The Role of Artificial Intelligence in Education

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Thursday, October 27th, 2022
School of Education, University of Strathclyde

SICSA DVF funding call

University of Strathclyde Glasgow

sicsa* The Scottish Informatics & Computer Science Alliance

At a Glance

2013
PhD in Computer Science
National and Kapodistrian
University of Athens
Greece

2016 Call
Marie Skłodowska-Curie
Action (MSCA)
Individual Fellowship
School of Computing Science
University of Glasgow, UK

June 2020
Assistant Professor
Department of Informatics
and Telecommunications
University of Thessaly
Greece
http://kostasks.users.uth.gr

July 2020
Founder of the
Intelligent Pervasive Systems
(iPRISM) Research Group
http://www.iprism.eu

Oct. 2020
Co-Founder of the Intelligent
Systems for Orchestrating
Pervasive Computing Applications
(METIS) Research Lab
http://metis.cs.uth.gr

Dec. 2020
Director of the METIS Lab

Current Activities:

- Applied Artificial Intelligence and Machine Learning
- Distributed Intelligence
- Pervasive Data Science

At a Glance

Intelligent Pervasive Systems (iPRISM)
http://www.iprism.eu

Lead: Dr Konstantinos (Kostas) Kolomvatsos

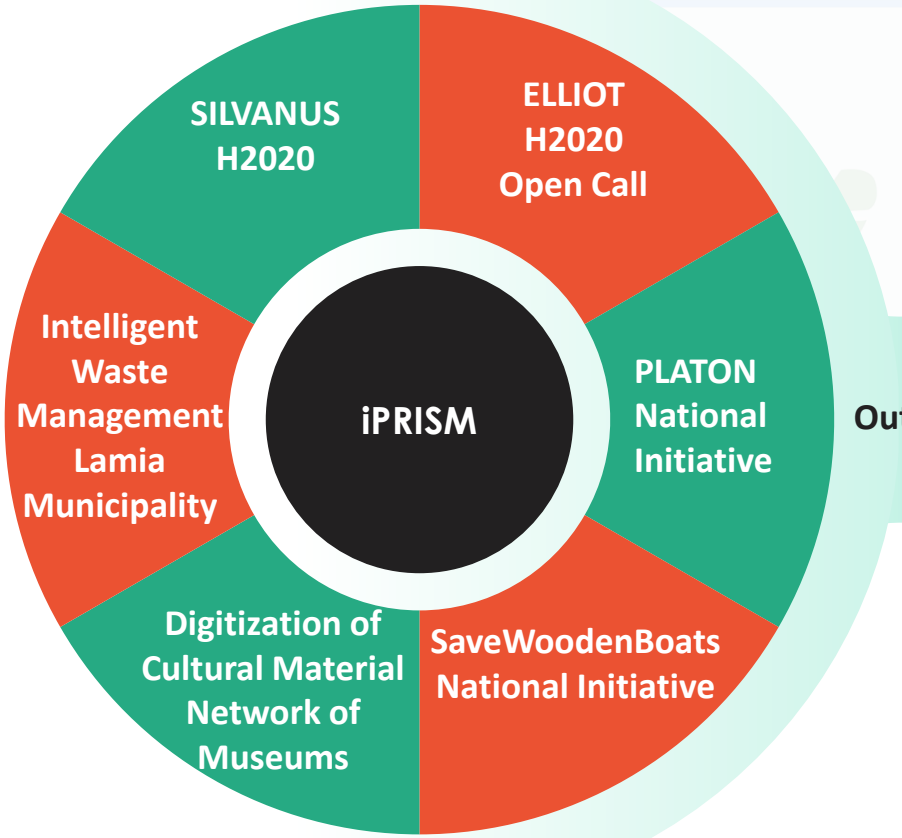
Research axes:

- Artificial Intelligence
- Applied (Deep) Machine Learning
- Computational Intelligence
- Distributed Intelligence
- Pervasive Computing
- Pervasive Data Science
- Proactive Decision Making
- Applications for Distributed Systems, Internet of Things, Edge Computing
- Predictive Intelligence
- Large Scale Data management

Research Projects

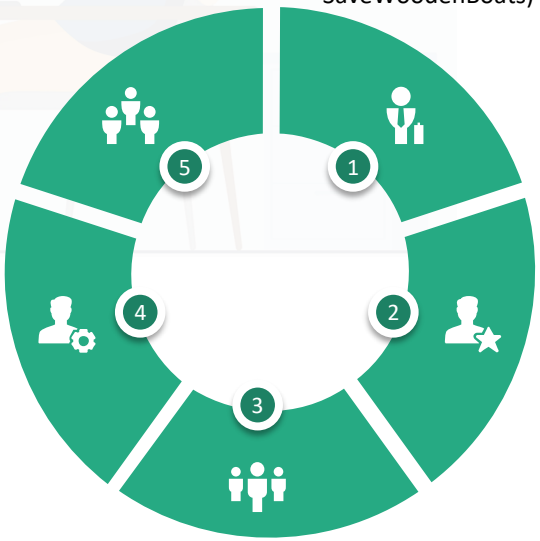
Subjects

- Sensors Data Management
- Situational Awareness for Emergency Management
- Intelligent Decision Making
- Deep Learning for Image Processing
- Analytics
- Digitization
- Augmented Reality



Outcomes

1. Heatlh Impact (SILVANUS, ELLIOT)
2. Evacuation Planning (SILVANUS)
3. Recommender (ELLIOT)
4. Chatbot, Drug impact assesment (PLATON)
5. Virtual World for presenting information and training (PLATON, SaveWoodenBoats)



Contents

Part A
Artificial Intelligence

Why AI?

Interact

- ✓ Ability to interact with World
- ✓ Speech, Vision, Motion, Manipulation, Data

Model

- ✓ Modeling of the surrounding World
- ✓ Reason based on the collected data and delivered models

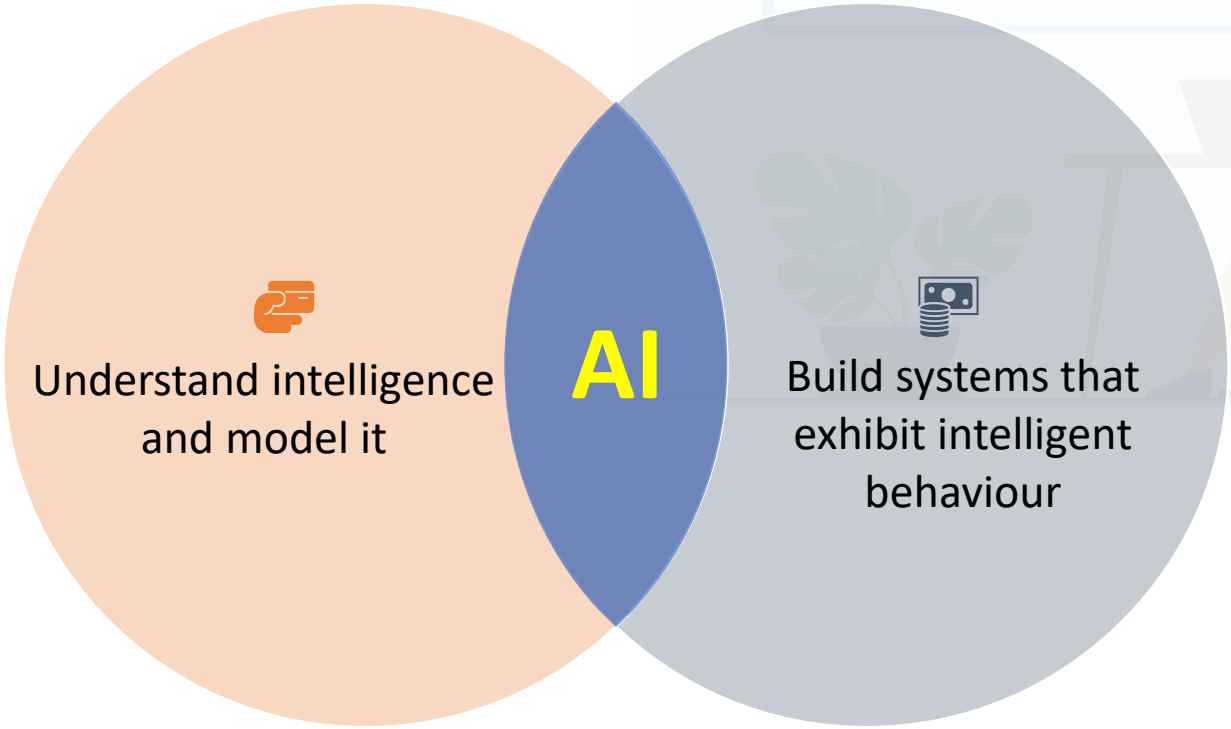
Learn

- ✓ Learn from data
- ✓ Use the appropriate algorithms per case

Adapt

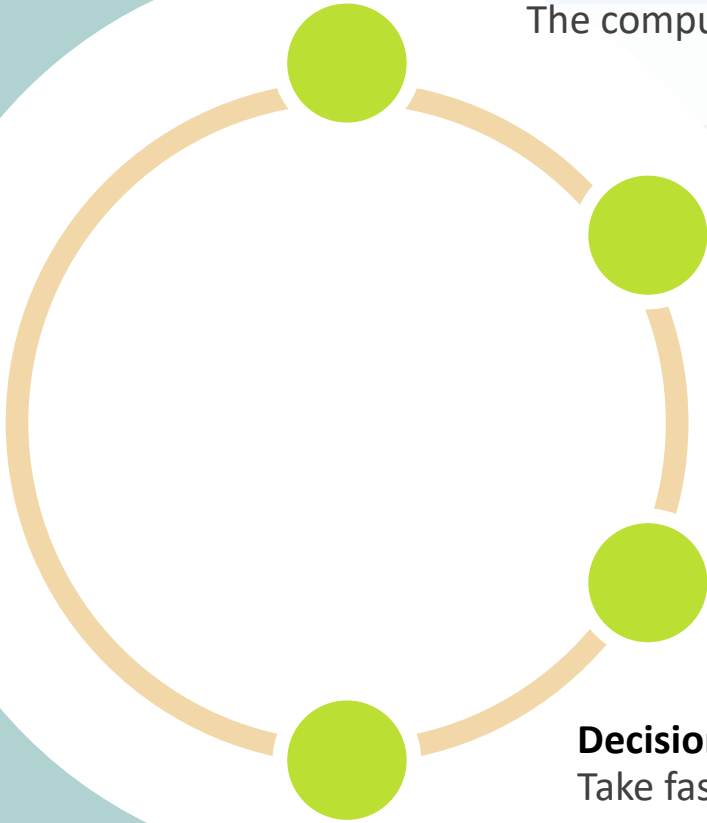
- ✓ Deliver components that can be adapted to dynamic conditions
- ✓ Be adaptive to the current status and predict the future

