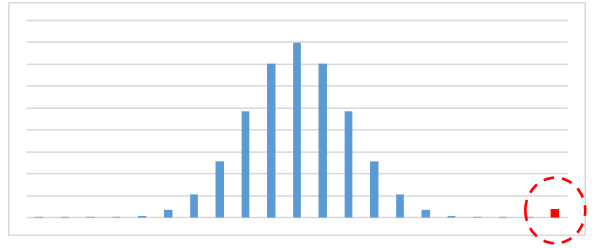
- K-Nearest Neighbors
- Decision Trees (random forest)
- Support Vector Machine
- Neural networks

Examples of use case

Outlier detection:

➔ Find the needle in the haystack

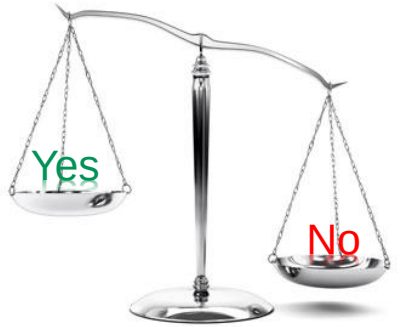
- Detect likely suspicious behavior (fraud, market abuse)
- Identify most probable downgrading or defaults in our counterparties



Forecasting

➔ Questions answered by yes or no (multi-choice by extension)

- Will this client trade today?
- Is a two-way request a bid or an ask?
- Is a trade toxic? (early signal)
- Etc.



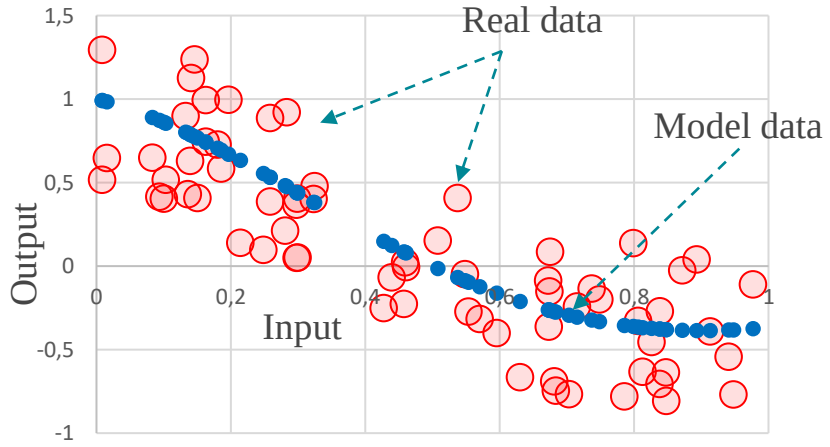
Machine Learning

Supervised learning
Regression

Supervised learning: regression

The task:

- Find the function to link inputs with outputs
- Output is a (set of) real value(s)



Standard algorithms:

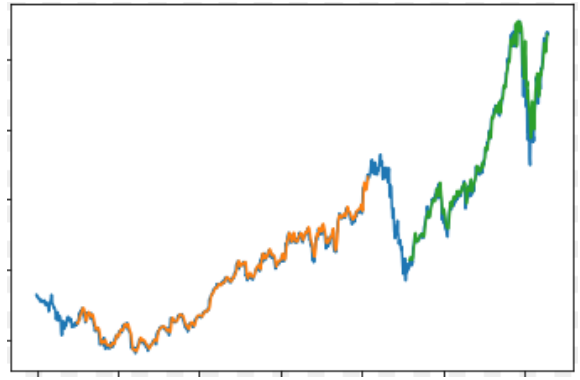
- Regression
- Logistic Regression
- Neural networks

Examples of use case

Prediction

➔ Explain future as a function of the past (in high dimensional space)

- Algo trading / market making
  - market move predictions
  - Market impact prediction
- Stress scenario
  - Joint behavior
  - Stress inverse problem



Learn complexity

➔ Simulate your time-consuming functions to learn them and re-use them real-time

- Fast pricing
- Fast model calibration
- Fast risk measure (Greeks)

