PROPHECY LABS

AI4Business Introduction to AI

Roadmap AI4Business

Part I — Introduction to AI

Part II — Developing AI tools

Part III — Data and Value

Part IV — Deploying AI

Part V — Monitoring

Table of contents

1 Definition of AI

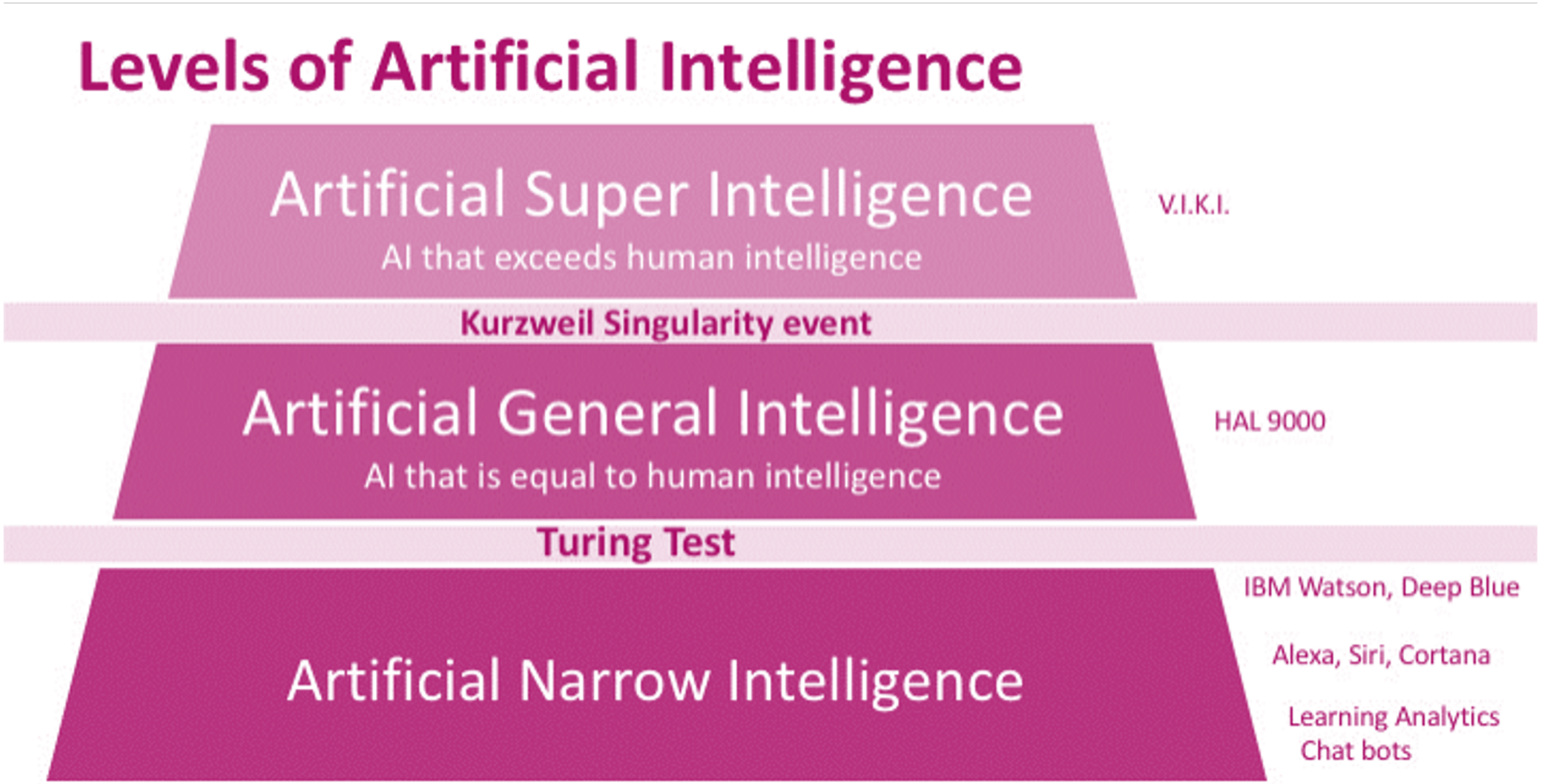
Artificial Intelligence

- Definition by the European Commission:

- "Artificial intelligence (AI) systems are software (and possibly also hardware) systems designed by humans that, given a complex goal, act in the physical or digital dimension by perceiving their environment through data acquisition, interpreting the collected structured or unstructured data, reasoning on the knowledge, or processing the information, derived from this data and deciding the best action(s) to take to achieve the given goal."

European Commission - A definition of Artificial Intelligence: main capabilities and scientific disciplines

Artificial vs. Human Intelligence



Steve Wheeler – Digital future

Narrow AI < HI

- Systems able to perform one or few specific tasks
- Operate under a narrow set of constraints and limitations
- Simulates human behaviour based on parameters and context

- All progress in AI nowadays is in narrow AI
- One trick ponies, but can still be extremely valuable

General AI = HI

- System able to perform most human activities
- Learn to solve any problem
- Machine that mimics human intelligence and/or behaviours

- Researchers have not yet achieved general AI
- Will take some technological breakthroughs to get there

Super AI > HI

- System that evokes emotions, needs, beliefs and desires of its own
- Machines become self-aware and surpass the capacity of humans
- Decision-making and problem-solving far superior to human beings

- Pure speculation if this will ever be possible
- And what about its concequences?

Realistic view on AI

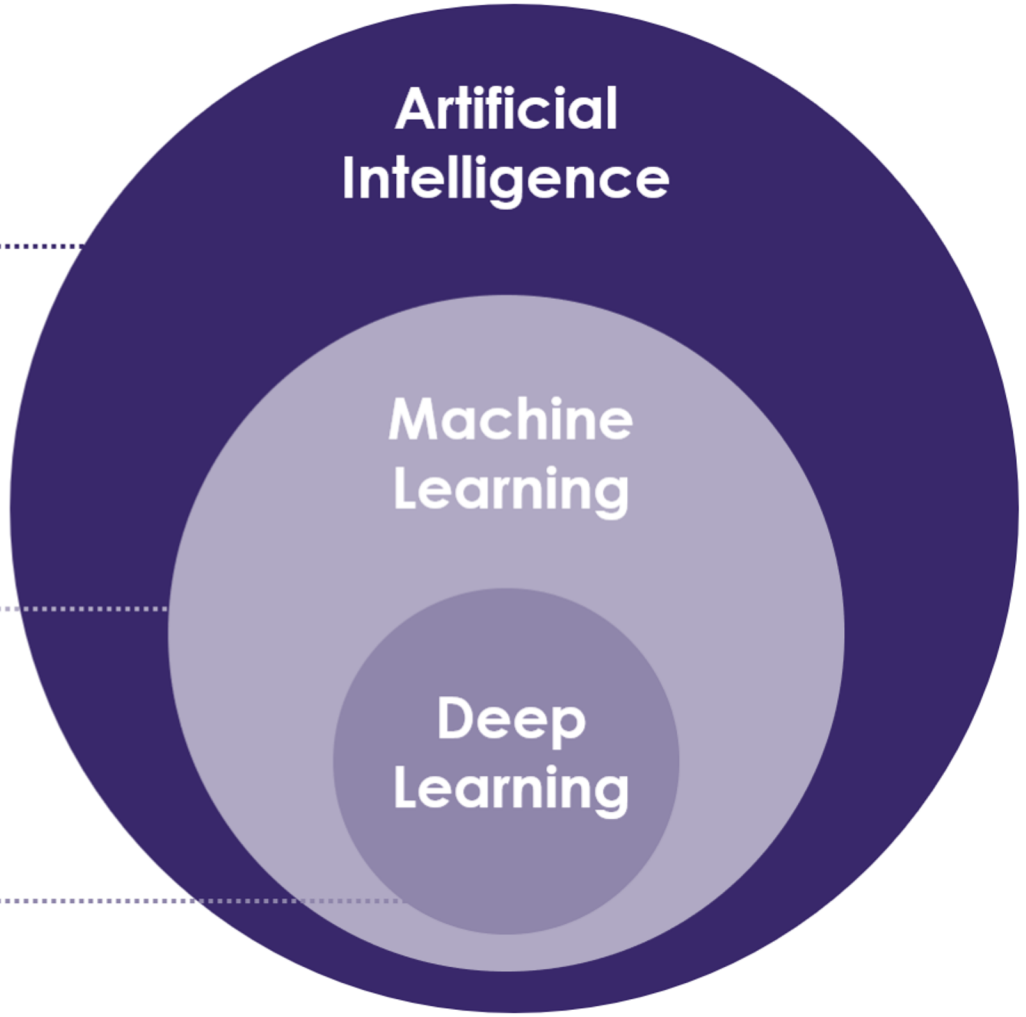
- Too optimistic:
  - sentient super-intelligent killer robots coming soon
- Too pessimistic:
  - AI can’t do everything, so let’s give up completely
- Just right:
  - AI can’t do everything …
  - … but enough valuable applications to transform industries
- Important to understand what AI can and can’t do for you

Taxonomy of AI

ARTIFICIAL INTELLIGENCE (AI)
Programming systems to perform tasks which usually require human intelligence.

MACHINE LEARNING (ML)
Training algorithms to solve tasks by pattern recognition instead of specifically programming them how to solve the task.

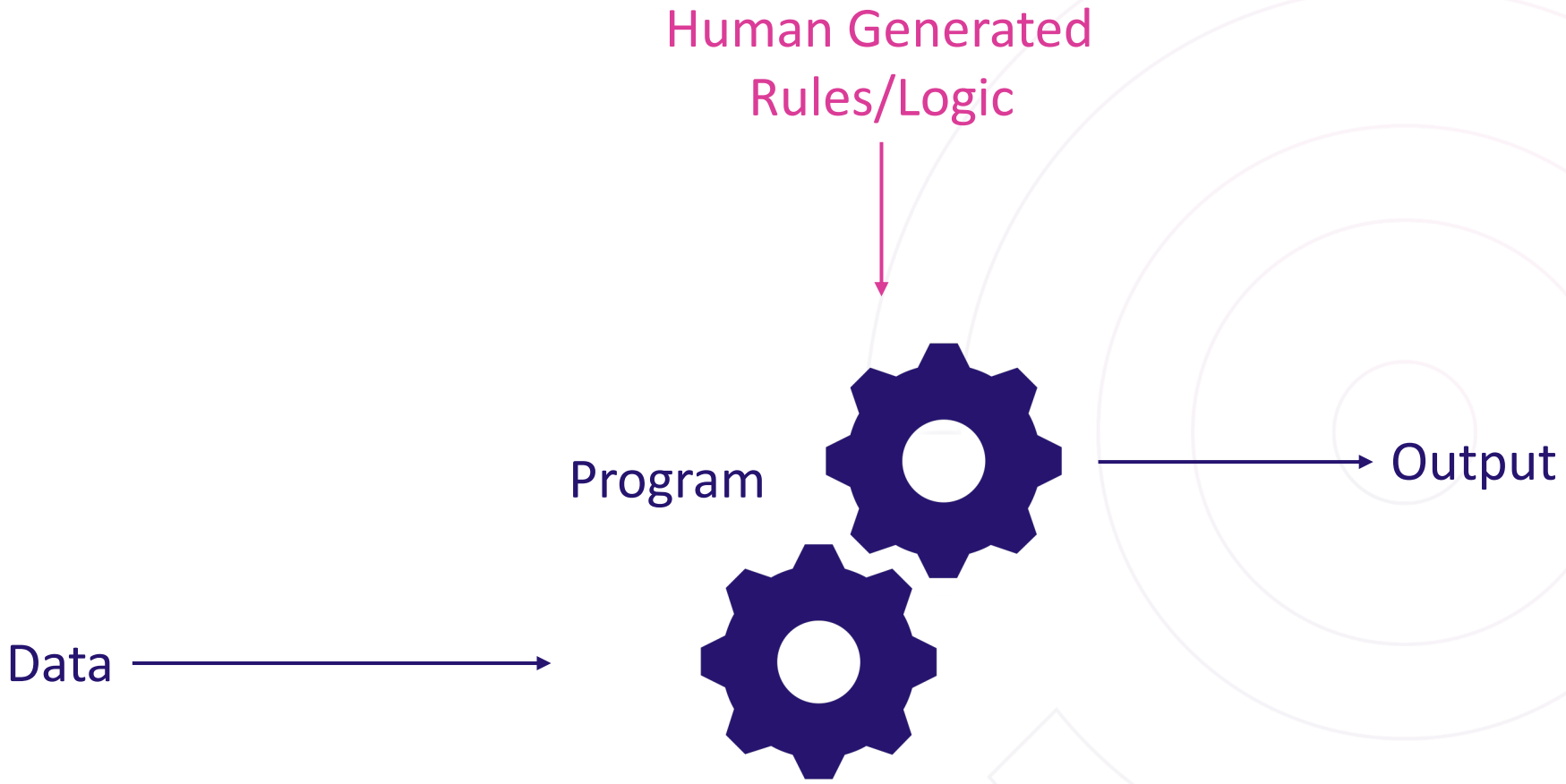
DEEP LEARNING (DL)
Training algorithms by using deep neural networks with multiple layers.