Goals in AI


Understand intelligence and model it
AI
Build systems that exhibit intelligent behaviour

Definition

Artificial intelligence (AI) is intelligence demonstrated by machines, as opposed to the natural intelligence displayed by animals and humans (wikipedia)



Intelligence
The computational part of the ability of achieving goals

Automation
Automate activities we associate with human thinking, like decision making, learning, etc

Computation
Make possible to perceive, reason and act

Decision Making
Take fast and efficient decisions under the current status

Sub-problems

Reasoning

Algorithms imitate step-by-step reasoning that humans use when making logical deductions

Knowledge

Knowledge representation allows AI to answer questions intelligently and make deductions about real-world facts

Planning

An agent models the state of the world, makes predictions about how actions will change it and make choices that maximize the utility

Learning

Machine learning (ML) is the study of computer algorithms that improve automatically through experience

Sub-problems

Natural Language Processing

Natural language processing (NLP) allows machines to read and understand human language

Perception

Machine perception is the ability to use input from sensors to deduce aspects of the world

Motion and manipulation

AI is heavily used in robotics where actions in static and dynamic environments pose a great challenge

Social Intelligence

Agents should recognize, interpret, process or simulate human feeling, emotion and collaboration

Brief History

1943-1956 (1)
- Artificial Neurons Model
- Neural Network Computer

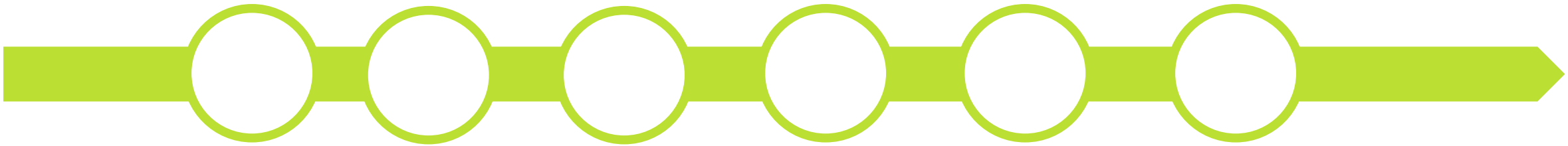
1952-1969 (2)
- Work on Neural Networks
- Shakey the robot

1966-1974 (3)
AI problems appear to be complex but computers are slow and expensive

1969-1979 (4)
Birth of expert systems

1980-1988 (5)
The first successful expert system

1990- (6)
Increases in computational power



Advantages

1

More powerful and more useful computers

2

New and improved interfaces

3

Solving new problems

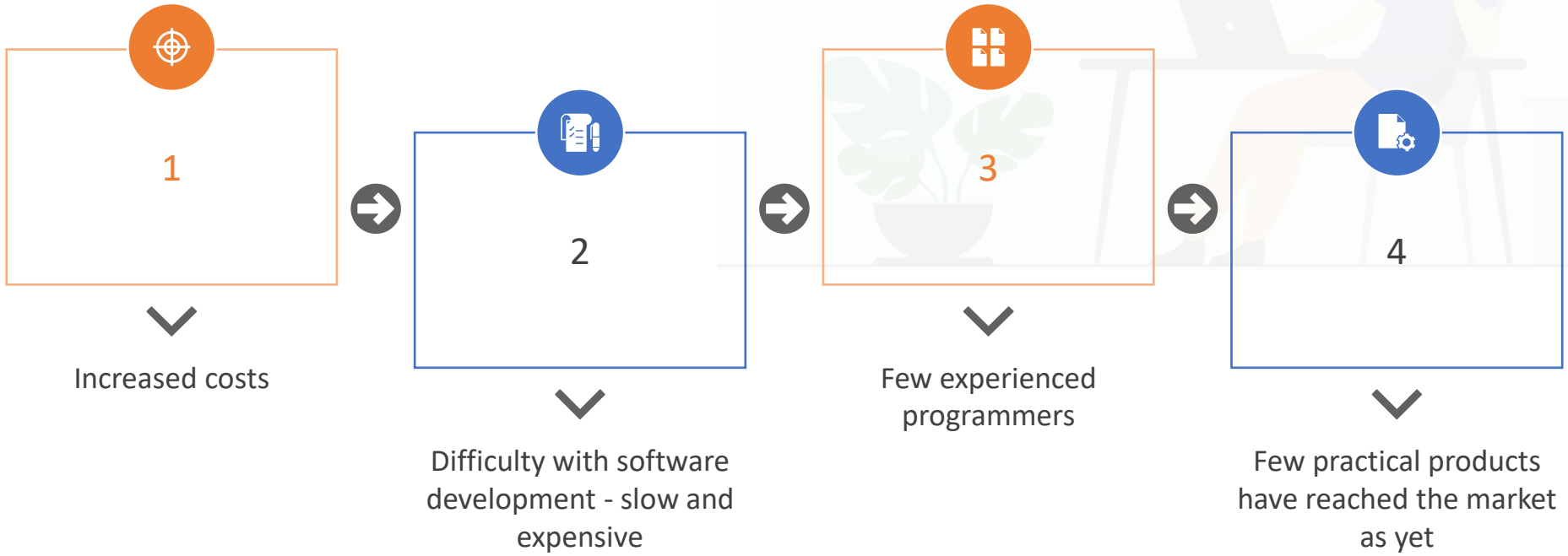
4

- Better handling of information
- Relieves information overload

5

Conversion of information into knowledge

Disadvantages



Special focus

Learning (ML)

- If a system will act truly appropriately, then it must be able to change its actions in the light of experience:
  - how new facts are generated from old ones?
  - how new concepts are generated upon the collected data?
  - how do we learn to distinguish different situations in new environments ?

Part B
Machine Learning

What is Machine Learning?

Machine learning (ML) is a field of inquiry devoted to understanding and building methods that 'learn', that is, methods that leverage data to improve performance on some set of tasks (wikipedia)

Artificial Intelligence
ML grew out from the quest for AI

Data Mining
ML focuses on prediction based on known properties of data while Data Mining focuses on the discovery of unknown data properties

Optimization
ML problems are usually modeled as optimization problems of a loss function upon a training dataset targeting to unseen samples

Statistics
ML tries to find generic predictive patterns while statistics target to draw inference from a population (samples)

Categories

Supervised Learning

- The data (observations, measurements, etc.) are labeled with pre-defined classes
- It is like that a “teacher” gives the classes (supervision)
- Test data are classified into these classes too

Unsupervised Learning

- Class labels of the data are unknown
- Given a set of data, the task is to establish the existence of classes or clusters in the data

Reinforcement learning

- Learning a policy: A sequence of outputs
- No supervised output but delayed reward
- Example: robots

Categories

Supervised Learning

Step 1: Learn a model using the training data
Step 2: Test the code using unseen test data

Classification: deliver class labels
Prediction: model continuous-valued functions

Applications:
- Credit card approval
- Medical diagnosis
- Fraud detection
- ….

Unsupervised Learning

No need for training a model
We want to explore data and find some intrinsic structures

Clustering: group data based on their 'similarity' (distance, density, etc)
Association rules: find frequent co-occurrences

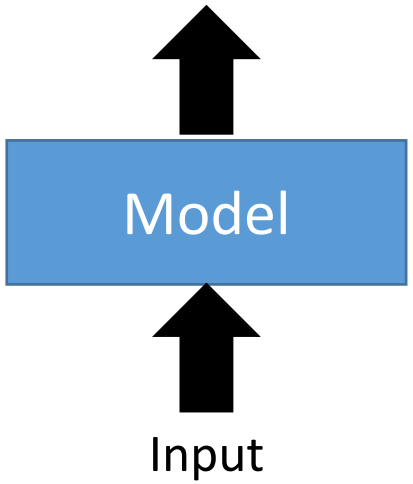
Link prediction: discover relationships in data

Applications:
- Customer segmentation
- Anomaly Detection in data
- ….