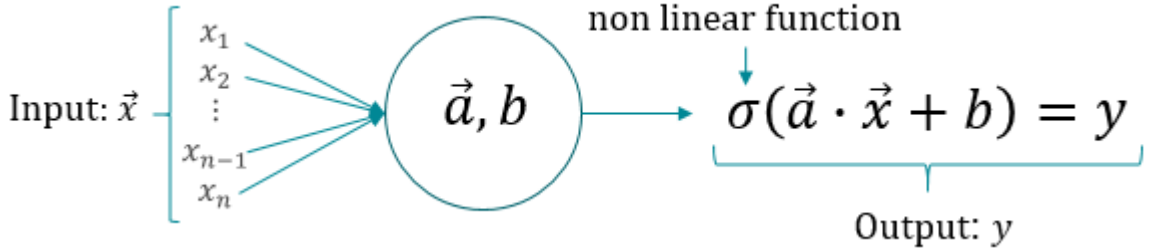
$$\partial_t u(t,x;\theta) + \frac{1}{2}\sigma(t,x)\partial_{xx}u(t,x;\theta) = r(t,x)u(t,x;\theta)$$
$$u(T,x;\theta) = g(x)$$

Machine Learning

Neural networks

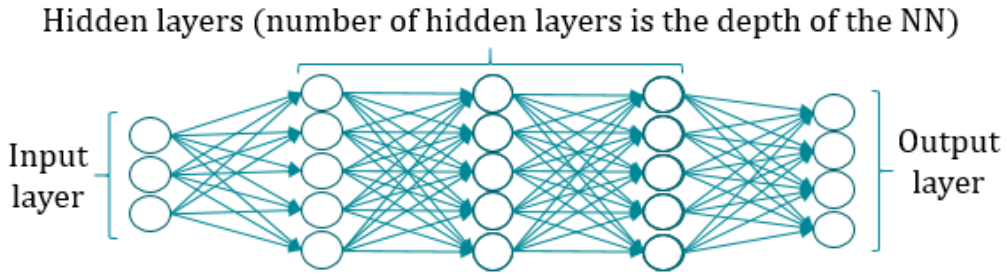
NEURON

- Neuron model inspired by natural neurons:



NEURAL NETWORK (NN)

- NN are a generic model for general functions
- Their internal architecture are adapted to GPU/TPU
- **Universal approximation theorem**



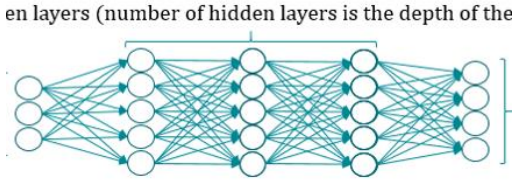
DEEP LEARNING

- A NN is a parametric function $\mathcal{NN}: \mathbb{R}^n \to \mathbb{R}^m, \mathcal{NN}(\vec{x}\,; \Theta) = \vec{y}$ where Θ is the set of $\vec{a}, b$ of each neuron i.e. the parameters of the function
- Learning a function f means finding the parameters Θ such that for any $\vec{x}$, $\mathcal{NN}(\vec{x}\,;\,\Theta) \cong f(\vec{x}\,)$
- This can be done in practice thanks to some ingredient put together: **stochastic gradient algorithm**, **Automatic-Adjoint Differentiation** algorithm, **GPU** (or other HPC technics) and **Big Data** (necessary for training set)

➔ **Neural network is a very powerful tool adapted to a wide range of situation**

Neural Networks

Architecture Examples

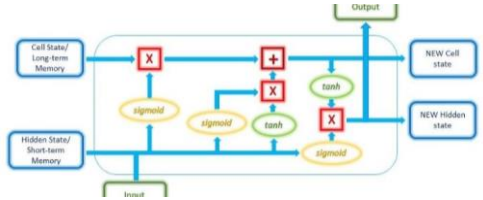


FEED-FORWARD (DNN)

- Simplest architecture

Use cases:

- Fast derivatives pricing (learn long pricing functions)
- Fast model calibration (learn simple products pricing in a complex model)
- Deep-hedging (in incomplete market)
- …

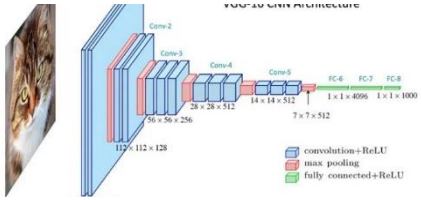


LONG SHORT TERM MEMORY (LSTM)

- Kind of recurrent NN used when input size is not fixed (e.g. time series)
- Includes Long and Short term memory hidden states

Use cases:

- Time series prediction (algo. Trading, automatic hedging)
- Natural Language Processing (NLP), see after
- …

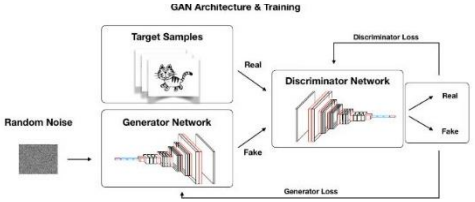


CONVOLUTIONAL (CNN)

- Kind of feed-forward NN with much fewer connections

Use cases:

- Time series prediction (algo. Trading, automatic hedging)
- Default prediction (pattern detection)
- Natural Language Processing (NLP), see after
- …



GENERATIVE ADVERSARIAL (GAN)

- Generator of data similar (in law) to the training set
- Based on a generative NN and a discriminative NN.

Use cases:

- Generate credible stress tests
- Generate credible illiquid market prices
- Fast model simulation (learn parametrized law of complex models)
- …

NLP

Neural networks
A fruitful application field

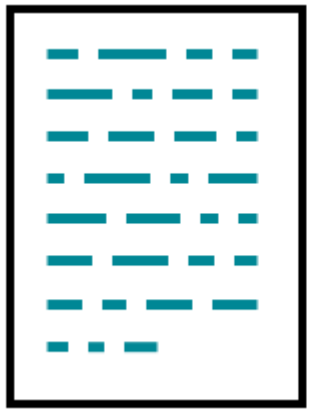
NLP steps:

Voice

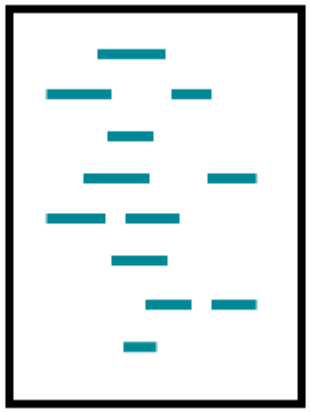
Image

Raw Text

Tokenization (partition)

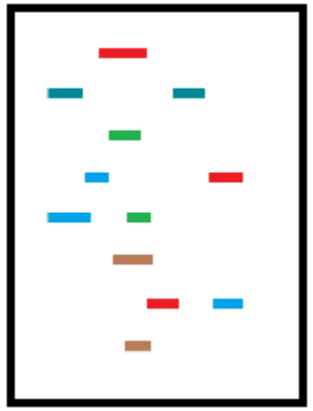


Cleaning (remove « empty » words)



Lemmatization, stemming (meaningful base)

Labeling (set context)



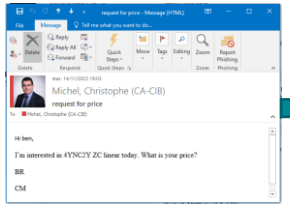
Algo (NN):

- Symbolic: make the link with concepts
- Statistic: what is next? What is missing?
- Hybrid: both

Use cases:

- Financial sentiment analysis
- Financial document analysis
- Credit scoring
- Compliance (fraud detection)
- ESG reporting …