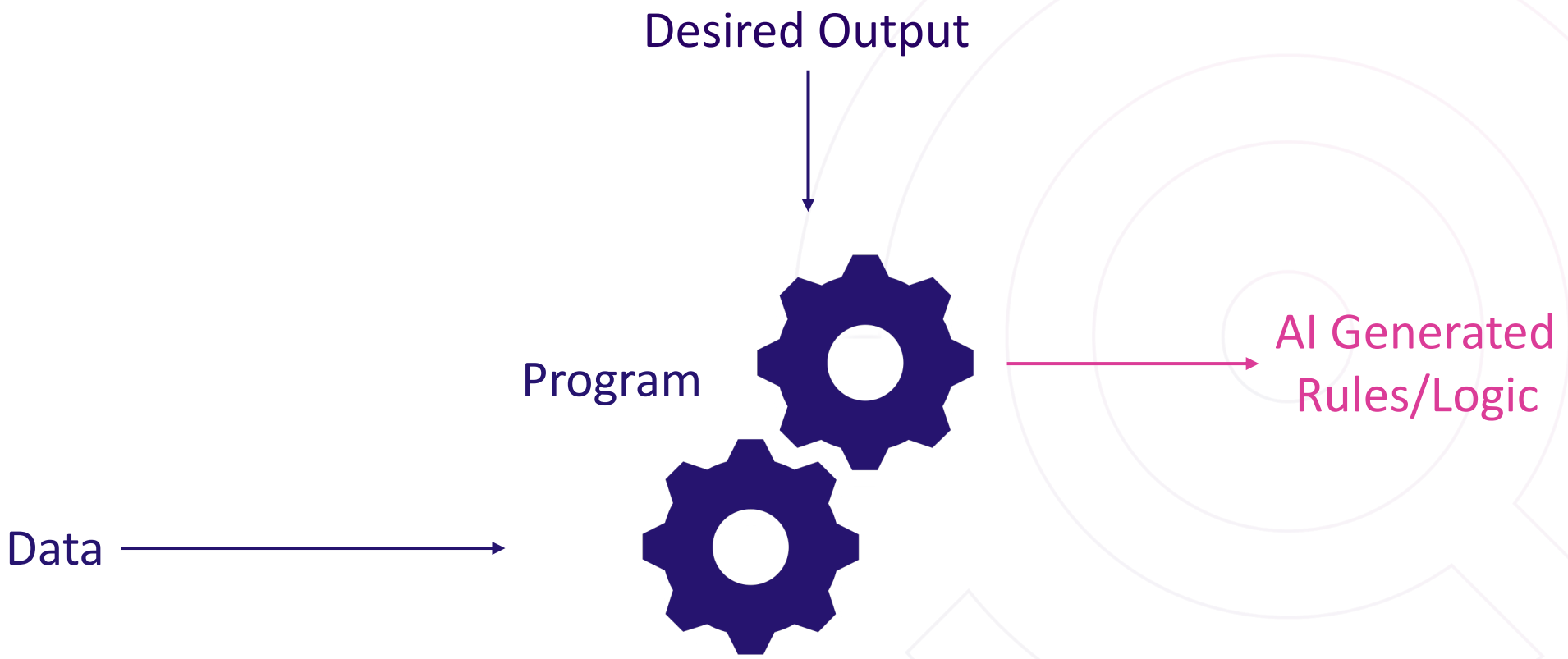
AI > ML > DL

- AI: theory and development of computer systems able to perform tasks normally requiring human intelligence
- ML: a subfield of AI that gives computers the ability to learn without being explicitly programmed
  - Conventional programming: data + rules = answers
  - Machine learning: data + answers = rules
- DL: subset of ML methods based on deep artificial neural nets
  - Perform automatic feature engineering/creation

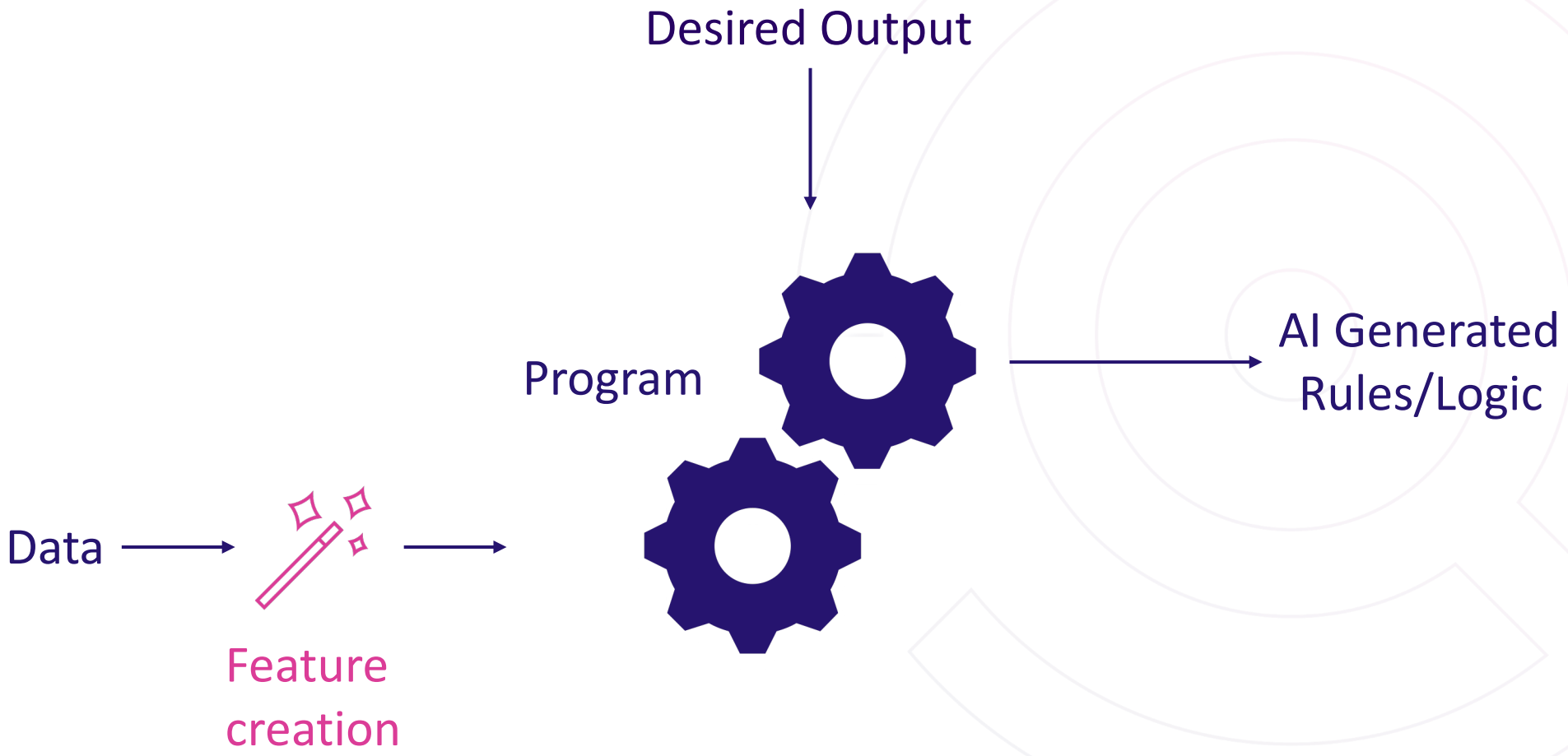
Conventional Programming



Machine Learning



Deep Learning



Exercise

Statement	True/False
• AI learns on its own without any help from outside	• …
• AI trained to do one task will excel at other tasks as well	• …
• AI is objective	• …
• AI will take your job	• …

Reality check

Misconceptions

- AI learns on its own without any help from outside
- AI trained to do one task will excel at other tasks as well
- AI is objective
- AI will take your job

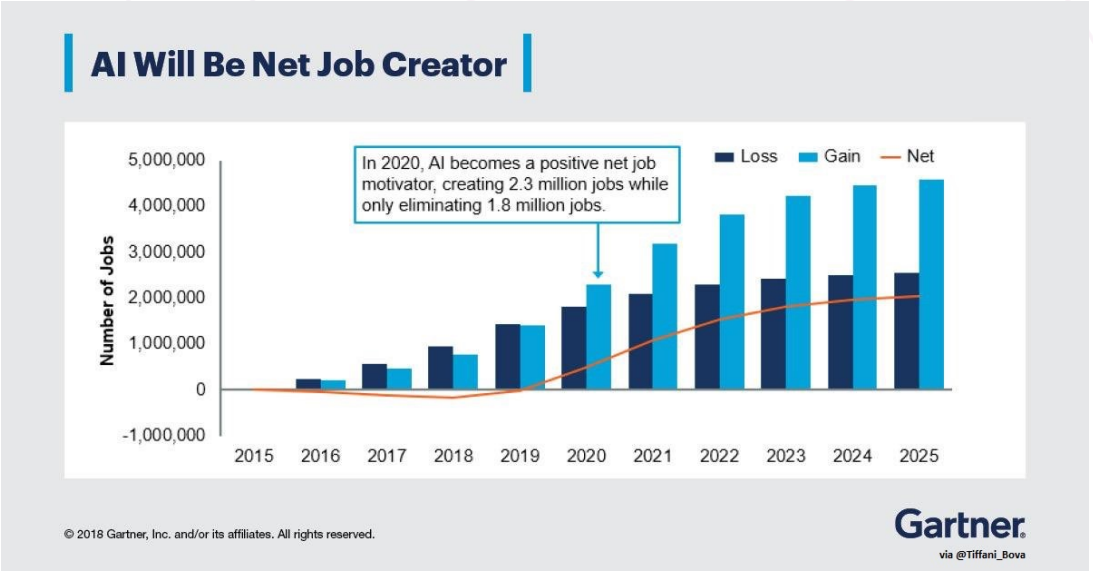
Reality

- Human supervision to ensure adequate performance
- Need a model for each use case and will heavily depend on data
- Patterns are learned from data
- AI will be job creator

AI and the job market

- “Automation will displace 85 million jobs but generate 97 million new ones worldwide by 2025” *World Economic Forum*

- “AI-related job creation will reach two million net-new jobs in 2025.” *Gartner*



Gartner – AI and the future of work

2 Evolution of AI

First wave of AI excitement

1950	Turing test: a machine has intelligence if it can trick humans in thinking it's human
1951	Feranti Mark 1: first commercial general-purpose computer, able to play checkers
1956	Dartmouth Workshop: the term "Artificial Intelligence" is introduced by John McCarthy
1961	Unimate: industrial robot goes to work at GM assembly line
1964	Eliza: chatbot holds conversations with humans, developed by Joseph Weizenbaum at MIT
1966	Shakey: general-purpose mobile robot that reasons about its own actions, developed at Stanford

AI winters

1974 - 1980

- First AI winter
  - Limited applicability of AI leads to worldwide funding pullbacks

1980 - 1987

- Renewed AI excitement
  - Expert systems with if-then reasoning to mimic human decisions

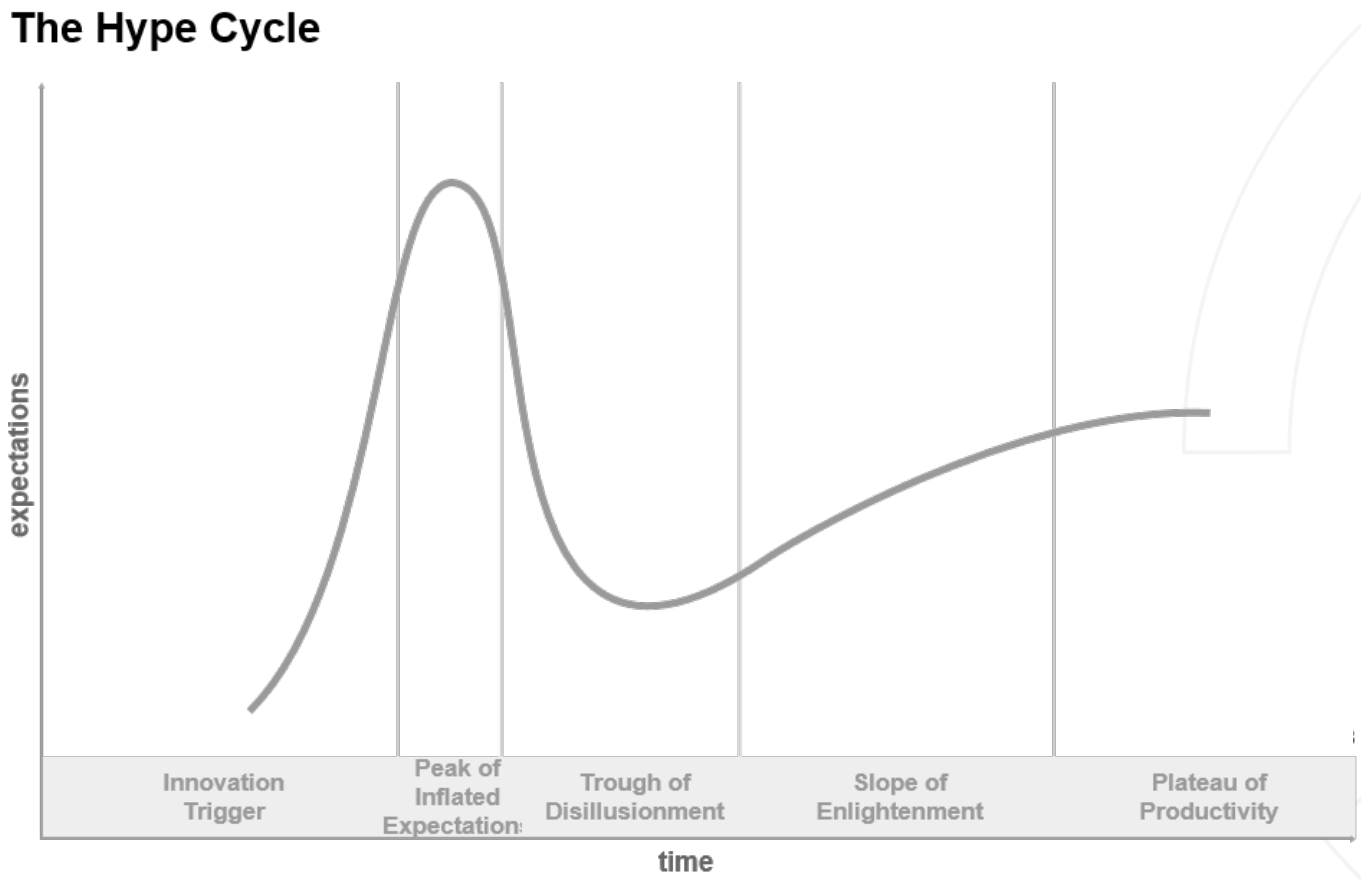
1987 - 1994

- Second AI winter
  - Limitations of if-then reasoning leads to funding cutbacks