Classification

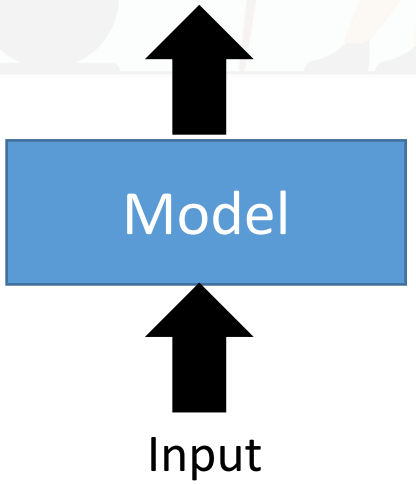
Binary Classification

{Yes or No}, {1 or 0}



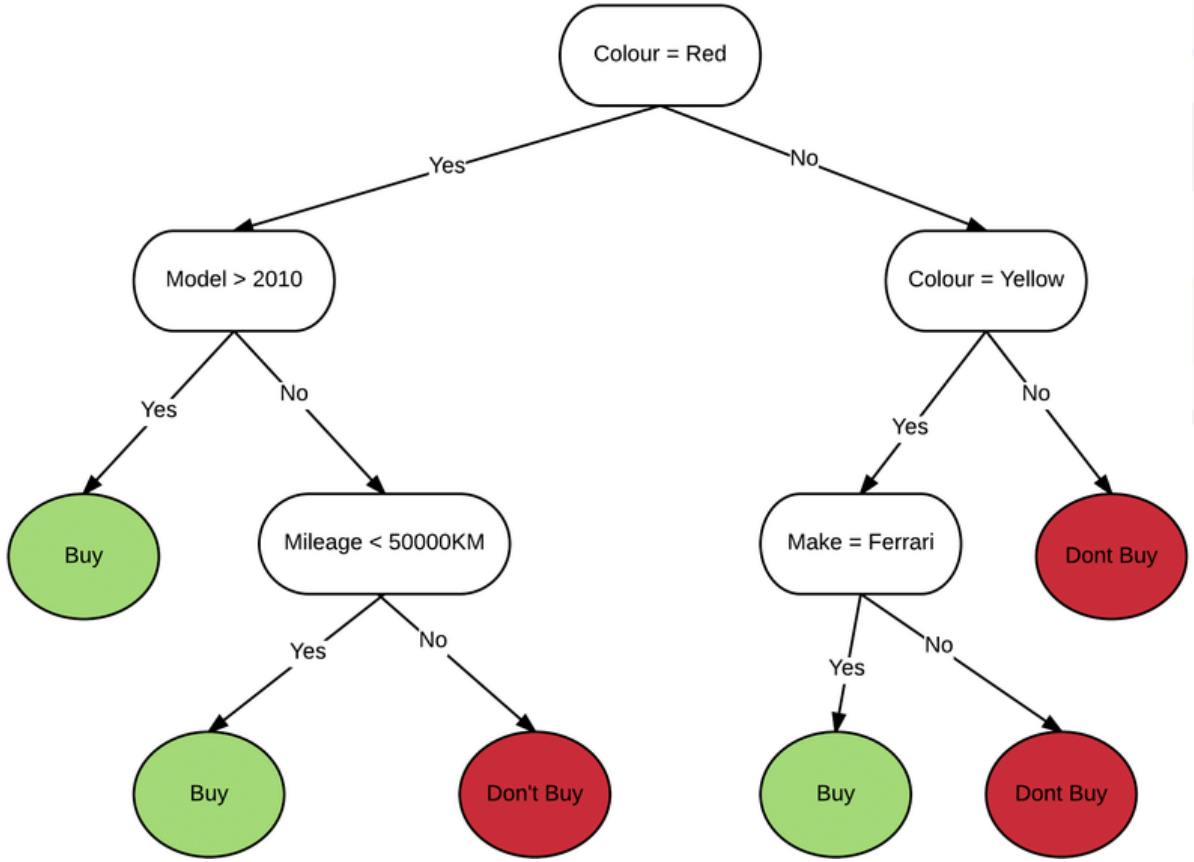
Multi-class Classification

Class 1, Class 2, … Class N



Classification

Decision tree learning is one of the most widely used techniques for classification



Color	Model	Mileage	Buy or Not
Black	2011	40000	?

Rule based Systems

Rule induction systems find a sequence of rules (also called a decision list) for classification
Usually, they are retrieved by Decision Trees

Association rules: have no fixed target, but we can fix a target

Class association rules (CAR): has a target class attribute

Own_house = true $\rightarrow$ *Class =Yes [support=6/15, confidence=6/6]*

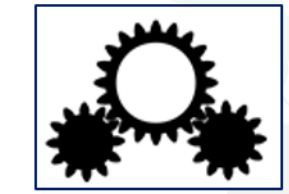
Decision tree vs. CARs

- There are many other rules that are not found by decision trees
- In many cases, rules not in the decision tree (or a rule list) may perform classification better
- Association mining require discrete attributes; Decision tree learning uses both discrete and continuous attributes

Association Rules

Set of Transactions

- item1,item2,item3
- item2,item4
- item1,item5
- item6,item7
- item2,item3,item4,item7
- item2,item3,item4,item8
- item2,item4,item5
- item2,item3,item4
- item4,item5
- …



Association Rule Mining

Association Rules

- item2 → item3
- item2 → item4
- item2,item3 → item4
- …

https://sherbold.github.io/intro-to-data-science/05_Association-Rule-Mining.html

Naïve Bayesian classification

Probabilistic view: Supervised learning can naturally be seen as computing the probability: **Pr(*c*|*d*)**

Given a test example *d* with observed attribute values a_1 through a_k, classification can be basically seen to compute the following posterior probability

$$\Pr(C = c_j \mid A_1 = a_1, \ldots, A_{|A|} = a_{|A|})$$

The predicted class is the class c_j such that the probability is maximized

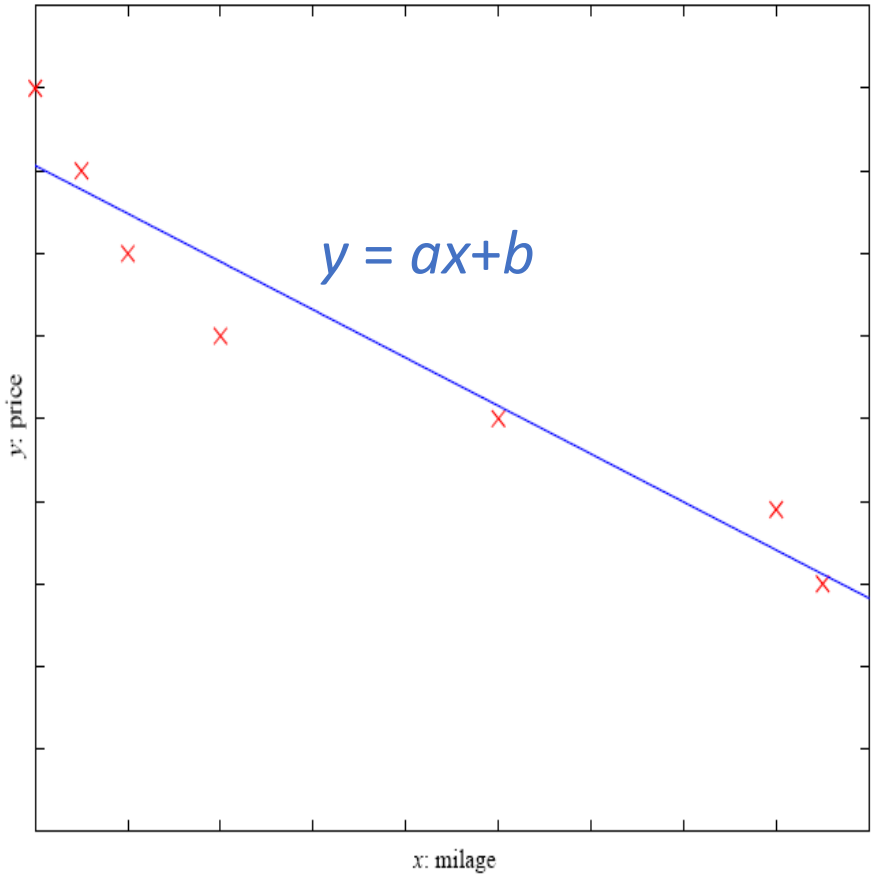
Apply Bayes' Rule for estimating that probability from the training dataset

Regression

Target: Find the weights a, b that minimize the total error between the estimated function and actual data points

Example: Price of a used car
x : car attributes (e.g., mileage) y: price

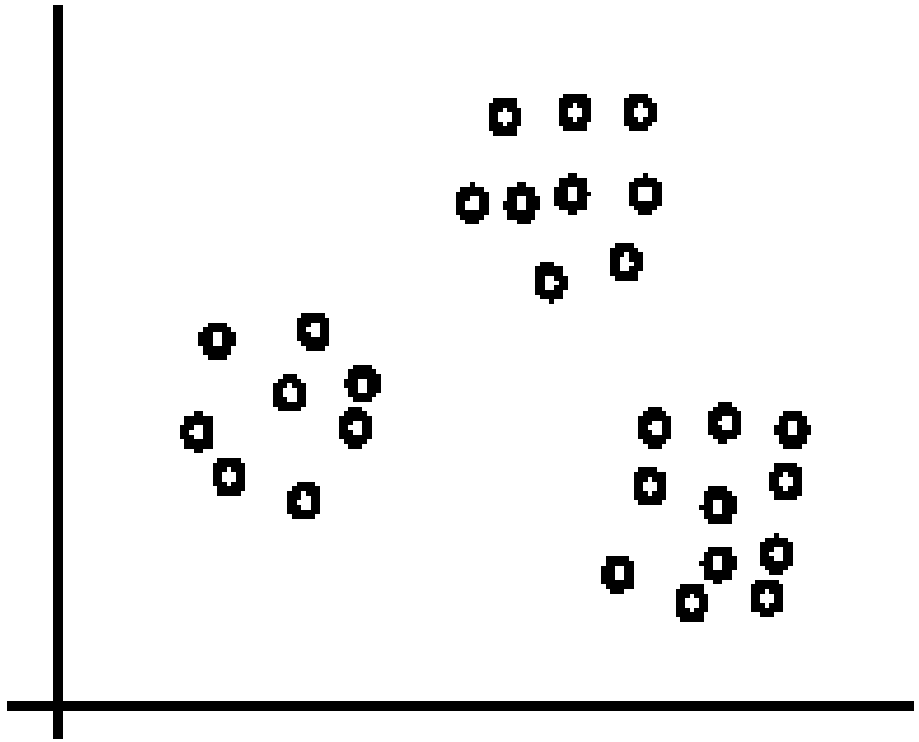
Use the training dataset to estimate weights