- Process automation: from chat request to booking system

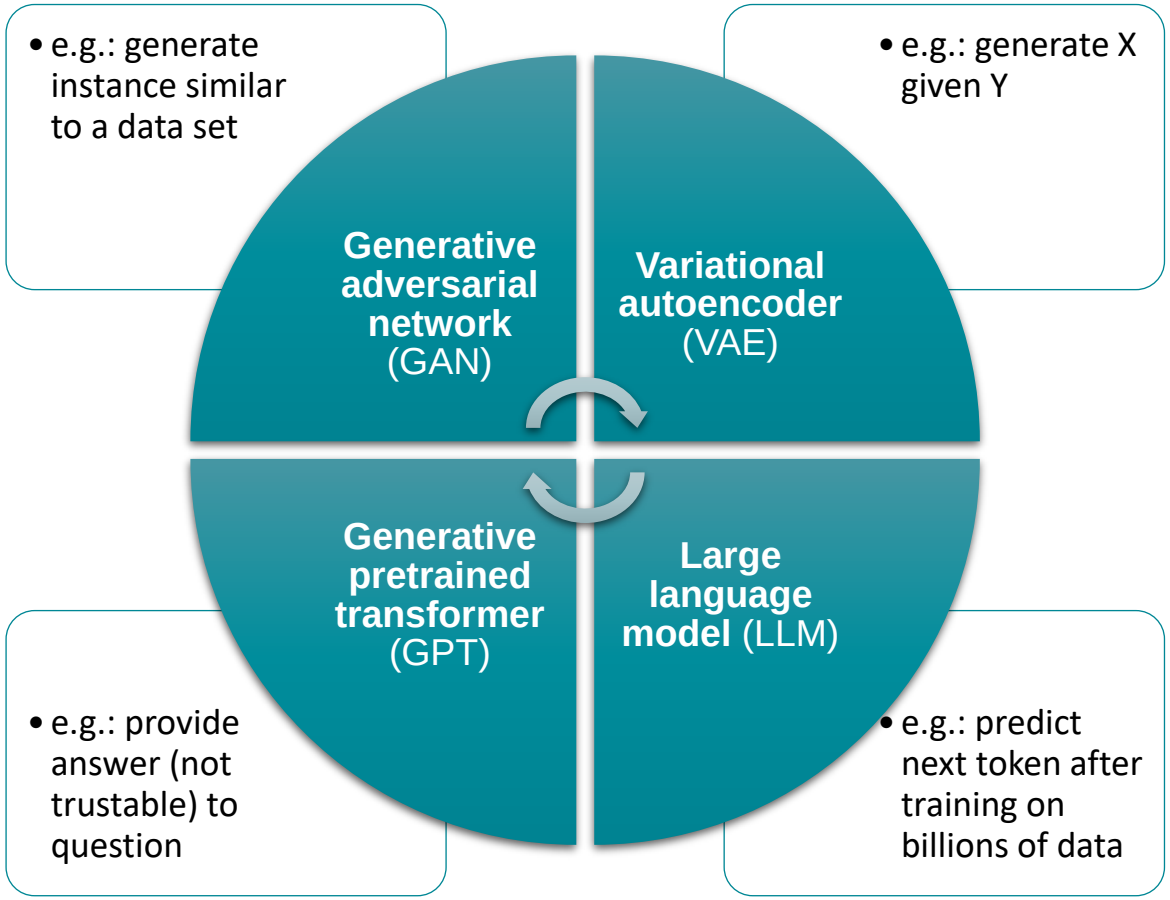


Propose filled template product → Propose price → Automatic booking

Generative AI

Combining specialized AI methods

Many Neural networks specialized architecture are involved and combined



Use cases: to be developed around the notion of assistant

What is being traded in EUR rate market?

Find here APA data on EUR rate last Month

And what was my market share on ST swaps compare to previous month?

Last month: 4,3%, previous month 4,8%

Do we have recent research papers on ST EUR rate?

Find here and there most recent publications on ST EUR rates

Can you summarize the second one (PDF format)?

I sent the summary in PDF format in your mail box

Conclusion

About ML process

Classical ML development process

- Data management: move to data-centric architecture (normalization, security, flexibility, easy access, constant updating)
- Find the problem to optimize is key (well-posed, one solution)
- Many models are directly available. Innovations works are on Neural Networks architecture (e.g. Tensor Networks)