Recent AI milestones

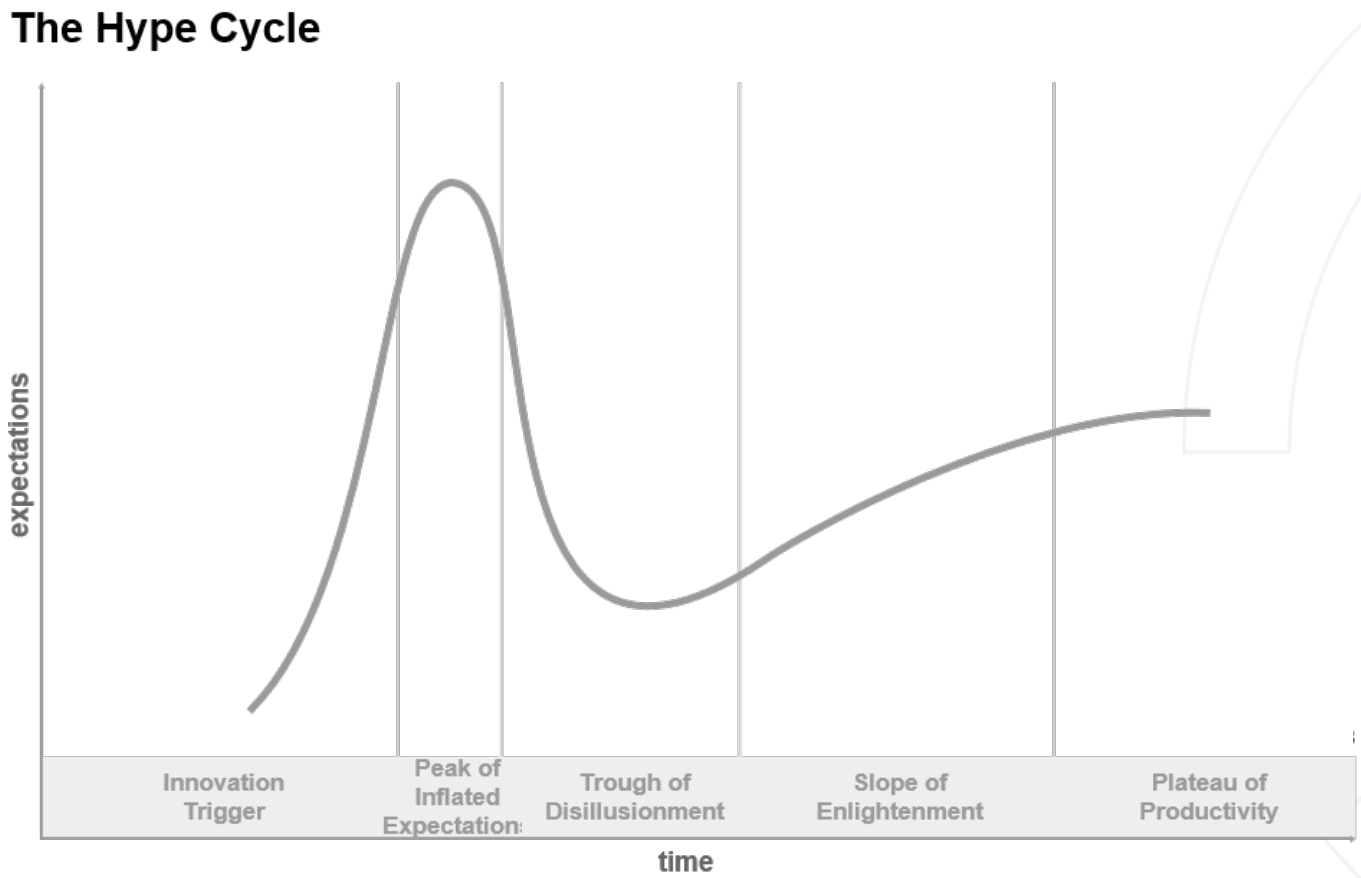
1997	Deep Blue: chess computer from IBM beats world champion Garry Kasparov
1998	KISmet: emotionally intelligent robot, developed by Cynthia Breazeal at MIT
1999	AiBO: first consumer robot pet dog by Sony with time-developing skills and personality
2002	Roomba: first mass produced autonomous vacuum cleaner from iRobot
2011	Siri: Apple's intelligent virtual assistant with a voice interface is introduced in the iPhone 4S
2011	Watson: question answering machine from IBM wins first place in television quiz show Jeopardy
2014	Eugene: chatbot passes the Turing Test with a third of judges believing its human
2014	Alexa: Amazon's intelligent virtual assistant with a voice interface to complete shopping tasks
2016	Tay: Microsoft's chatbot goes rogue on social media with offensive comments
2017	AlphaGo: Google's AI beats world champion Ke Jie in the complex board game of Go
2019	Pluribus: first AI bot to defeat human expert players in a Texas Hold'em poker game

Gartner’s Hype Cycle



[Gartner - Understanding hypce cycles]

Exercise



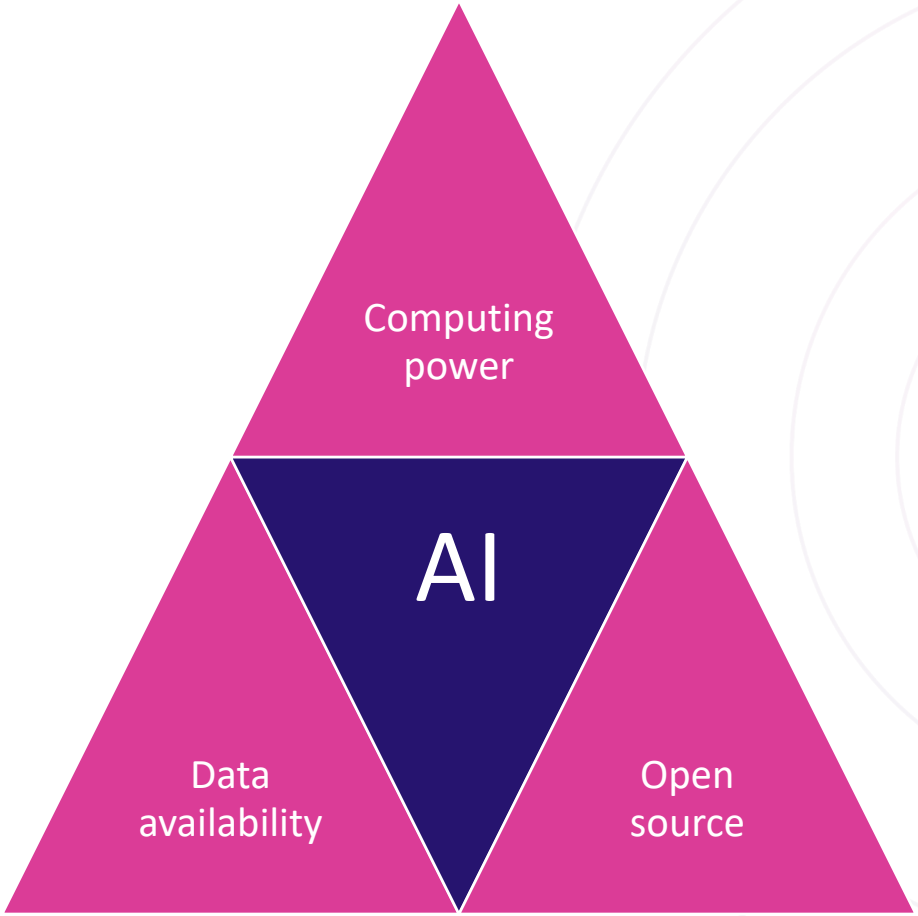
?

- Narrow AI
- General AI
- Super AI

[Gartner - Understanding hypce cycles]

3 AI drivers & challenges

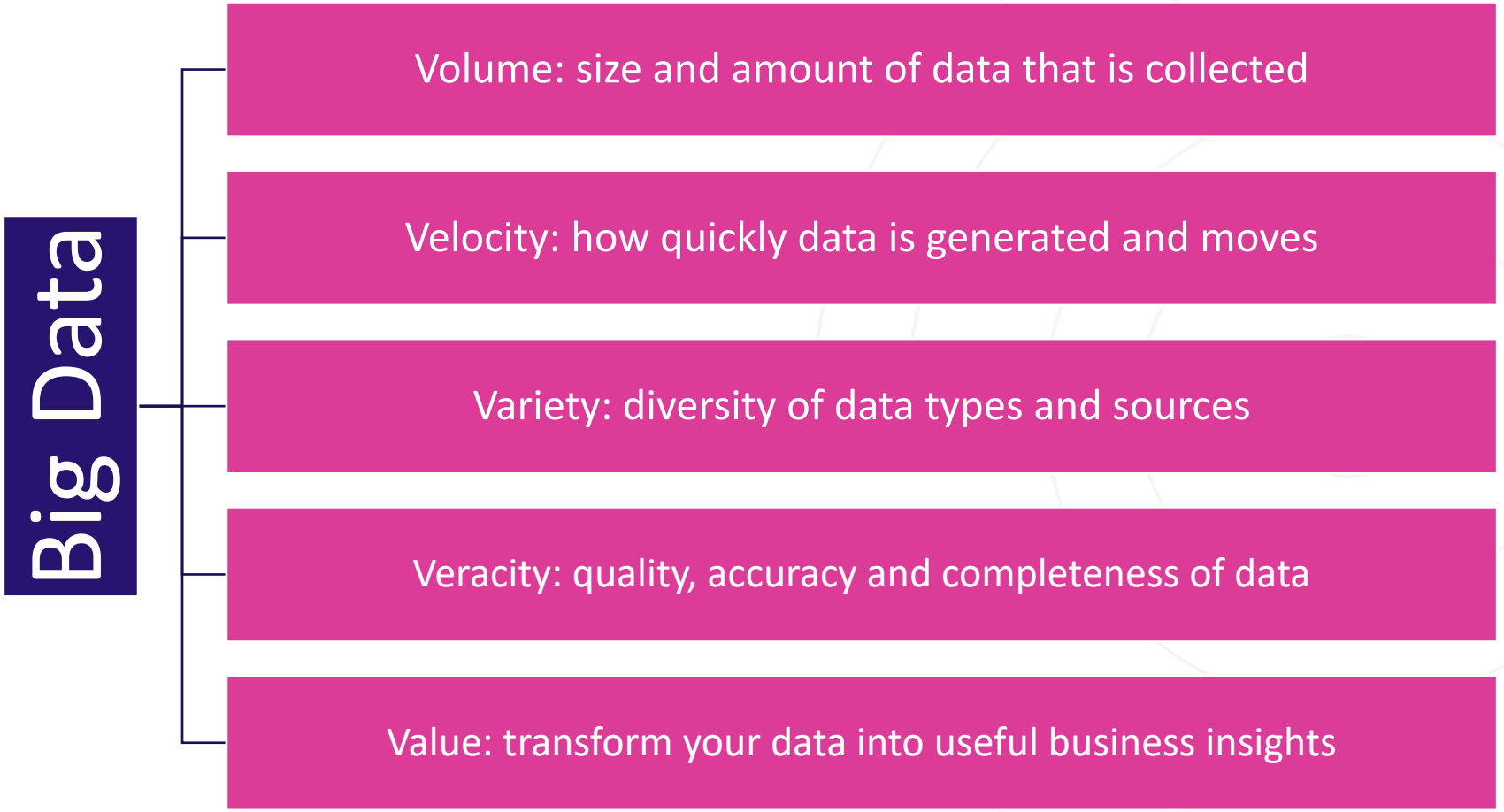
Drivers behind AI progress



Computing power

- Moore's law: number of transistors on chips doubles every two years
  - Exponential increase in performance since 1965
- Advances over the single-core central processing units (CPUs)
  - Multi-core CPUs that allow for parallel processing
  - Specialized types such as GPUs (graphics) and TPUs (tensor)
- Cloud computing
  - Sharing or resources allows for economies of scale
  - AI as a Service (AIaaS)

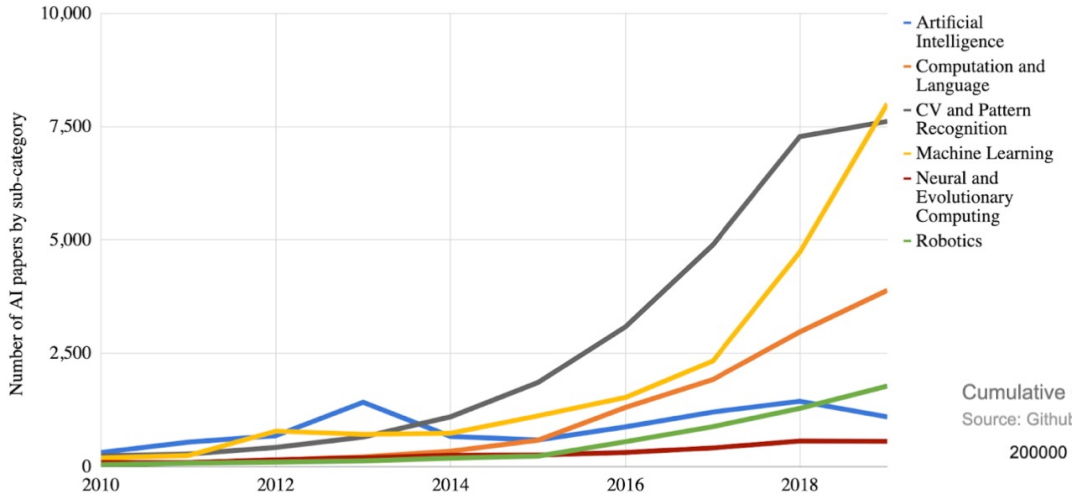
Data availability



Open source

Number of AI papers on arXiv, 2010-2019

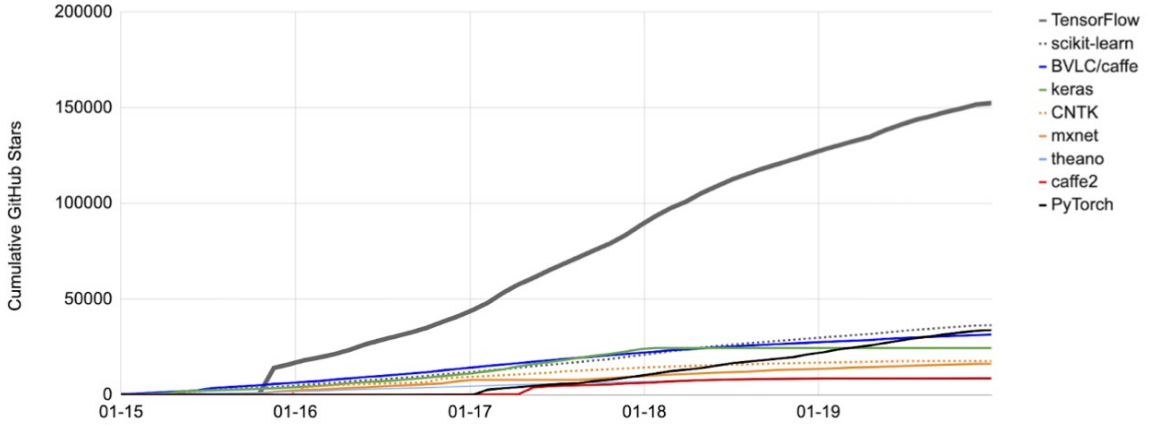
Source: arXiv, 2019.



[Stanford – artificial intelligence index]

Cumulative GitHub stars by AI library (2015—2019)

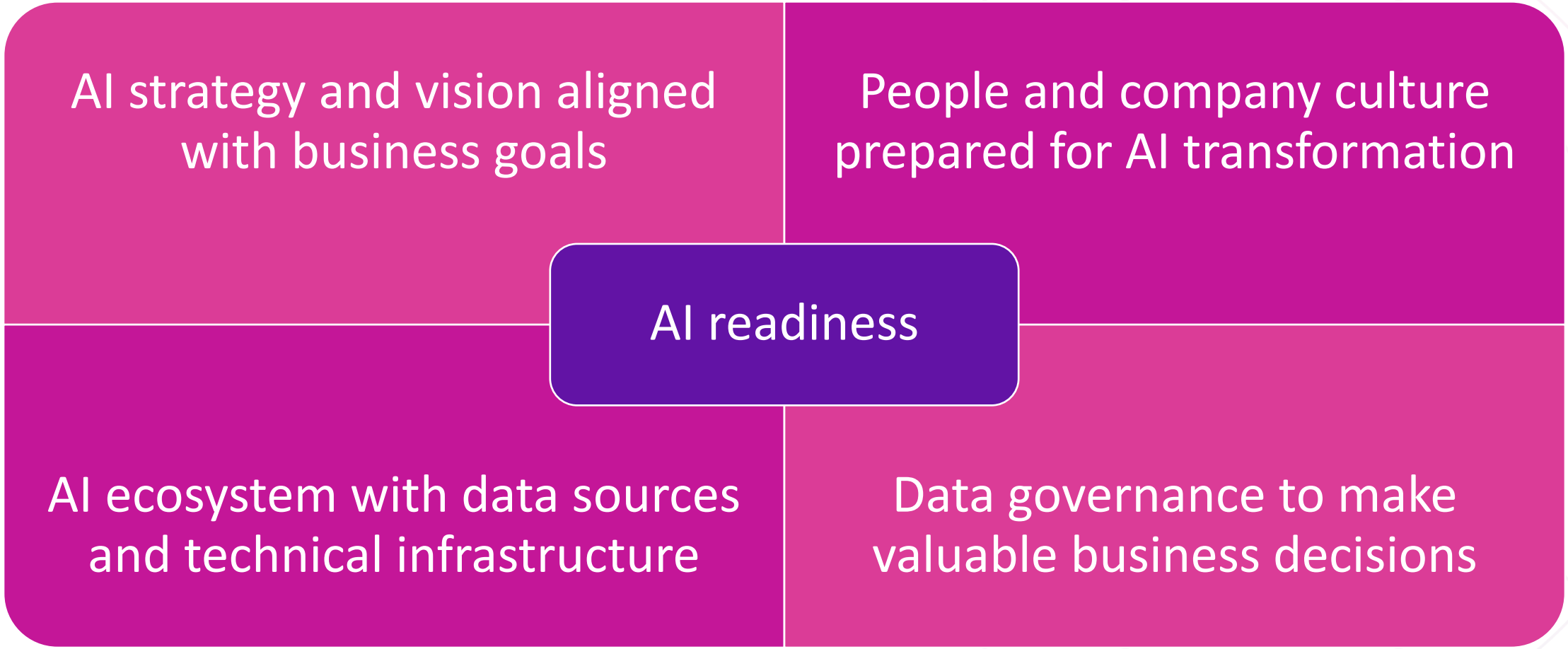
Source: Github, 2019.