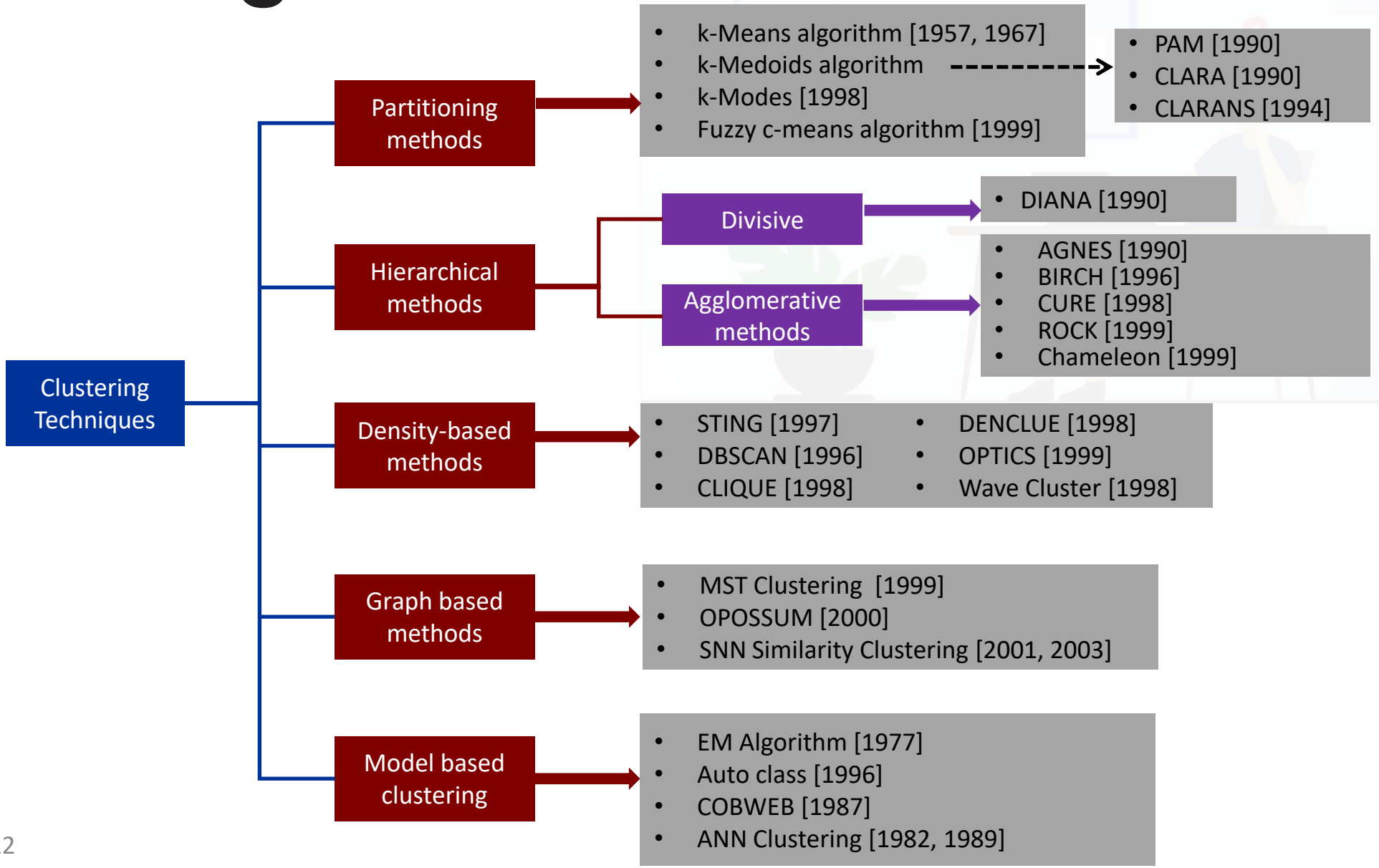
Clustering

Partitioning a dataset ***D*** of ***n*** objects into a set of ***k*** clusters, such that the sum of squared distances between every object and the cluster centroid c_i is minimized

The below data set has three natural groups of data points, i.e., 3 natural clusters.



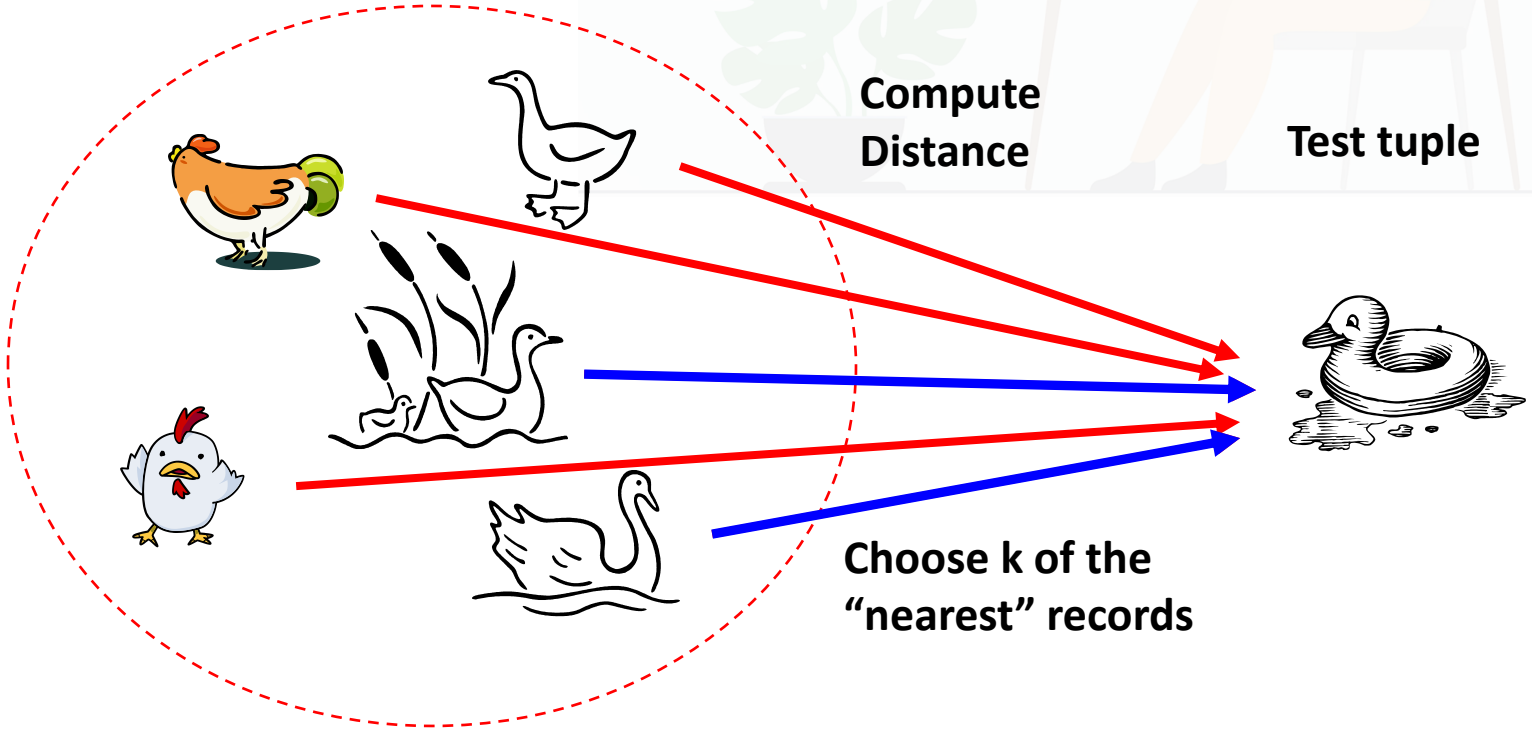
Clustering


Clustering Techniques
Partitioning methods
k-Means algorithm [1957, 1967]
k-Medoids algorithm
k-Modes [1998]
Fuzzy c-means algorithm [1999]
PAM [1990]
CLARA [1990]
CLARANS [1994]
Hierarchical methods
Divisive
DIANA [1990]
Agglomerative methods
AGNES [1990]
BIRCH [1996]
CURE [1998]
ROCK [1999]
Chameleon [1999]
Density-based methods
STING [1997]
DBSCAN [1996]
CLIQUE [1998]
DENCLUE [1998]
OPTICS [1999]
Wave Cluster [1998]
Graph based methods
MST Clustering [1999]
OPOSSUM [2000]
SNN Similarity Clustering [2001, 2003]
Model based clustering
EM Algorithm [1977]
Auto class [1996]
COBWEB [1987]
ANN Clustering [1982, 1989]

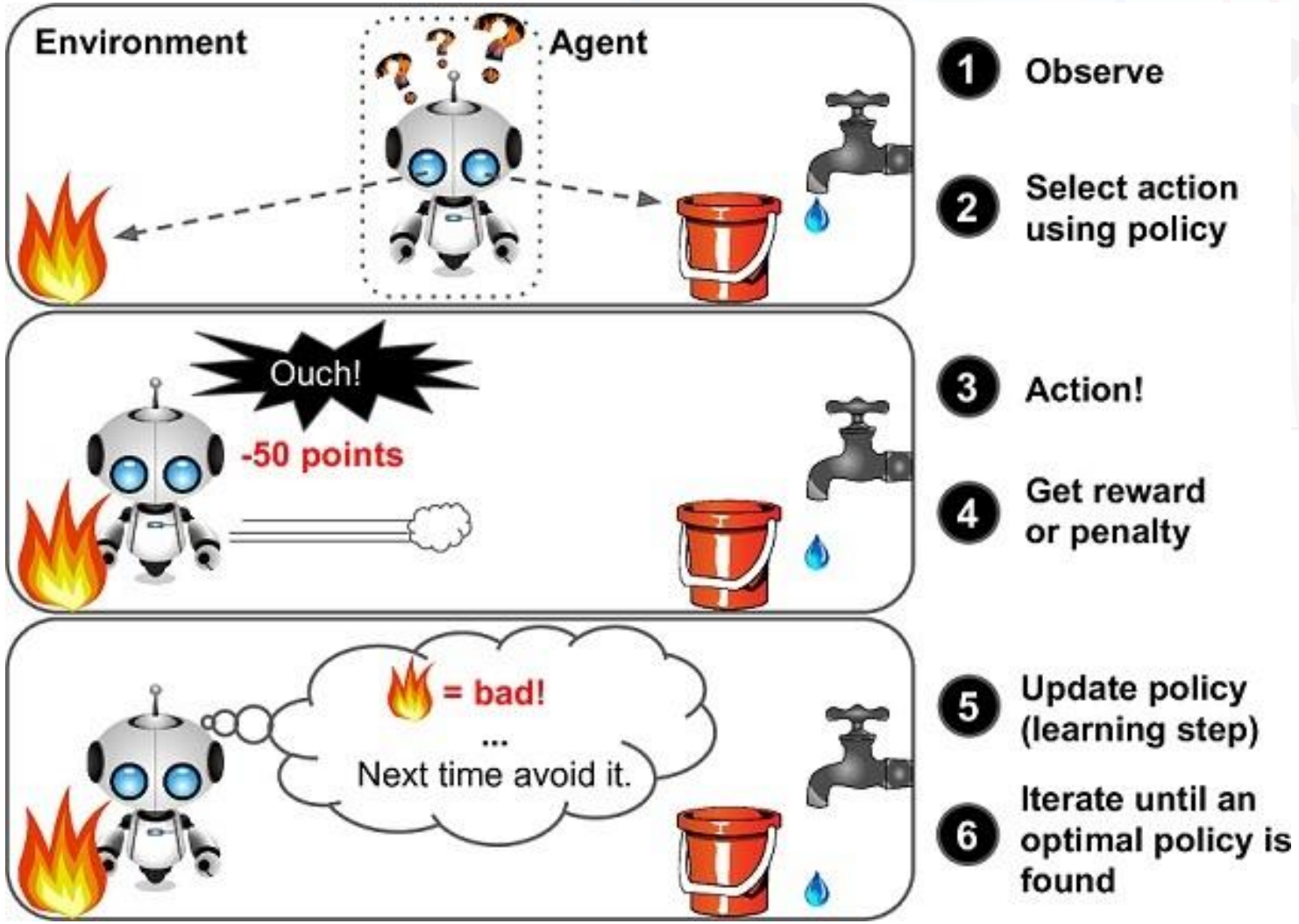
k-Nearest Neighbors

Basic idea:

If it walks like a duck, quacks like a duck, then it's probably a duck

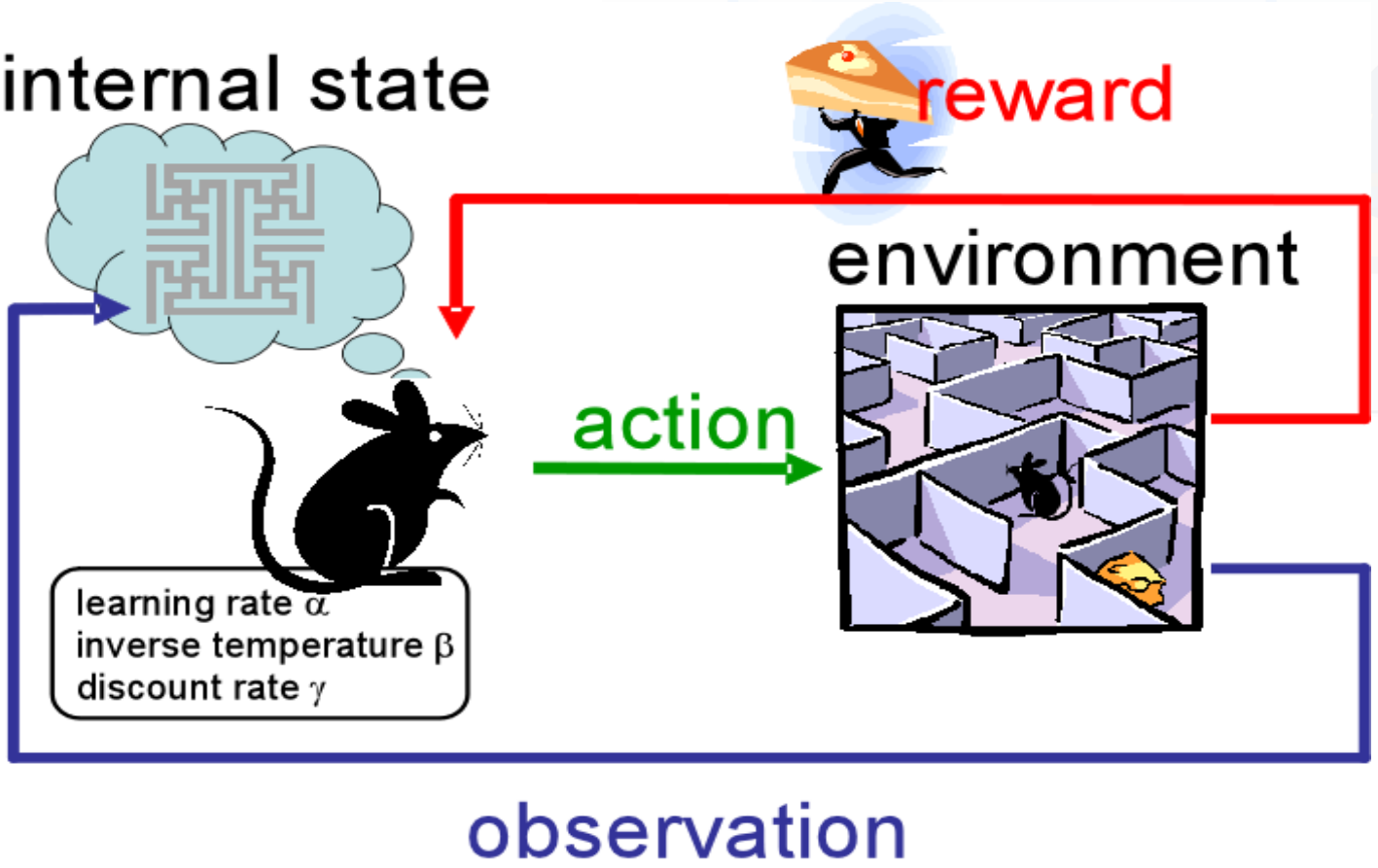


Reinforcement Learning



https://www.marutitech.com/businesses-reinforcement-learning/

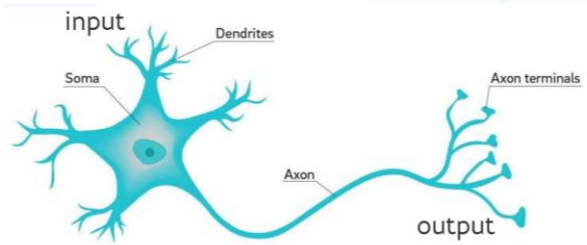
Reinforcement Learning

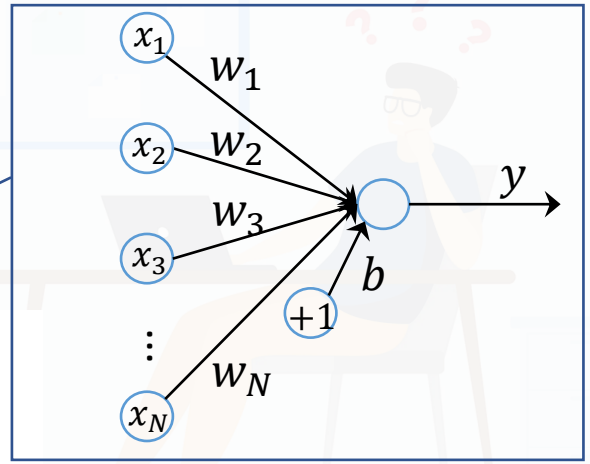


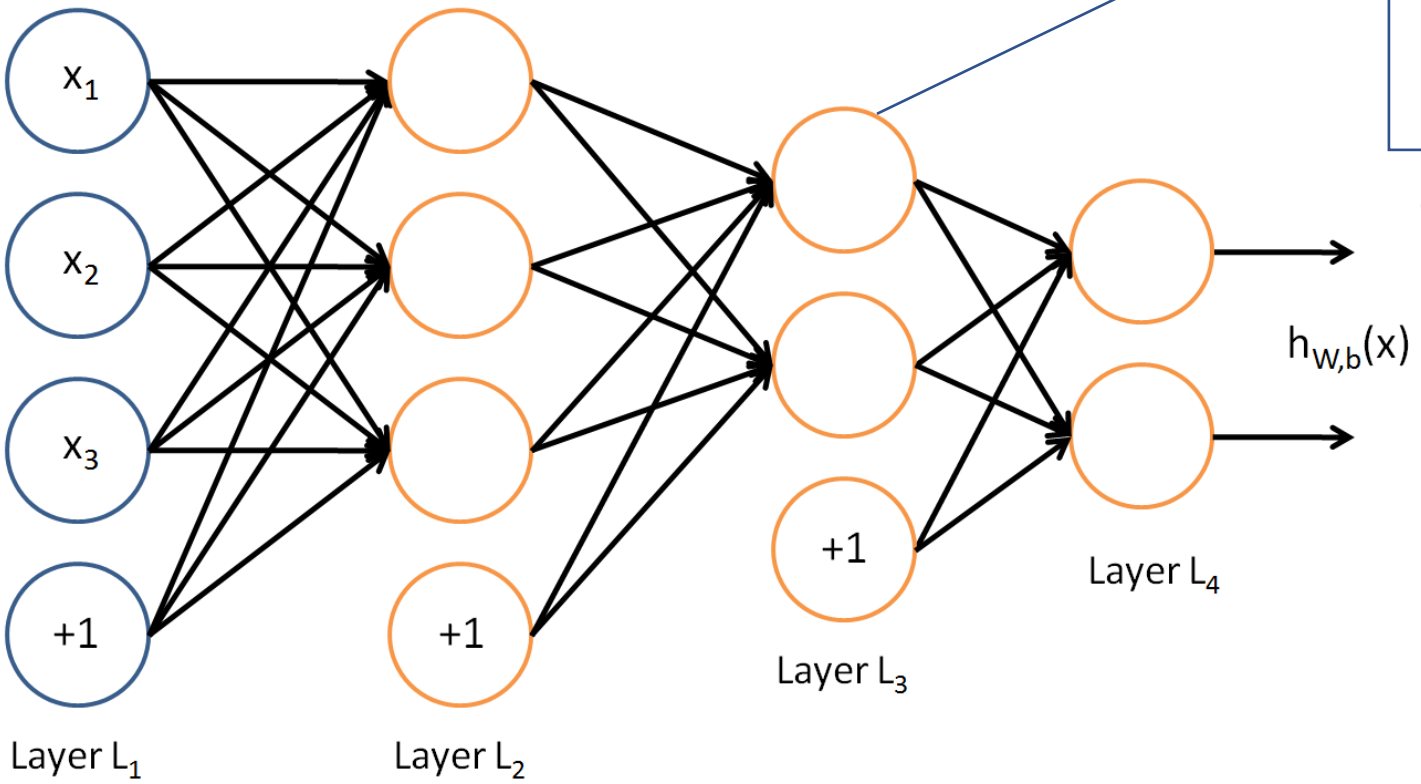
https://becominghuman.ai/the-very-basics-of-reinforcement-learning-154f28a79071

Artificial Neural Networks

inspiration



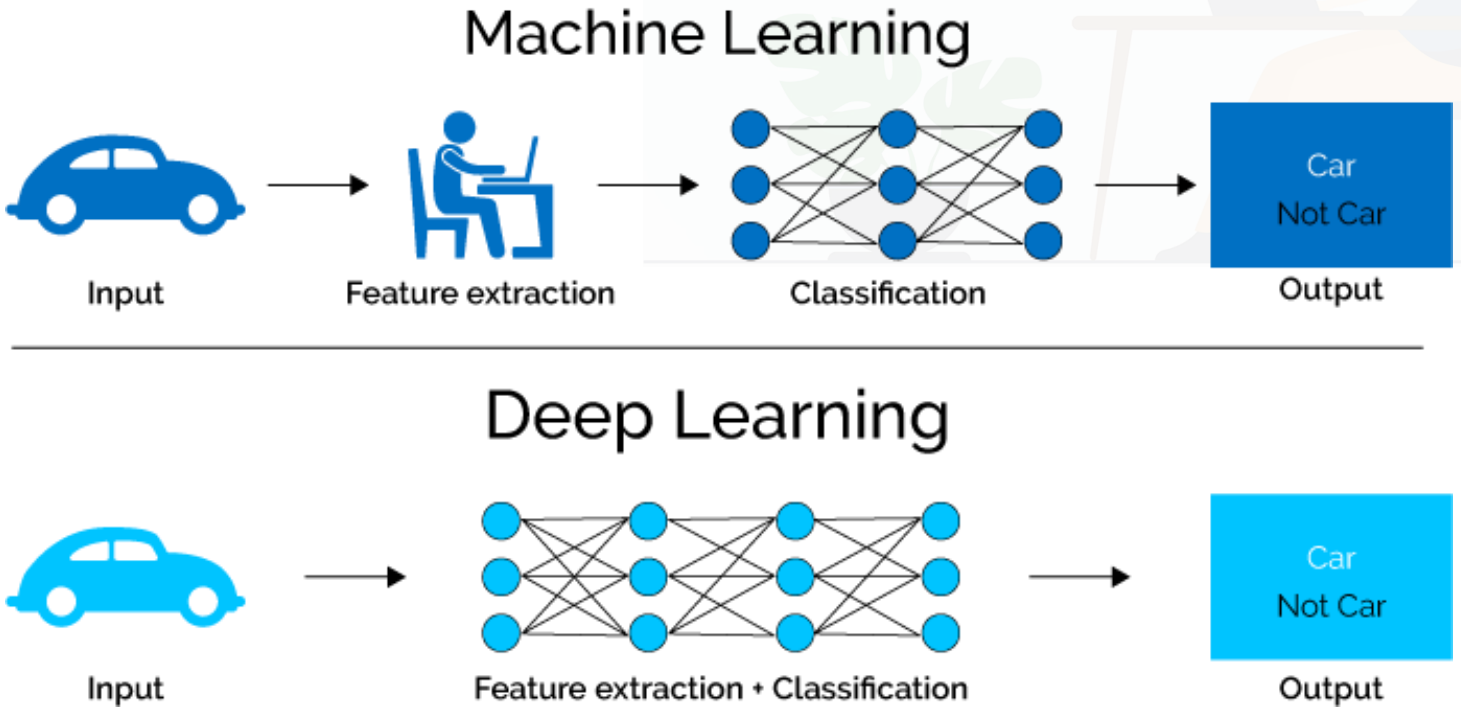




Target: determine weights based on the training dataset

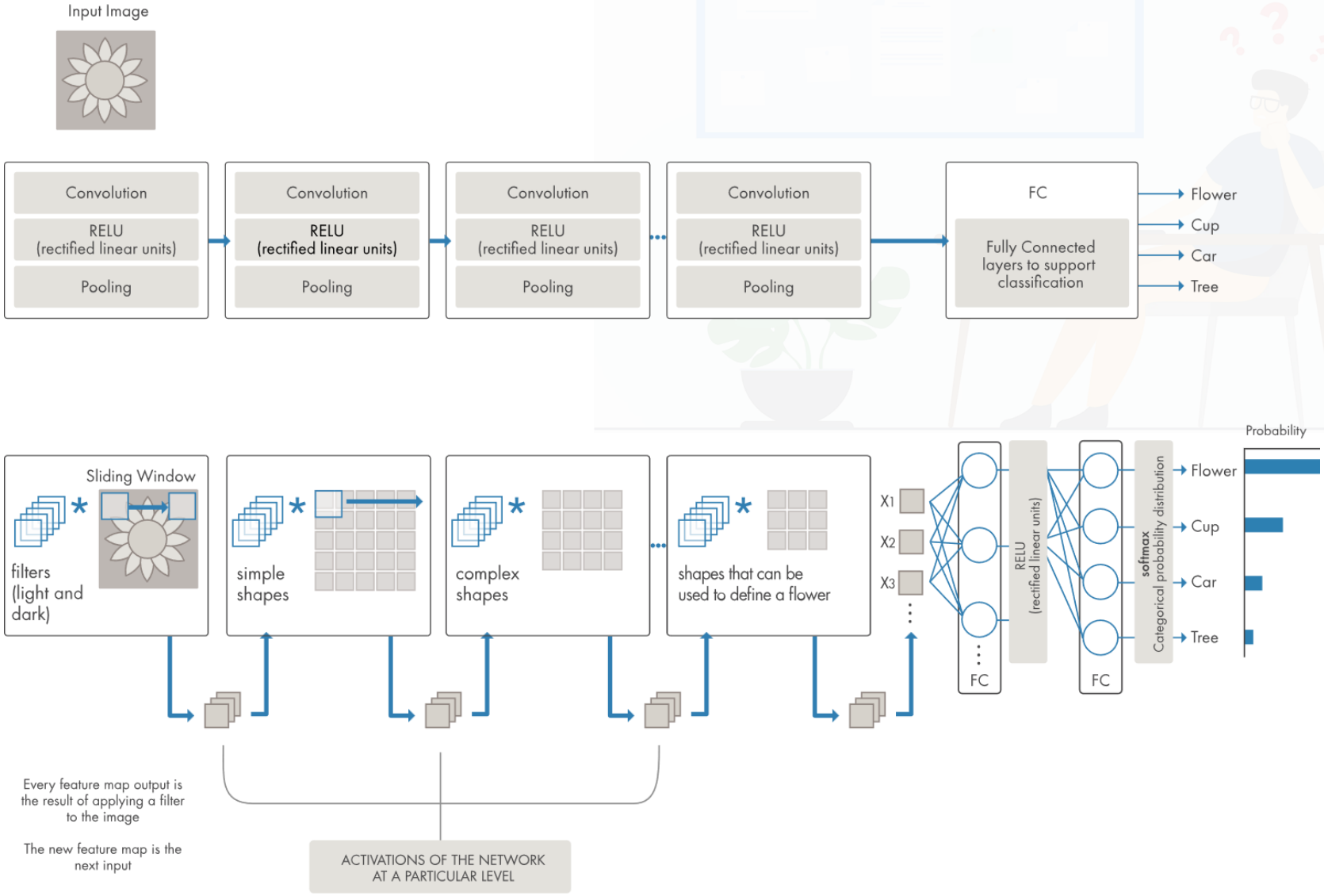
Deep Learning

- Deep learning algorithms attempt to learn (multiple levels of) representation by using a **hierarchy of multiple layers**
- If you provide the system **tons of information**, it begins to understand it and respond in useful ways.