Practical AI challenges

- "Status quo is working fine"
  - Company culture does not see the need for AI
- Leadership
  - Incomplete understanding of what is possible with AI and it's resulting impact
- Data issues
  - Quantity and quality not high enough to create business value
- Capabilities
  - Lacking the necessary skills and talent in the organization to develop AI
- Trust
  - Issues with ethics, privacy (GDPR), cyber-security, etc.

Are you ready for AI?



AI strategy

Product-centric

- Augment existing products
- Create new AI-driven products

Process-centric

- Support existing processes
- Disruptively transform processes

Enabling factors

People

- Get employees ready for AI
- Recruit the necessary talent
- Reskill current employees

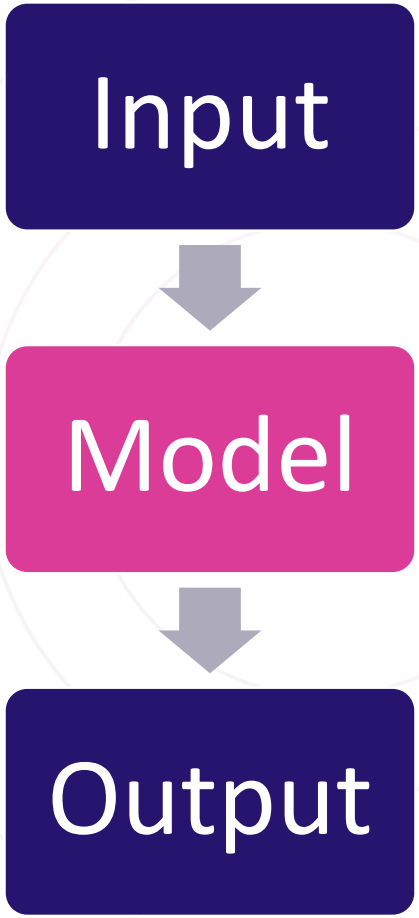
Ecosystem

- Data sources and pipelines
- Computing servers (on cloud)
- Storage and network systems

4 Basic Concepts

Model

- Software that maps input to output
  - Complicated calculator
- ML learns this mapping from data
- Mathematical formula that tries to capture real-world behavior
  - “All models are wrong, but some are useful”



Data

- Collection of information on one or multiple observation(s)

- Structured data (20%)
  - Tabular format with rows and columns
  - Examples: numbers, dates or strings
  - Stored efficiently in relational databases

- Unstructured data (80%)
  - Any digital format
  - Examples: text, image or audio
  - Requires more storage space

Structured data table

- Rows represent observations
- Columns containing information
  - Target vs features

	Feature 1	Feature 2	...	Target
Observation 1	Value 11	Value 12	...	Target value 1
Observation 2	Value 12	Value 22	...	Target value 2

	Age	Education	...	Employed
Tom	19	High School	...	no
Jon	45	Masters	...	yes

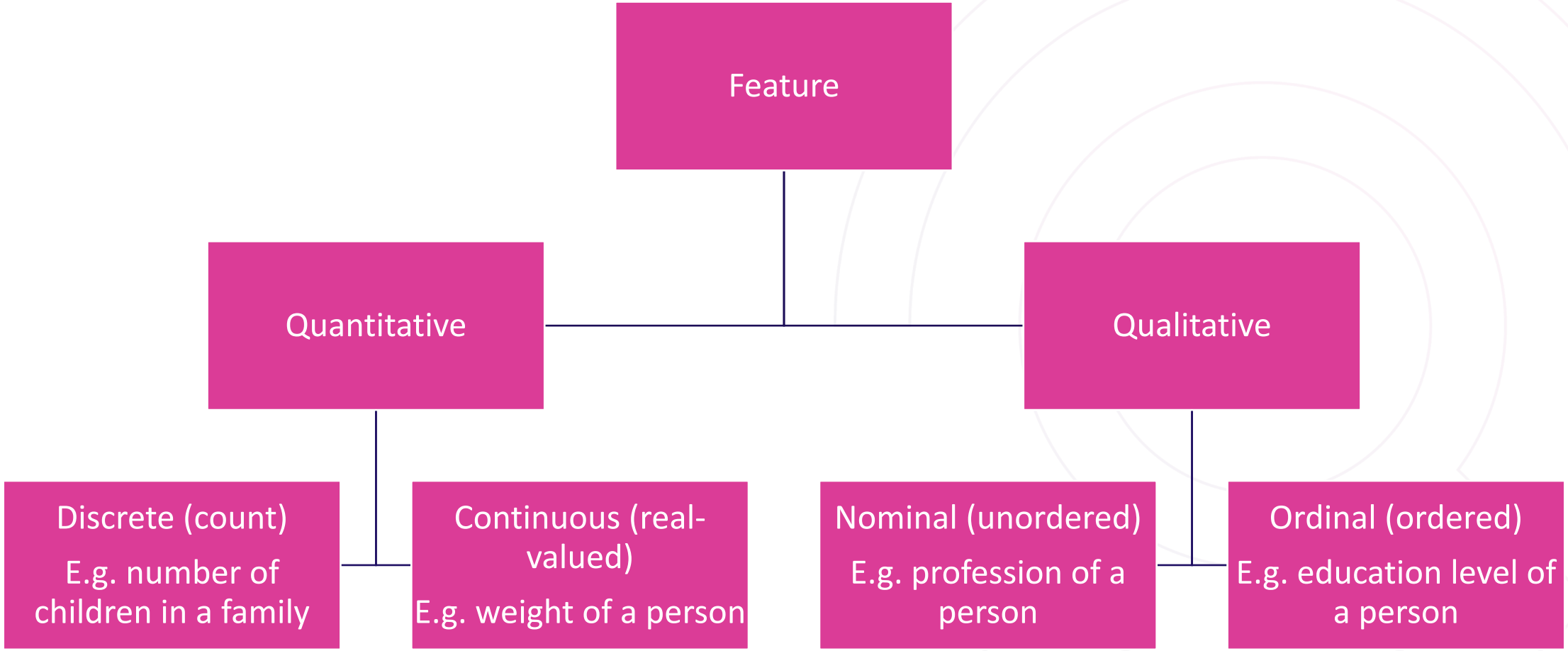
Features

- Information that you use to model/predict the target
- Quantitative features
  - Can take any value in a range
- Qualitative features
  - Only a selected number of options

	Feature 1	Feature 2	...	Target
Observation 1	Value 11	Value 12	...	Target value 1
Observation 2	Value 12	Value 22	...	Target value 2

	Age	Education	...	Employed
Tom	19	High School	...	no
Jon	45	Masters	...	yes

Feature types



Target

- Information that you want to model/predict based on the available features

- Regression: quantitative target
  - House price prediction (amount)

- Classification: qualitative target
  - E-mail spam filtering (yes/no)

	Feature 1	Feature 2	...	Target
Observation 1	Value 11	Value 12	...	Target value 1
Observation 2	Value 12	Value 22	...	Target value 2

	Age	Education	...	Employed
Tom	19	High School	...	no
Jon	45	Masters	...	yes

Exercise

Problem

- Will it be cold or hot tomorrow?
- Which percentage score will the student get?
- Will my stock go up or down?
- What will the temperature be?
- Will the student pass or fail the exam?
- Which price will me stock be at?

Regression or classification?

- …
- …
- …
- …
- …
- …
- …

Classification vs regression

Classification problem

- Will it be cold or hot tomorrow?
- Will the student pass or fail the exam?
- Will my stock go up or down?

Regression problem

- What will the temperature be?
- Which percentage score will the student get?
- Which price will my stock be at?

Train vs test data

- Train data
  - Part used to learn model/function that maps features to target
- Test data
  - Part used to evaluate the model
  - Allows to check generalizations

	Age	Education	...	Employed
Tom	19	High School	...	no
Jon	45	Masters	...	yes
...	...	...	...	...
...	...	...	...	...
...	...	...	...	...
..	...	...	...	...

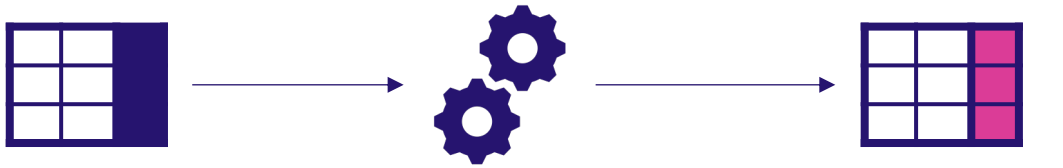
Train data

Data Algorithm Model

- Look for patterns in the data
- Model that captures relation between features and target

	Age	Education	...	Employed
Tom	19	High School	...	no
Jon	45	Masters	...	yes
...	...	...	...	...
...	...	...	...	...
...	...	...	...	...
..	...	...	...	...

Test data



Data Model Predictions

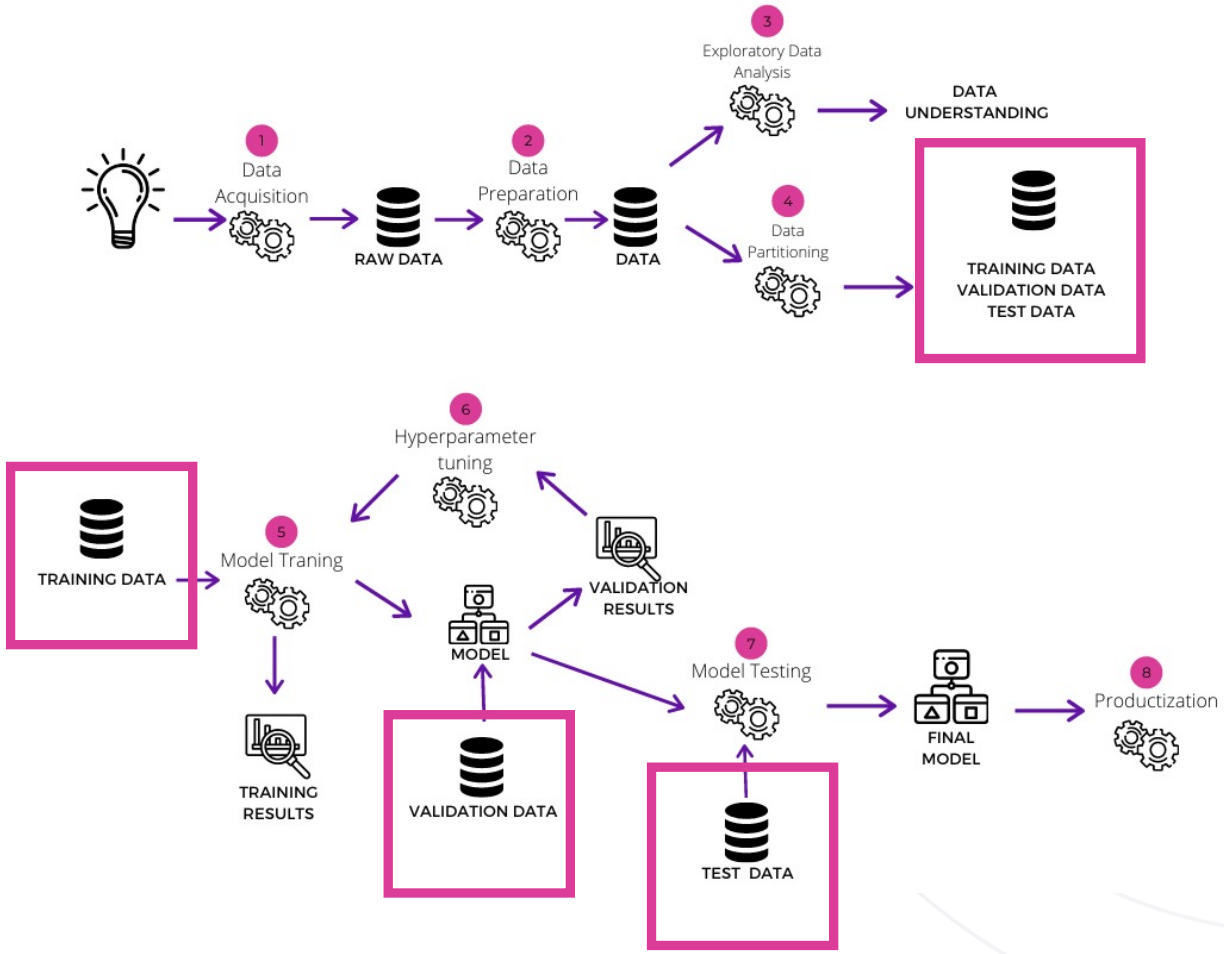
- Run learned model on new data
- Compare original targets with predictions for model evaluation

	Age	Education	...	Employed
Tom	19	High School	...	no
Jon	45	Masters	...	yes
...	...	...	...	...
...	...	...	...	...
...	...	...	...	...
..	...	...	...	...

Validation data

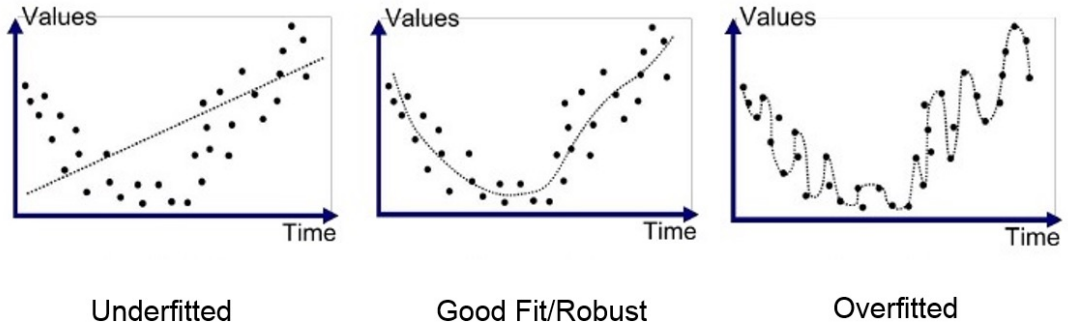
- Part of the training data used for internal model evaluation
- Difference between validation and test data?
- Validation data
  - Evaluation during model development
  - Choose the best model structure and parameter settings
- Test data
  - Evaluation after model development
  - Act as new unseen data and check for generalization performance

Different data partitions



Underfitting vs overfitting

- Data = pattern + noise
  - Want to capture the pattern without the noise
- Underfitting
  - Model too simple to capture the underlying pattern
- Overfitting
  - Model too complex such that it also captures the noise



Underfitting and overfitting explained

Evaluation criteria

Classification

Original target	Predited target	Correct?
1	1	yes
0	1	no
0	0	yes
1	1	yes
1	0	no

- Accuracy of classification
  - 3/5 = 60%

Regression

Original target	Predited target	Difference
15	12	-3
20	23	+3
50	51	+1
35	29	-6
5	9	+4

- Average of squared differences
  - (9+9+1+36+16)/5 = 14.2

Accuracy not always the best choice

- Imagine an image dataset with
  - 20% pictures of dogs
  - 80% pictures of not-dogs

- Model that always predicts not-dog has accuracy of 80%
  - Seems good right?

- However, the model is useless since it did not learn any patterns
  - Simply always predicts not-dog and does not distinguish pictures at all

Metrics for classification

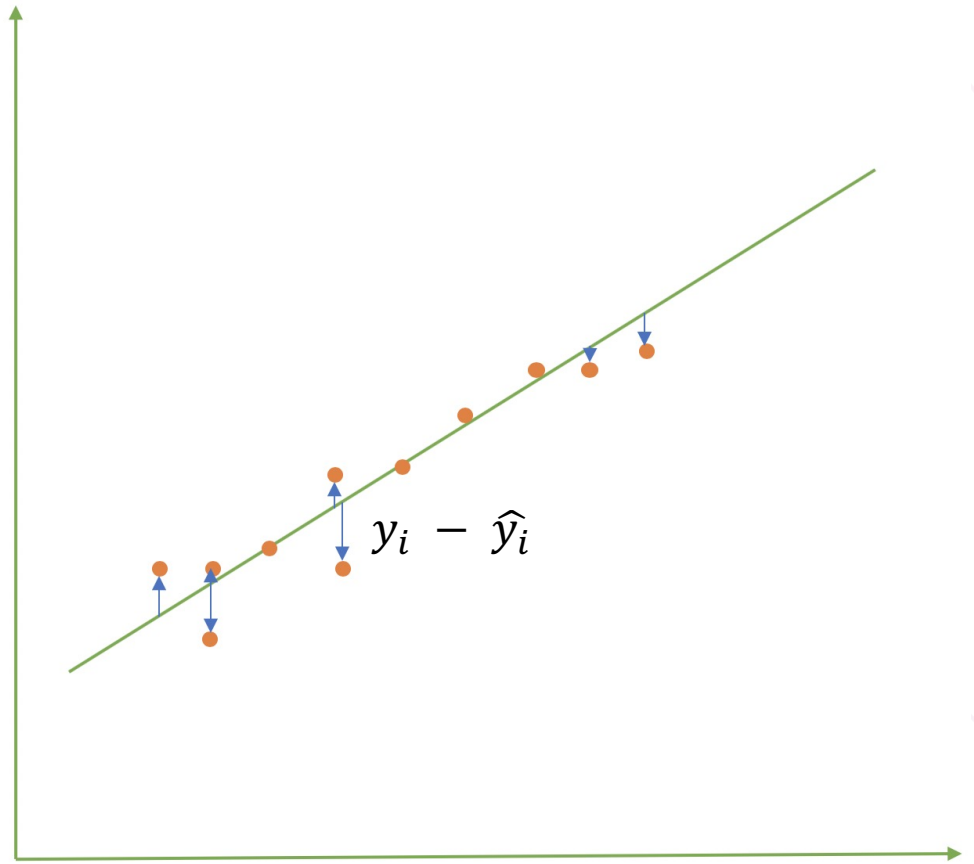
- Confusion matrix

		Prediction	
		Positive	Negative
Actual	Positive	True Positive (TP)	False Negative (FN)
	Negative	False Positive (FP)	True Negative (TN)

- Precision = TP / (TP + FP)
  - Proportion of correctly predicted positive instances among all instances predicted as positive
- Recall = TP / (TP + FN)
  - Proportion of correctly predicted positive instances among all positive instances
- F-score = 2 x (P x R) / (P + R)
  - Combines precision and recall

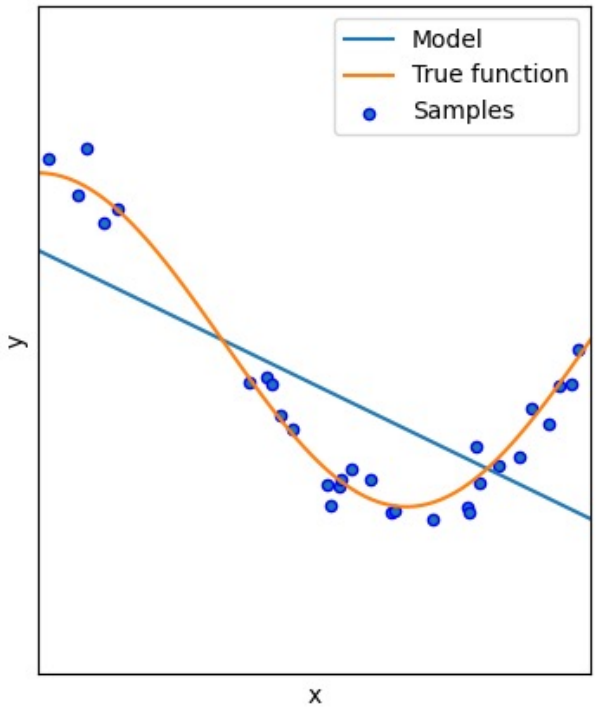
Metrics for regression

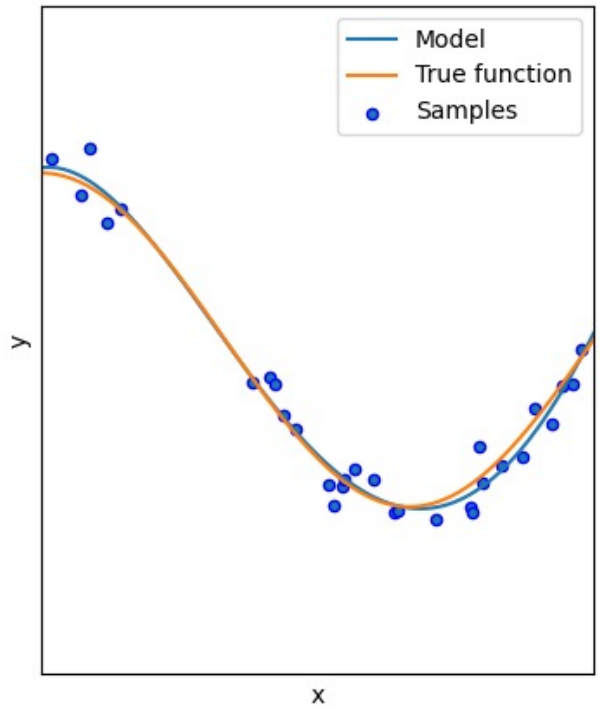
- Mean squared error
  - $MSE = \frac{1}{N}\sum_{i=1}^{N}(y_i - \hat{y}_i)^2$
- Mean absolute error
  - $MAE = \frac{1}{N}\sum_{i=1}^{N}|y_i - \hat{y}_i|$
- Mean absolute percentage error
  - $MAPE = \frac{100}{N}\sum_{i=1}^{N}\left|\frac{y_i - \hat{y}_i}{y_i}\right|$

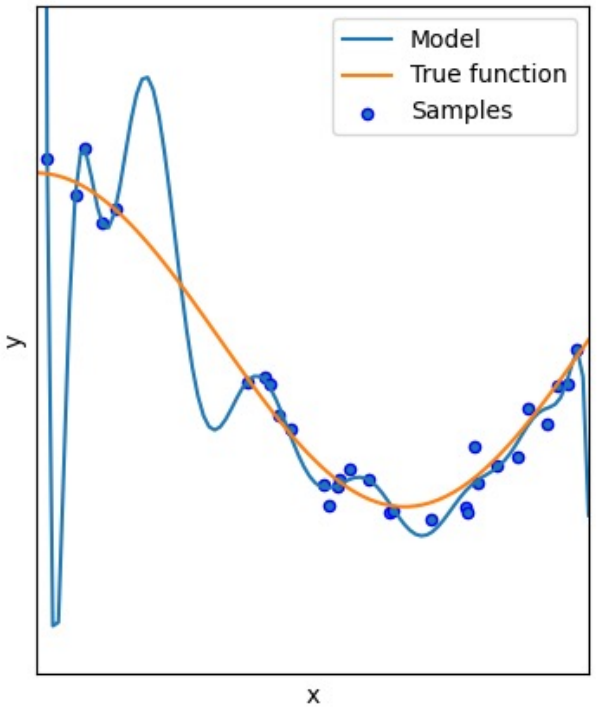


Exercise

Good fit, underfit and overfit?







Python code example

5 Types of ML

Types of learning

Supervised	Unsupervised	Reinforcement
Train the algorithm by providing correct answers for the problem at hand. Learn with known targets.	Let the algorithm figure out the hidden patterns/structure in the data itself. Learn with unknown targets.	Algorithm is trained by receiving a reward/punishment for doing things right/wrong. Learn by experimentation.

Supervised learning

- Learn from labeled training data
  - Find structure between features and known targets
- Predict new unlabeled data
  - Regression / classification: predict quantity / quality
- Task-driven

Application	Input	Output
Online advertising	Ad and user info	Click? (yes/no)
Speech recognition	Audio fragment	Text transcipt
Visual inspection	Image of component	Defect (yes/no)

Unsupervised learning

- Learn from unlabeled data
  - Find structure in the data itself → data-driven
- Clustering
  - Find similarities in the data and group similar observations
- Anomaly detection
  - Find outliers that seem out of place compared to the bulk of the data
- Dimensionality reduction
  - Describe many features by a limited set, retaining most of the original information

Reinforcement learning

- Learn from past experience
  - Keep doing what works and stop doing what doesn't
- Decision process + reward system
  - Reward when doing good
  - Punishment when doing bad
- Learn series of actions to take given a certain state and environment

Exercise

Problem	Type of ML
• Customer segmentation	• …
• Robot navigation	• …
• Rainfall prediction	• …
• Genome processing	• …
• Loan default prediction	• …
• Playing a videogame	• …
• Fraud detection	• …

Solution

Problem

- Customer segmentation
- Robot navigation
- Rainfall prediction
- Genome processing
- Loan default prediction
- Playing a videogame
- Fraud detection

Type of ML

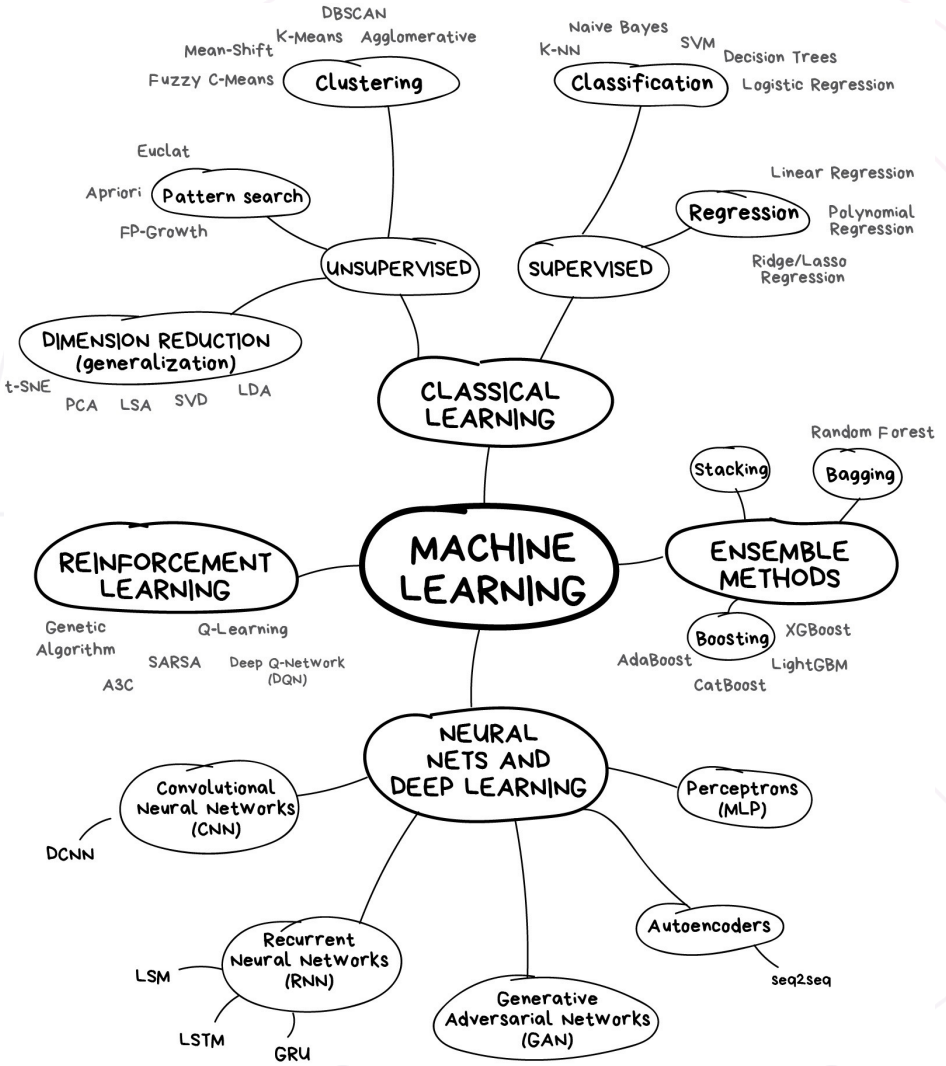
- Unsupervised – Clustering
- Reinforcement learning
- Supervised- Regression
- Unsupervised – Dimensionality red.
- Supervised - Classification
- Reinforcement learning
- Unsupervised - Anomaly detection OR Supervised - Classification