http://www.nitttrc.edu.in/nptel/courses/video/106102220/lec89.pdf

Deep Learning: Example



https://www.mathworks.com/discovery/deep-learning.html

Part C
AI in Education: Opportunities

Potential Uses

Activities Automation, e.g., grading, students feedback generation

Adaptation to Students' needs

Analysis of education activities to point out where courses need improvement

AI-driven programs can deliver useful feedback

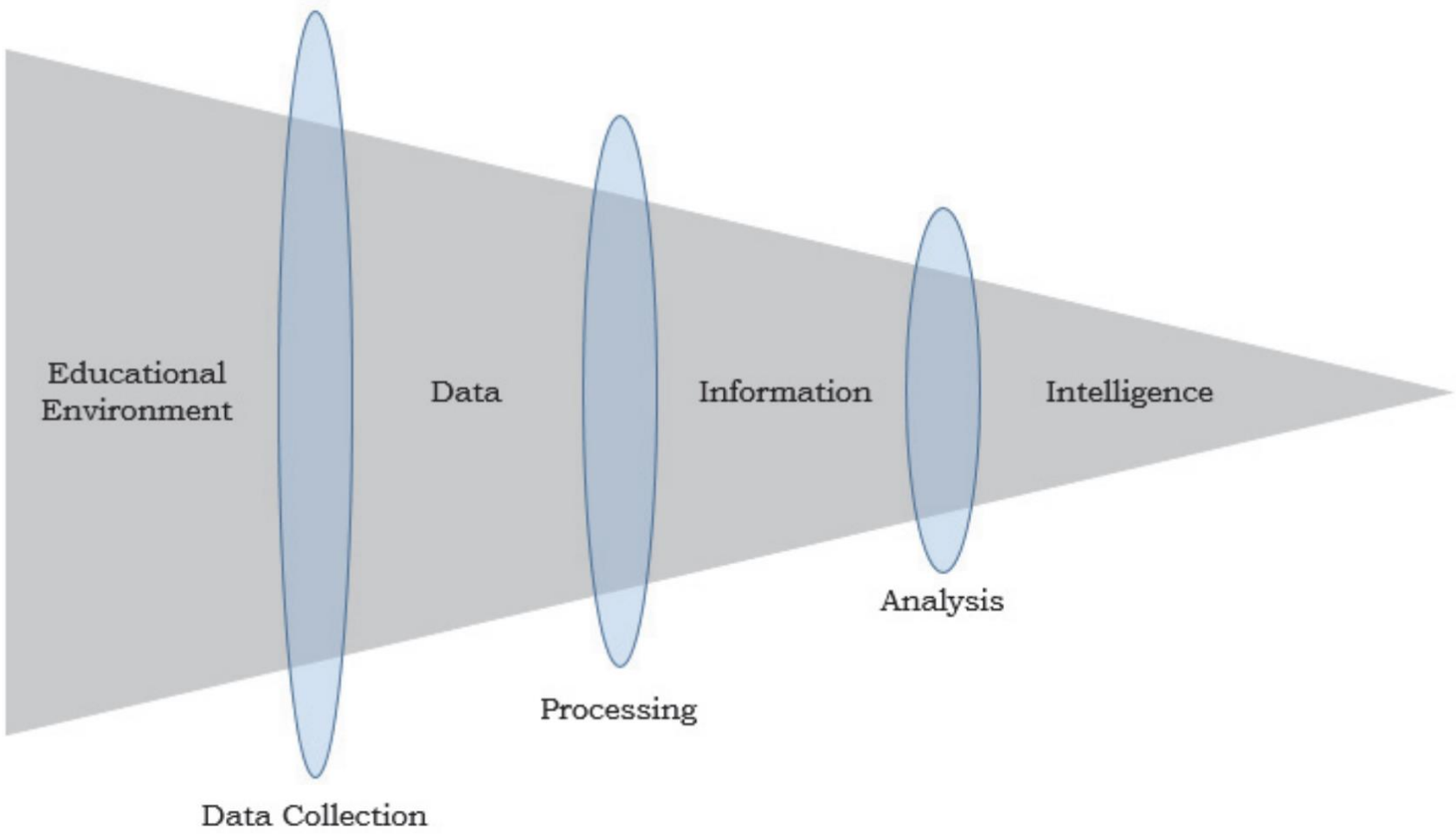
Personalized/individualized learning

Adaptation to changing learning habits

Analysis of a high number of 'distributed' data related to the educational process

Spread of online education

Analytics



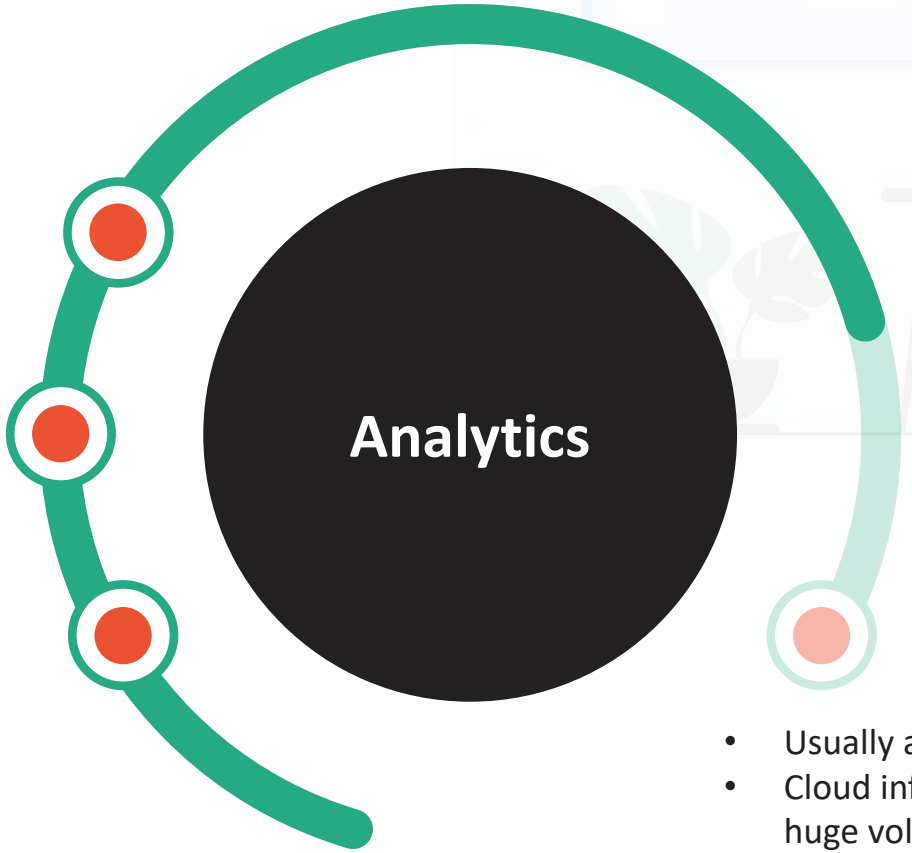
https://onlineinnovationsjournal.com/download/07ea372322ccb0f5.pdf

Analytics

Behaviour Analysis
- Upon multiple type of resources
- Upon one type of resource

Learning Content
- Node link diagrams
- Keywords

Students' Interaction
- Behaviour analysis
- Interaction content analysis



Trends, patterns, Visual graphs, etc

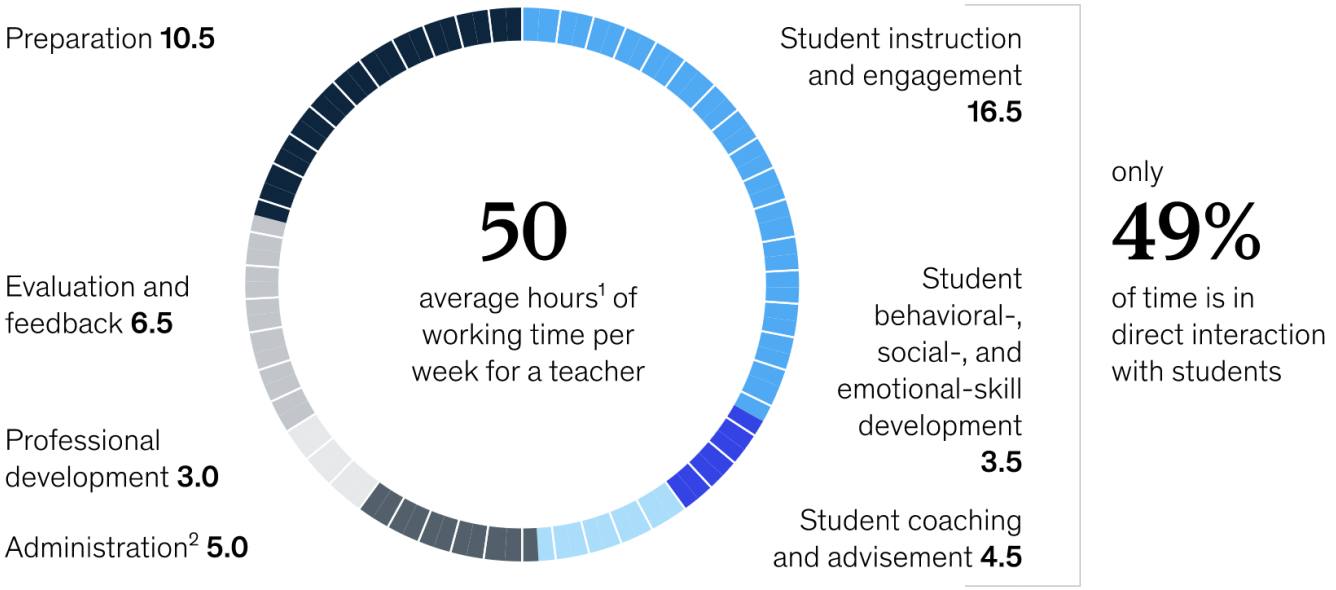
- Usually adopted for online learning
- Cloud infrastructure is necessayr to process huge volumes of data (especialy when 'distributed' datasets are the case)
- Real-time processing is also necessary to support live educational activities

A survey can be found in Xiaoyan Kui, et. al., A survey of visual analytics techniques for online education, Visual Informatics, 2022, https://doi.org/10.1016/j.visinf.2022.07.004

Tasks Automation

Teachers work about 50 hours a week, spending less than half of the time in direct interaction with students.

Activity composition of teacher working hours, number of hours



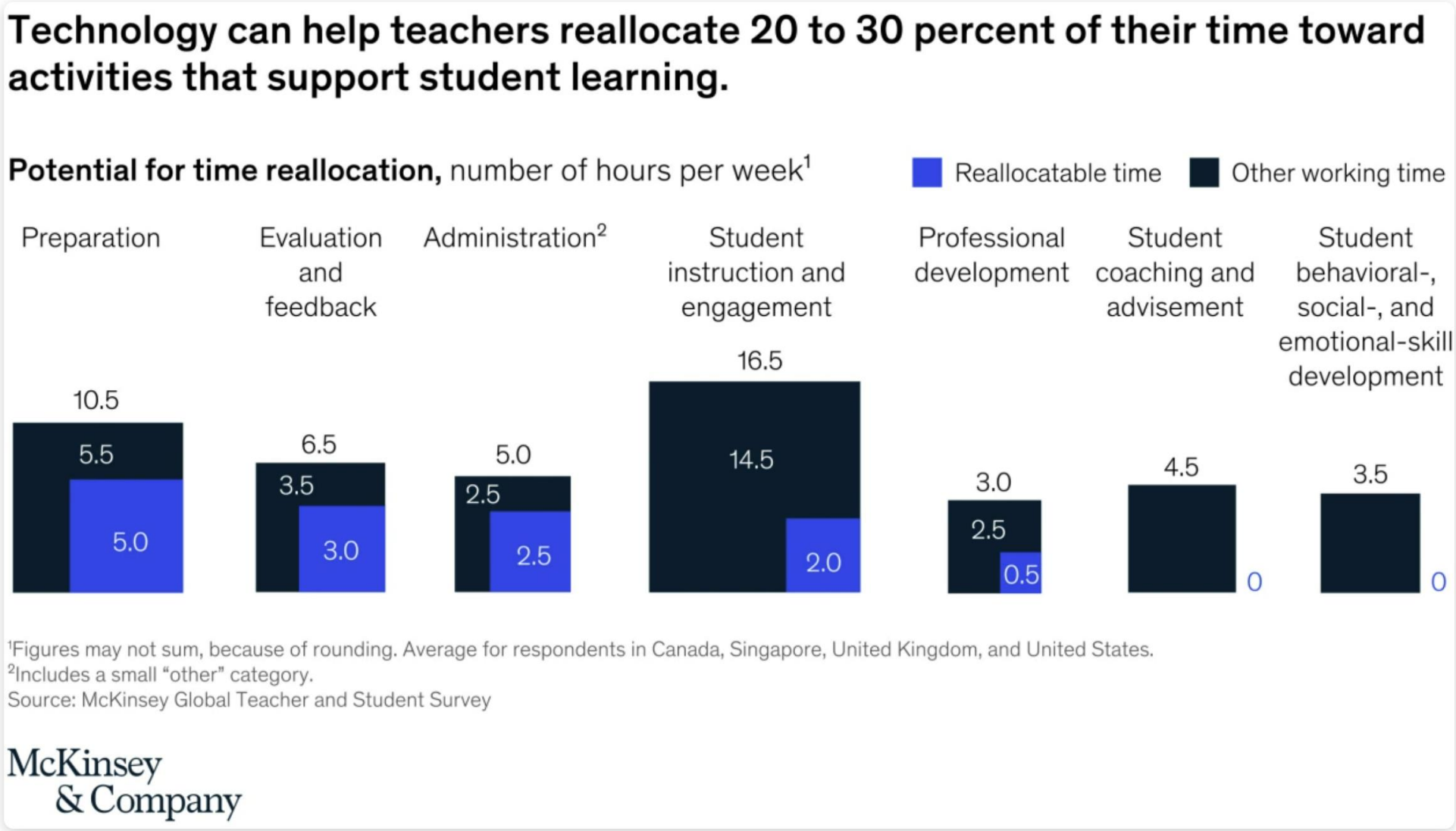
[1]1 Average for respondents in Canada, Singapore, United Kingdom, and United States.
[2]Includes a small "other" category.
Source: McKinsey Global Teacher and Student Survey