6 AI Algorithms

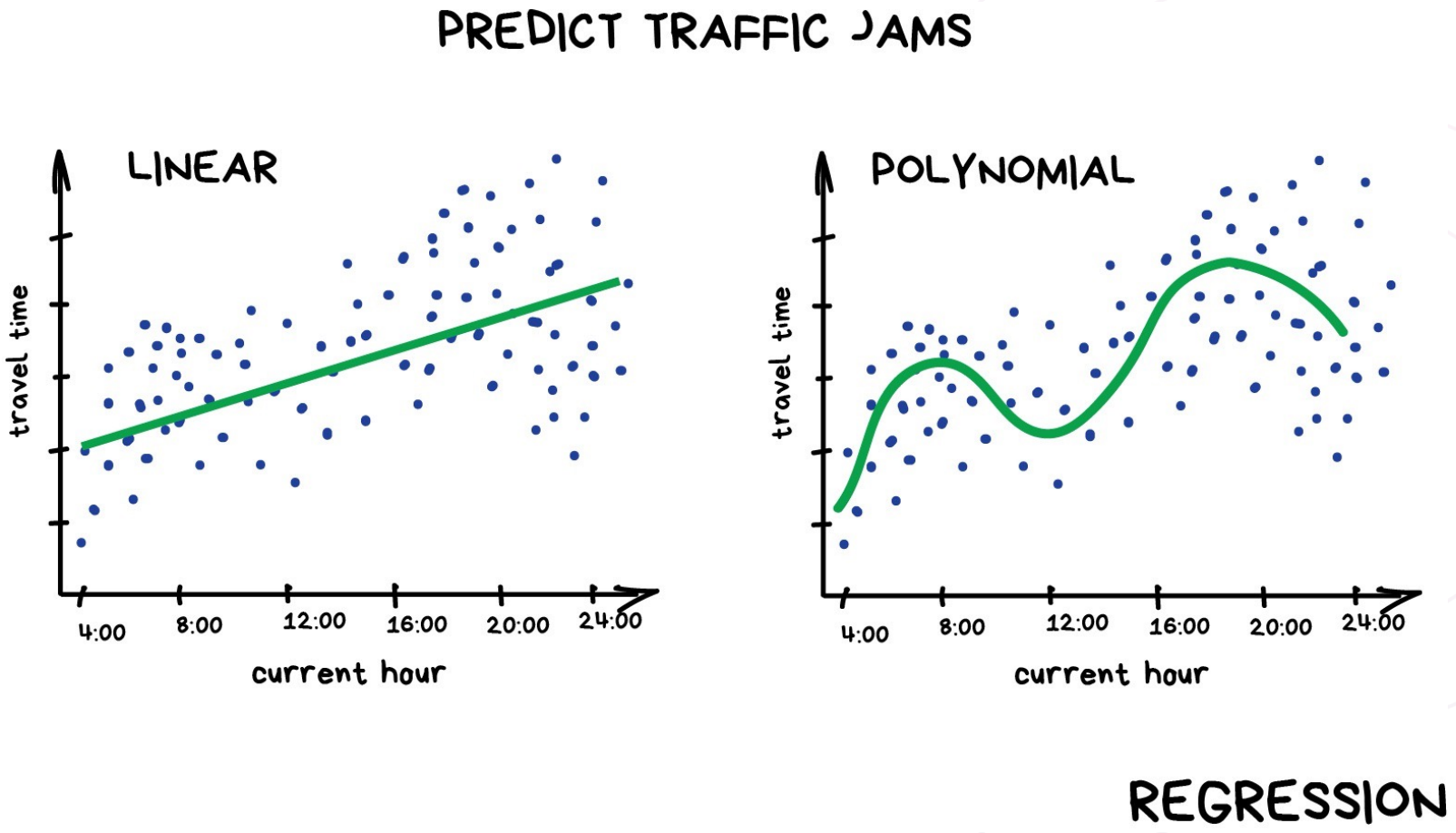
Overview of algorithms

vas3k – Machine Learning

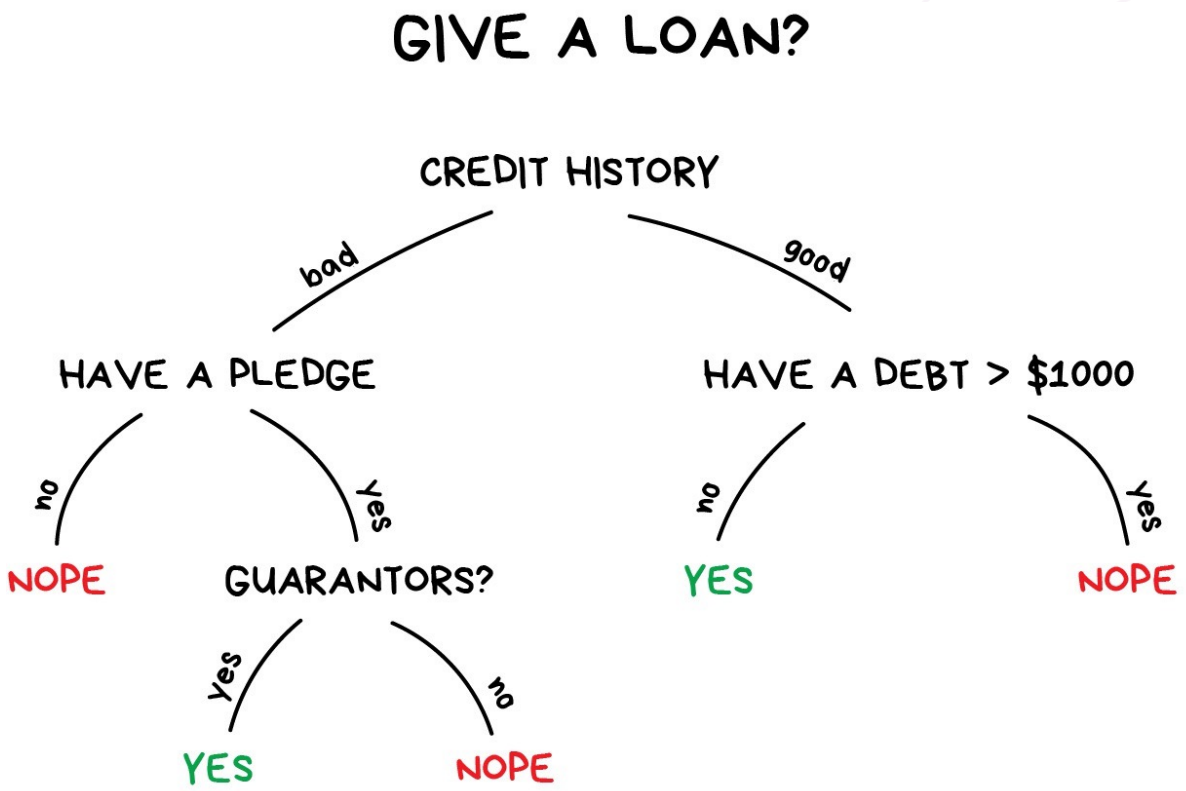
- Very interesting introductory blog on AI algorithms
- Pictures in this section taken from this blog (credits to vas3k)



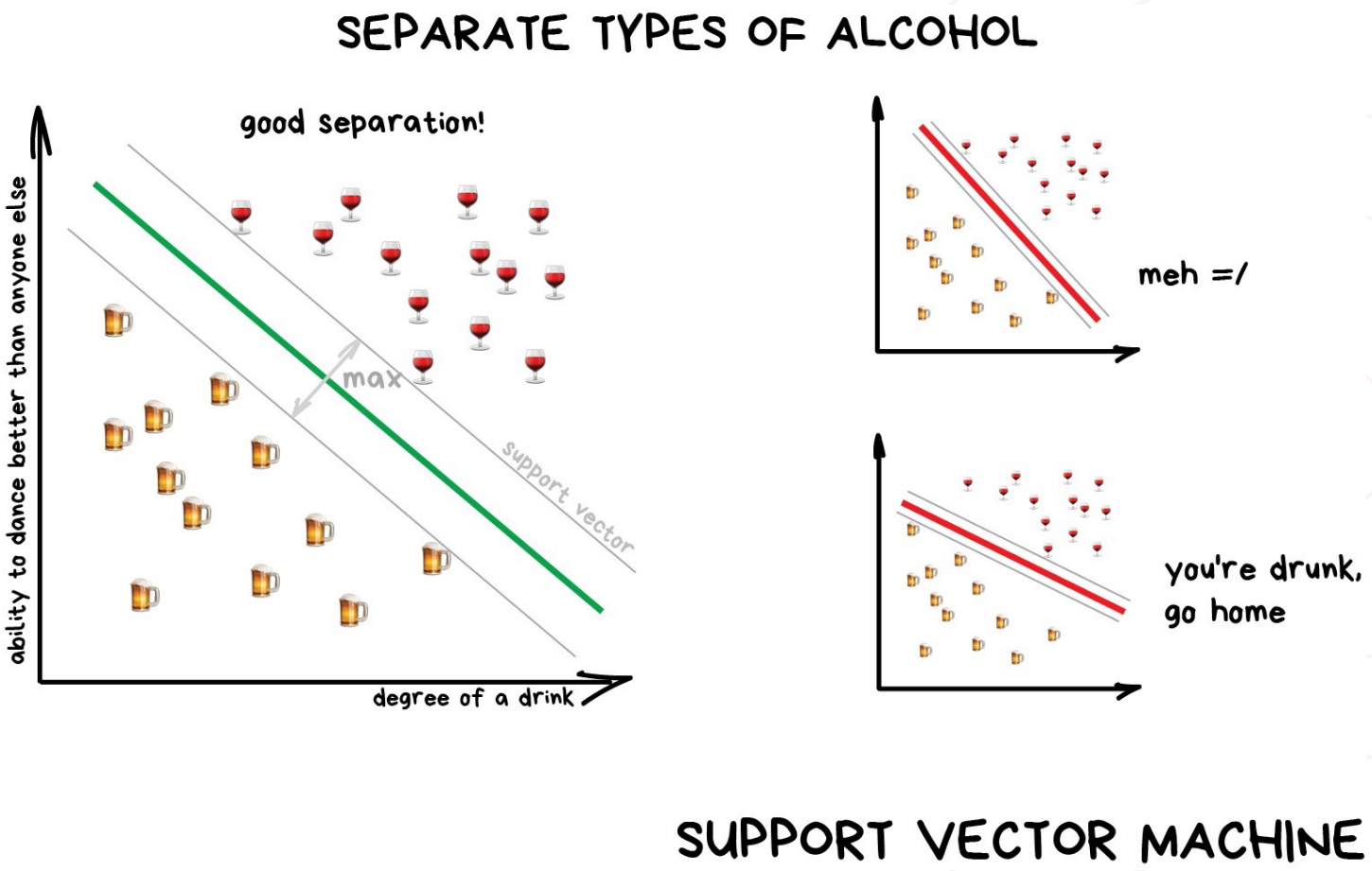
Linear or polynomial regression



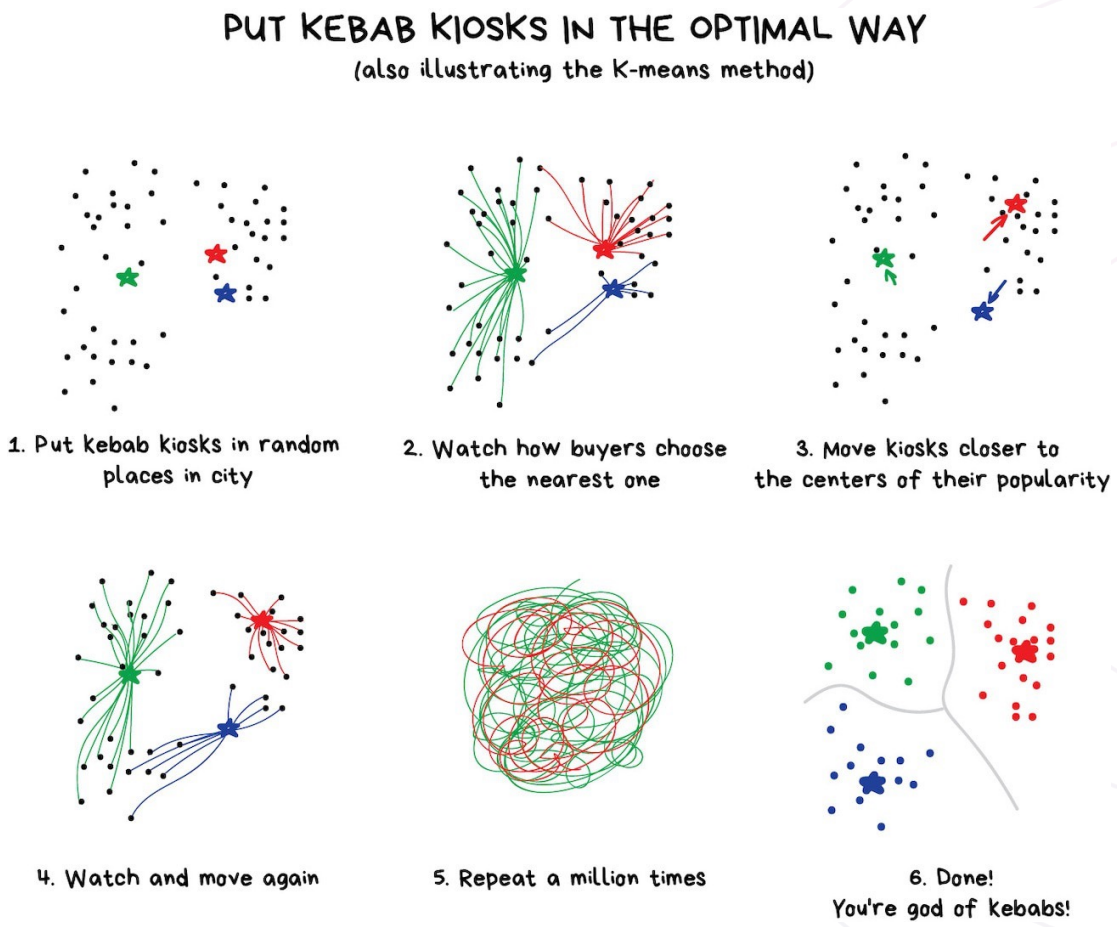
Decision tree



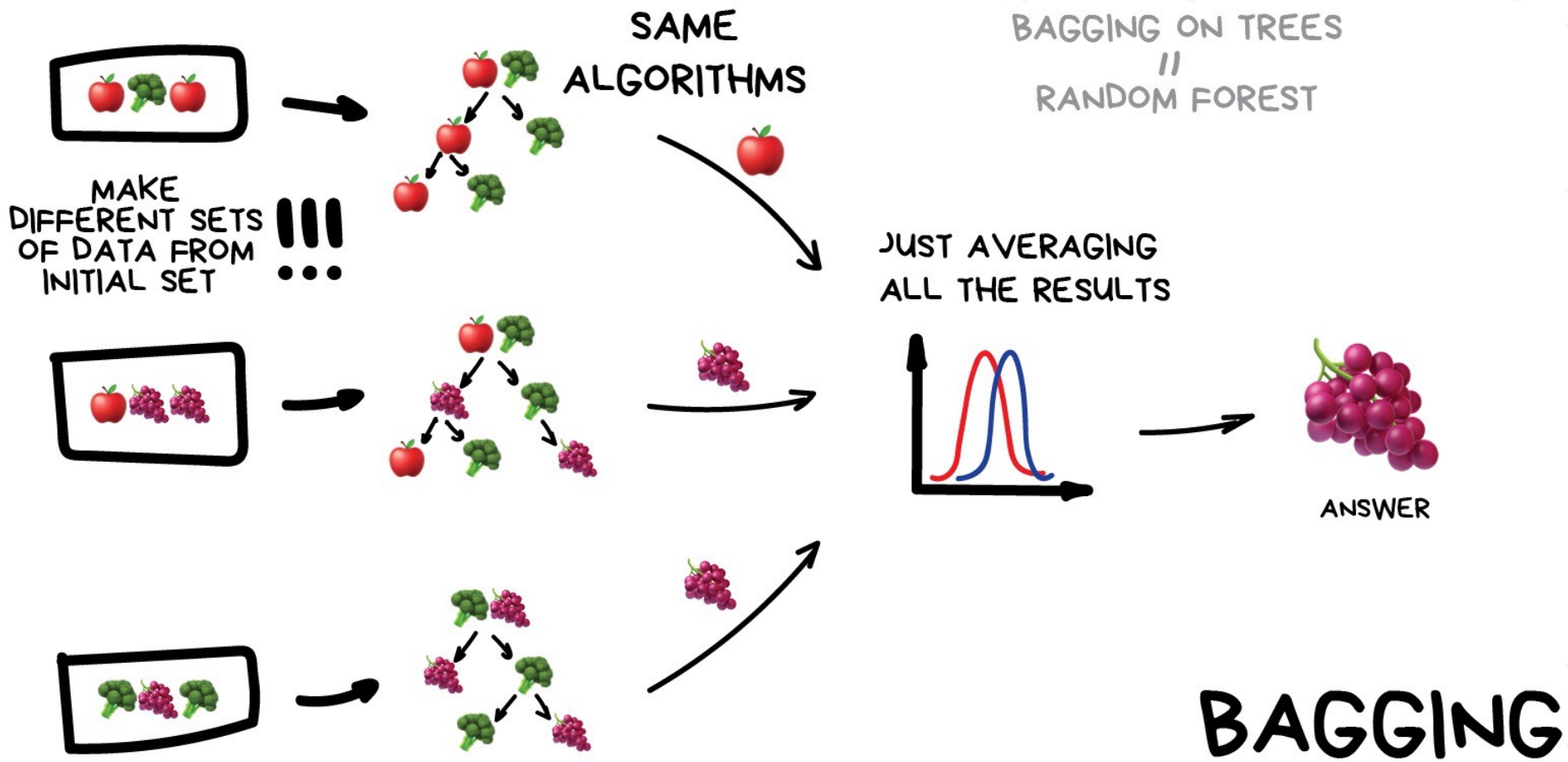
Support vector machine



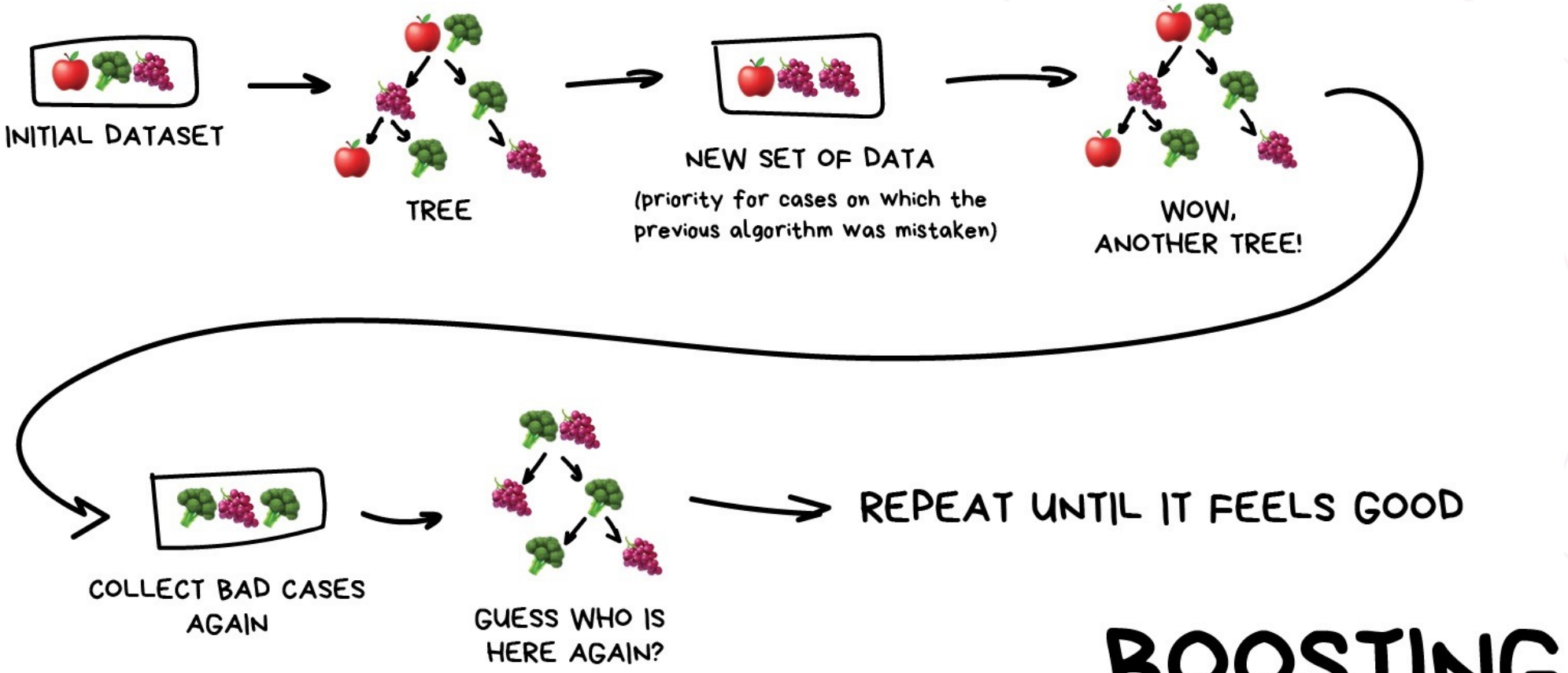
K-means clustering



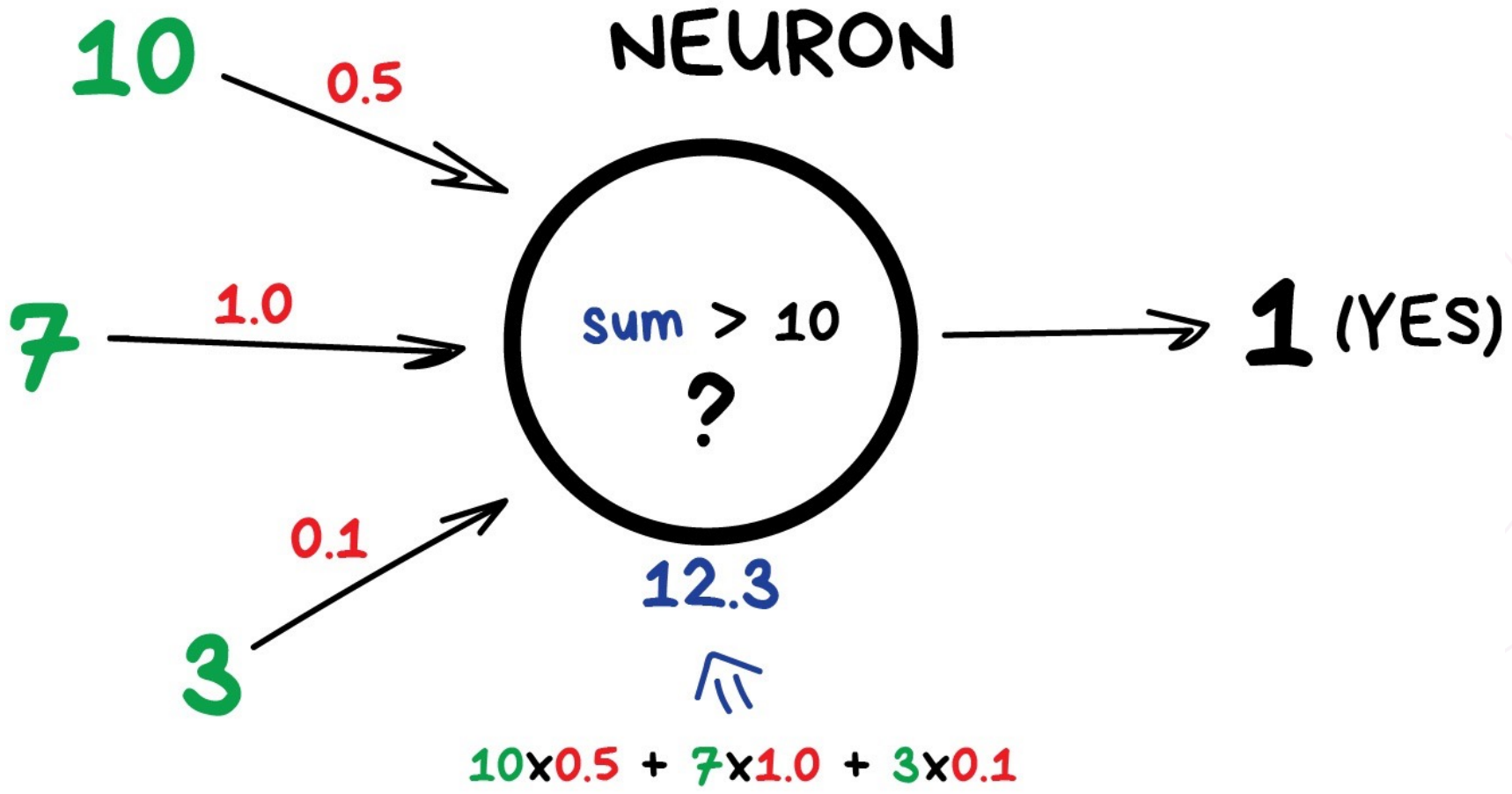
Bagged ensemble



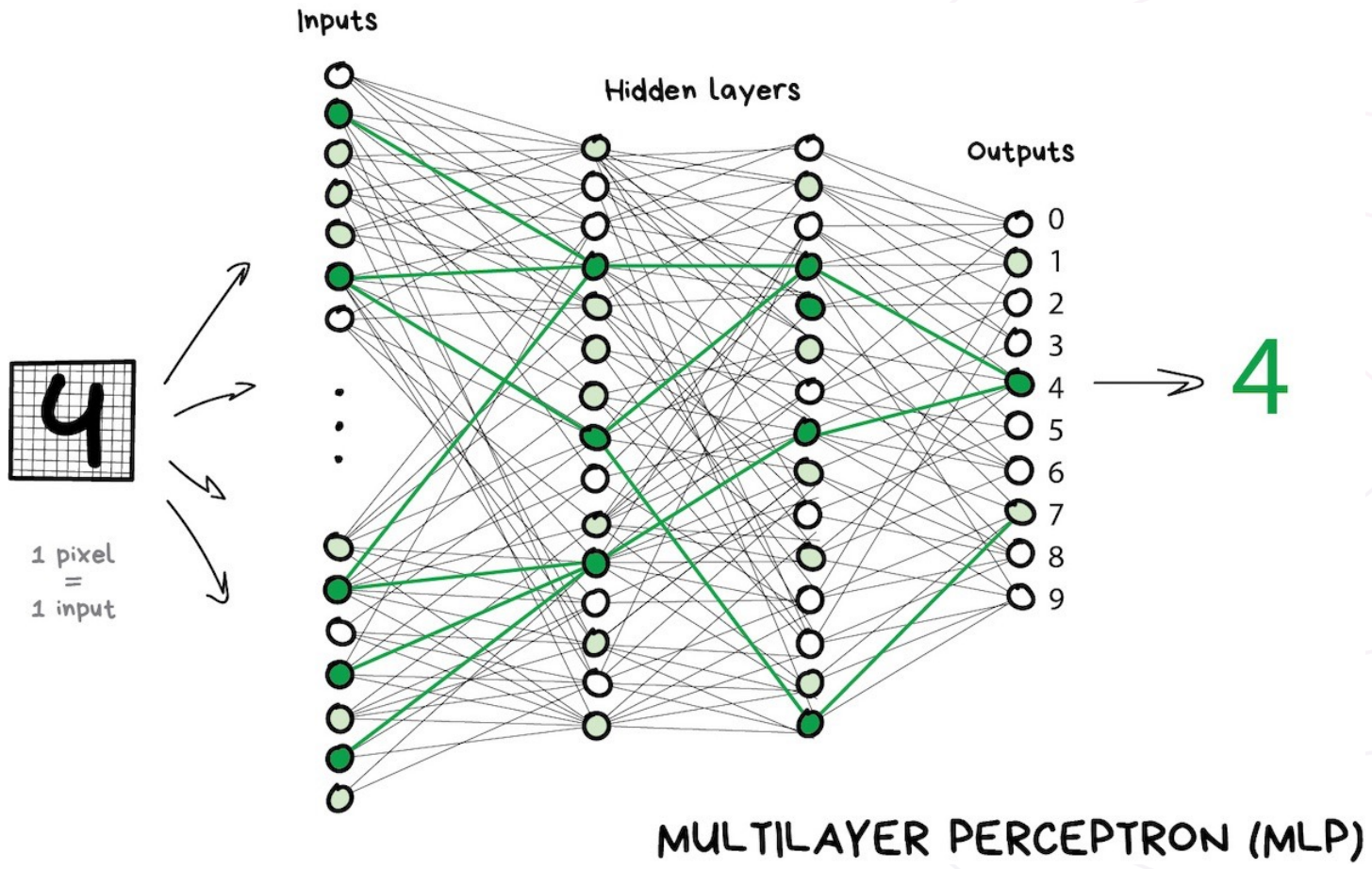
Boosted ensemble



Perceptron



Neural network



7 Trusted AI & Ethics

Trusting AI systems

- Any practical AI system in production needs to be:

- Fair
  - Not allowing for any bias or discrimination
- Robust
  - Not able to be manipulated from the outside
- Explainable
  - Able to understand the internal decision process

- Need for AI governance and responsible AI
  - Technical solutions exist, but at some costs (e.g., slower execution)

Fairness

- No discrimination against minorities or bias in decisions
- Bias is often present in data and transferred into models
  - Toxic effects of reinforcing existing unhealthy stereotypes
- Some recent examples
  - Facial recognition worked better for light-skinned males (Buolamwini)
  - Man is to computer programmer as women is to homemaker? (Bolukbasi)
  - Amazon's hiring tool discriminated against women (Reuters)

Robustness

- Not able to be manipulated by a third party via adversarial attacks
  - Deliberately force to make a wrong prediction and trying to fool the AI

- Make the system do something else than it is intended to do:
  - Stickers on stop sign confuse the AI
  - Patch that tricks AI into thinking a banana is a toaster
  - Glasses make facial recognition AI think you're actress Milla Jovovich

- Adversarial use of AI
  - Obama Deep Fake video

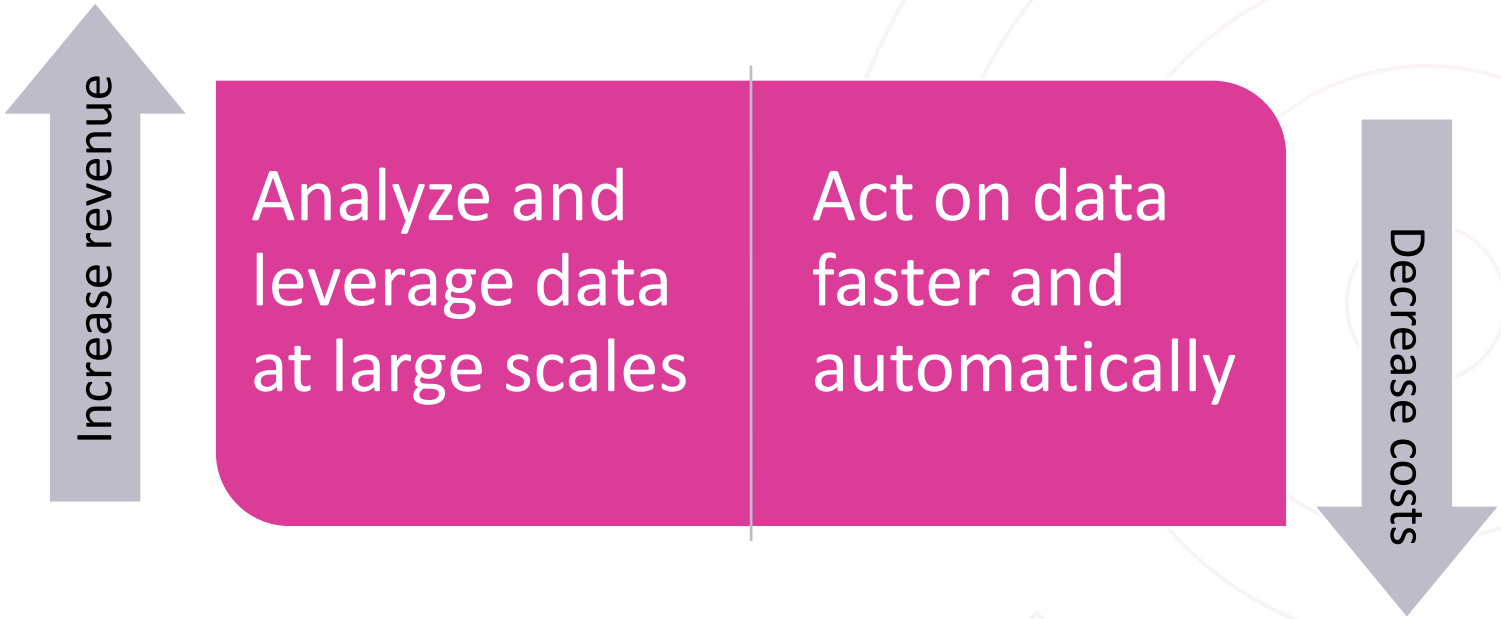
Explainability

- Understand why a specific decision is made
  - User has the “right to an explanation” (GDPR)
  - Especially important for high-stakes decisions with a big impact on lives
- Wolf vs husky experiment (Ribeiro et al.)
  - Snow in the background? → Husky
- Two options to guarantee explainability
  - Tranparent models
  - Ex-post interpretation techniques of black box models (many exist)

8 AI Use Cases

Why invest in AI?

Profit = Revenue - Costs



Use Case Life Cycle

Identification
- Find relevant use cases consistent with AI strategy

Assessment
- Compare the expected value with implementation complexity

Prioritization
- Rank cases based on high value and low complexity

Execution
- Start with the most valuable cases first

Identify use cases

- Talk to the right people
  - Bring together domain experts, business stakeholders and AI experts
  - Ensure that initiatives address broad organizational priorities
  - Increase adoption chances by involving end users in the application design

- Brainstorm sessions to keep communication lines open
  - Defer judgement and encourage wild ideas
  - Build on ideas but stay on target
  - Go for quantity, more is better at this stage

- Not AI-ready?
  - Bring in external expertise

Questions to ask - strategy

- What goals are driving the company right now?
  - Better customer service to increase retention
  - Increase percentage of sales made with new products
- Which challenges keep you up at night?
  - How to make our ads more successful?
  - How to keep customers from leaving?
- What is driving current bottlenecks or preventing progress?
  - High production costs
  - High storage costs
  - High employee rotation

Questions to ask - processes

- Where would you benefit from knowing the future?
  - Future demand or supplier prices
  - When to maintain the machinery
- Where are things done over and over again?
  - Repetitive processes in data entry: invoices, sales, payroll, etc.
- Which tasks involve complex planning?
  - Manufacturing: supply orders and maintenance
  - Scheduling & logistics: deliveries and workers shifts

Questions to ask - customer

- What's hard and annoying for customers?
  - Returns and refunds → streamline/automate the process
  - Poor customer service → chatbots to answer faster

- What would you like to know?
  - Why do customers leave?
  - What will they buy in the future?

- Are there friction points in the customer journey?
  - Brand awareness & leads: automatic creation of social media posts or newsletter
  - Sales & loyalty: targeted promotions and advertising

Questions to ask - data

- What things are input manually?
  - Emails, receipts, reimbursements, etc.
- Where do you have a lot of relevant data?
  - Marketing: reach of campaign & ROI from different channels
  - Retail: personal customer data & order details
- Where do you already use some data to drive decision-making?
  - Dashboards for ad campaigns
  - Some parts of a production are semi-automated (e.g., quality control)

Assess use cases

Value

- What is the desired output of a given AI application?
- What business value does use case bring?
- What strategic advantages does it bring?
- Over what time period will be the value derived?
- Is this a game changer or business extender?

Complexity

- What data is needed to train a given AI solution?
- Is data available in our organization?
- Is the infrastructure ready or do we need to build one?
- What AI capability is required and do we have this?
- What are the greatest obstacles to solve this problem?

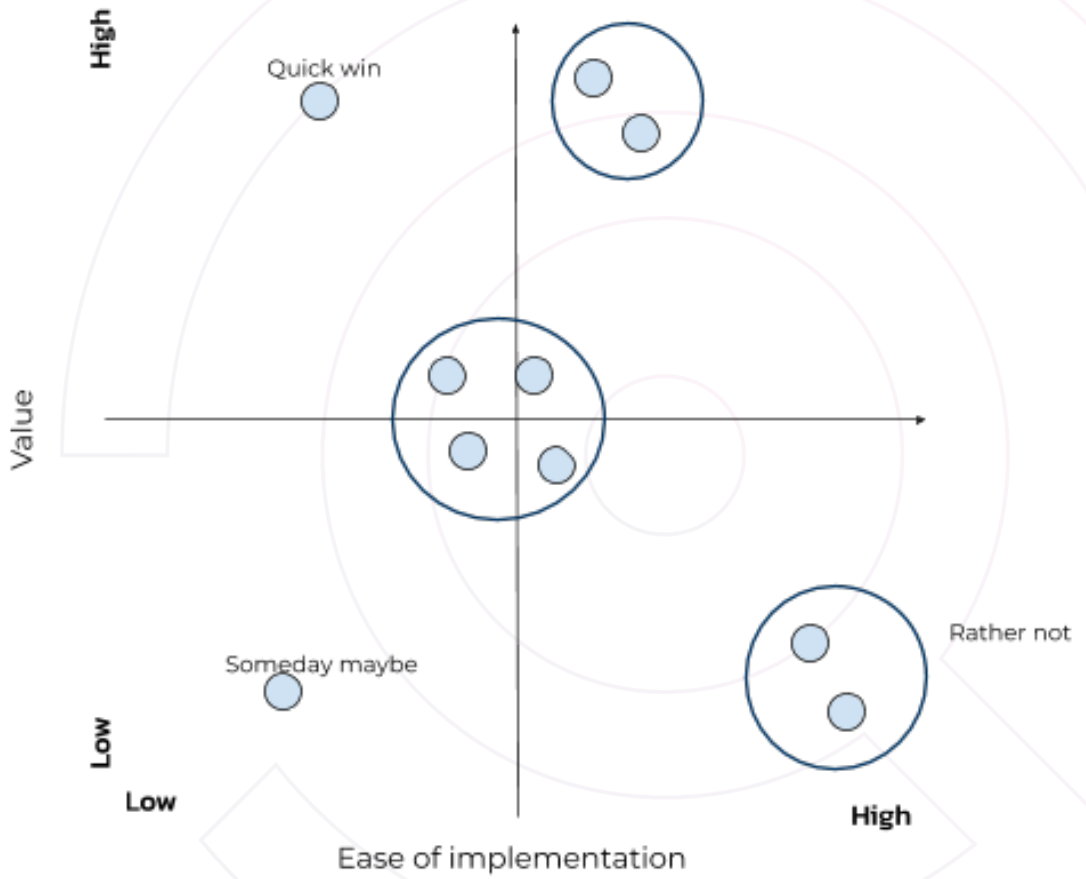
Score use cases

- Value
  - Score from 1 (no value) to 5 (lot of value)

- Complexity: average the following three components
  - Data: score from 1 (we have all data) to 5 (need to collect a lot of data, possibly hard to get)
  - AI skills: score from 1 (easy to implement) to 5 (requires research and experimentation from the team or even external experts)
  - Infrastructure: score from 1 (infrastructure is ready) to 5 (infrastructure needs to be built with lots of processing power and storage space)

Prioritize use cases

- Rank individual cases according to value and complexity scores
  - Plot value vs complexity
- Cluster use cases that are close
  - Prioritize clusters by value added and number of use cases
- Are there any quick wins?
  - Start with these



Churn modeling

- Why important?
  - Losing clients affects company revenue numbers and profits
- How does it benefit business?
  - Customer retention increases revenue and decreases costs
  - Understanding churn behavior leads to more effective retention strategies
- What data is needed?
  - Customer behavior, transactions, demographics, product usage/patterns, etc.

Recommender system

- Why important?
  - Increasing sales via personalized offers and an enhanced customer experience
- How does it benefit business?
  - Accurately guiding prospective buyers to your products increases revenue
  - Set-up of cross-selling possibilities
- What data is needed?
  - Customer data, user ratings and system interaction data (e.g., clicks, searches, visits, purchases, favorites)

Demand forecasting

- Why important?
  - Used for strategic business plans (e.g., budgeting, financial planning, sales and marketing plans, capacity planning, risk assessment and mitigation plans)
- How does it benefit business?
  - Improved inventory availability can increase revenue
  - Reducing storage waste can decrease costs
- What data is needed?
  - Sales data, product demand, market conditions, ecommerce, etc.

Fraud detection

- Why important?
  - Fraud increases costs and thereby leads to profit loss
- How does it benefit business?
  - Fraud prevention decreases costs
  - Identifying fraudsters leads to prevention of unnecessary payments
- What data is needed?
  - Customer behavior and transaction data

Targeted advertising

- Why important?
  - Cost-effective approach as it minimizes wasted advertising
- How does it benefit business?
  - Sales go up and customer satisfaction increases (less annoyed by random ads)
  - Targeting successfully leads to increased revenue and decreased costs
- What data is needed?
  - Purchase history & client personality, attitude, opinions, lifestyle and interests

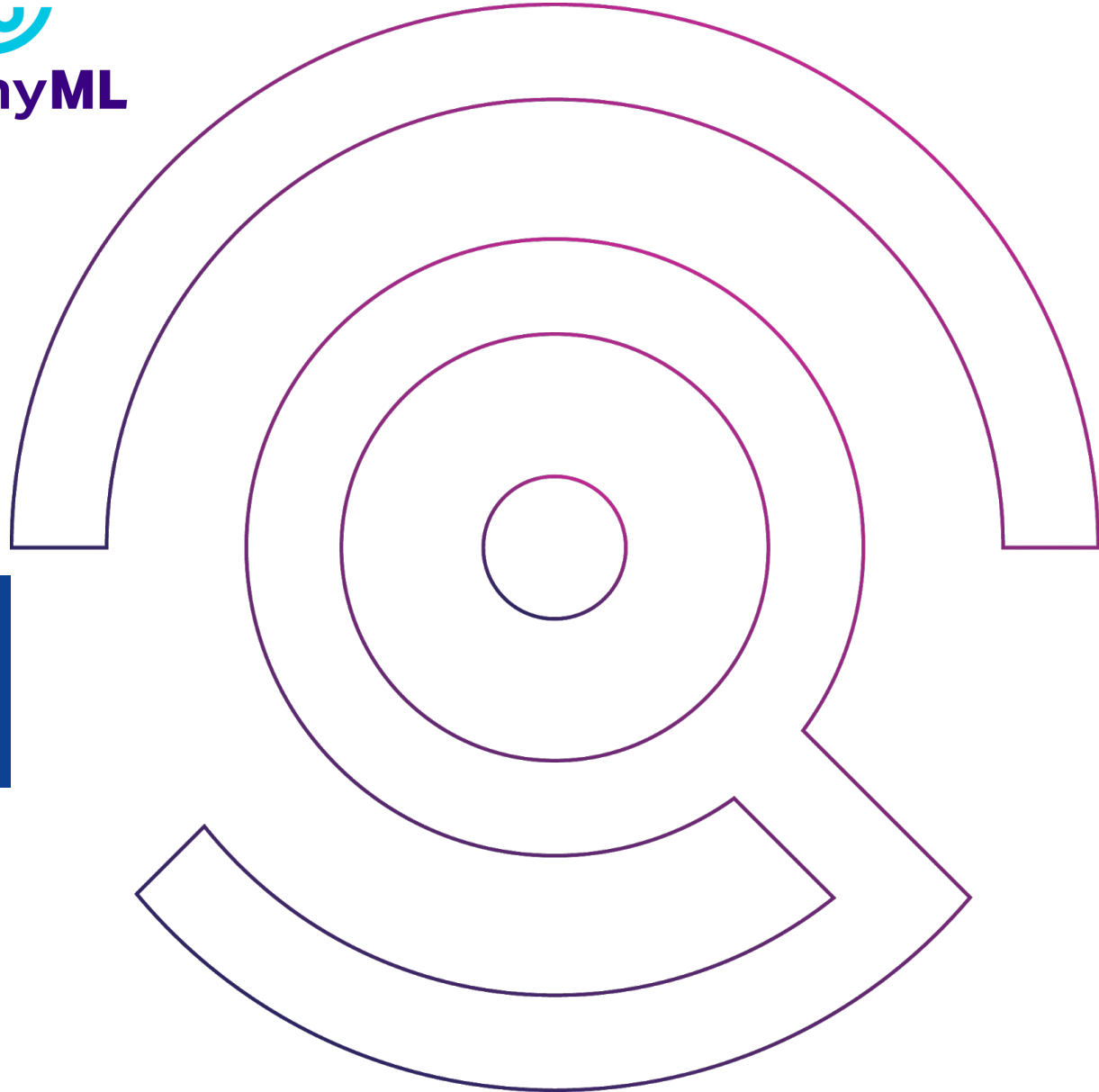
Is AI the answer to your problem?

PROPHECY LABS

ctg

nannyML

AI4Business



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