McKinsey & Company

** The Telegraph survey (https://www.telegraph.co.uk/news/2019/07/21/teachers-spend-time-marking-planning-classroom-ofsted-survey/) claims that teachers spend up to 31% of their time planning lessons, grading tests, and doing administrative work*

https://www.mckinsey.com/industries/education/our-insights/how-artificial-intelligence-will-impact-k-12-teachers

Tasks Automation



https://www.xredu.tech/new-blog-content-creators/2021/3/3/the-growing-future-of-ai-task-automation-in-education

Tasks Automation

Administration Work

Scheduling, rescheduling of classes, marking attendance, grading papers, finance and accounting, etc

Grading Software

- AI-powered software combines ML to create calculating systems
- Templates may be used for papers

Data Collection

Collect data on metrics for grading assignments

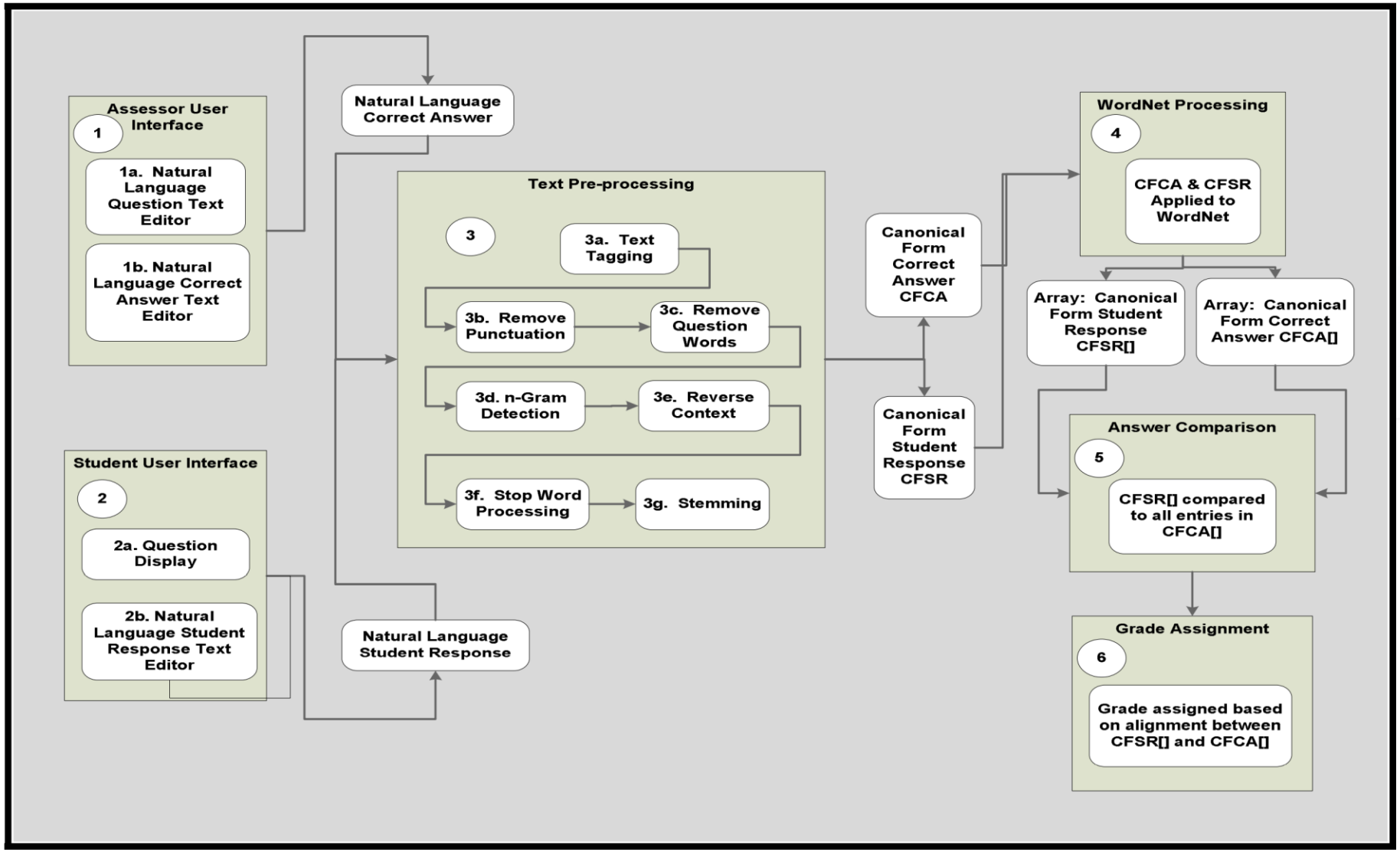
Teachers

- Their approach should be replicated
- Teachers' inputs and AI can grade essays, papers and tests very fast
- Such software may grade in different languages (use of Natural Language Processing - NLP

AI can assist in:

- Correspondence to parents automatically
- Automate routine students forms, enrollments, etc
- Shorten the time spent on progress reports (NLP, pre-filling, etc)
- Grade papers and essays
- Save time for teachers to focus on the core educational activities

Tasks Automation: Example



L. A. Cutrone and M. Chang, "Automarking: Automatic Assessment of Open Questions," 2010 10th IEEE International Conference on Advanced Learning Technologies, 2010, pp. 143-147, doi: 10.1109/ICALT.2010.47.

Smart Content Creation

AI in education can start with question-answer pairs used for texting or training, and end with complex study environments

Smart content can range from digital textbooks, guides, instructional snippets, videos to AI tools that create customized environments based on strategies and goals

Learning Objects

They are any items which have the potential to promote learning

Units of Learning

They range between 2 and 15 minutes

Discrete Nature

They can be stored independently being self-contained

Re-usability

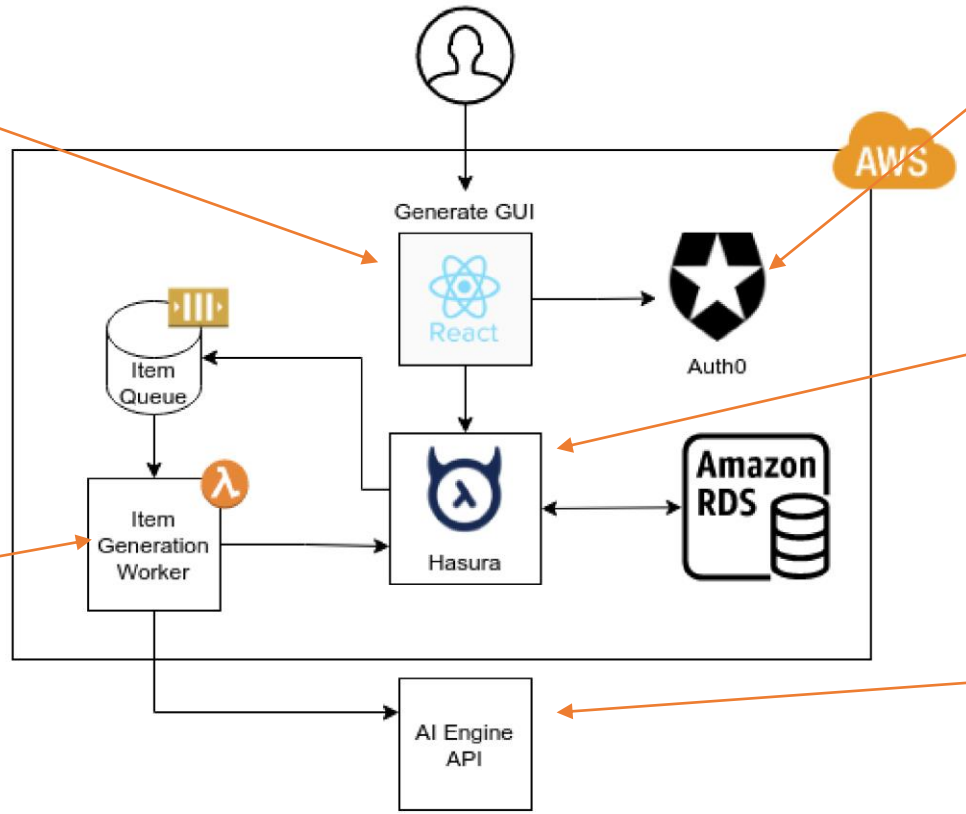
They may be used in multiple contexts for multiple purposes

Schools can create AR/VR based learning environments and web-based lessons accompanied by AI Monitoring and Evaluation tools that can streamline content for different learning styles and match pace with diverse learning curves

Smart Content Creation: Example

Generate: A Natural Language Generation (NLG) for content creation

React Javascript-based graphical user interface
Users can select pre-uploaded AI models, generate an item, visualize and edit the item and visualize metrics



The **authentication platform**, a third party service specialized in secure authentication and authorization

Hasura connects the GUI with the database and the serverless services

The **item generation services** are responsible for interfacing with the NLG engine

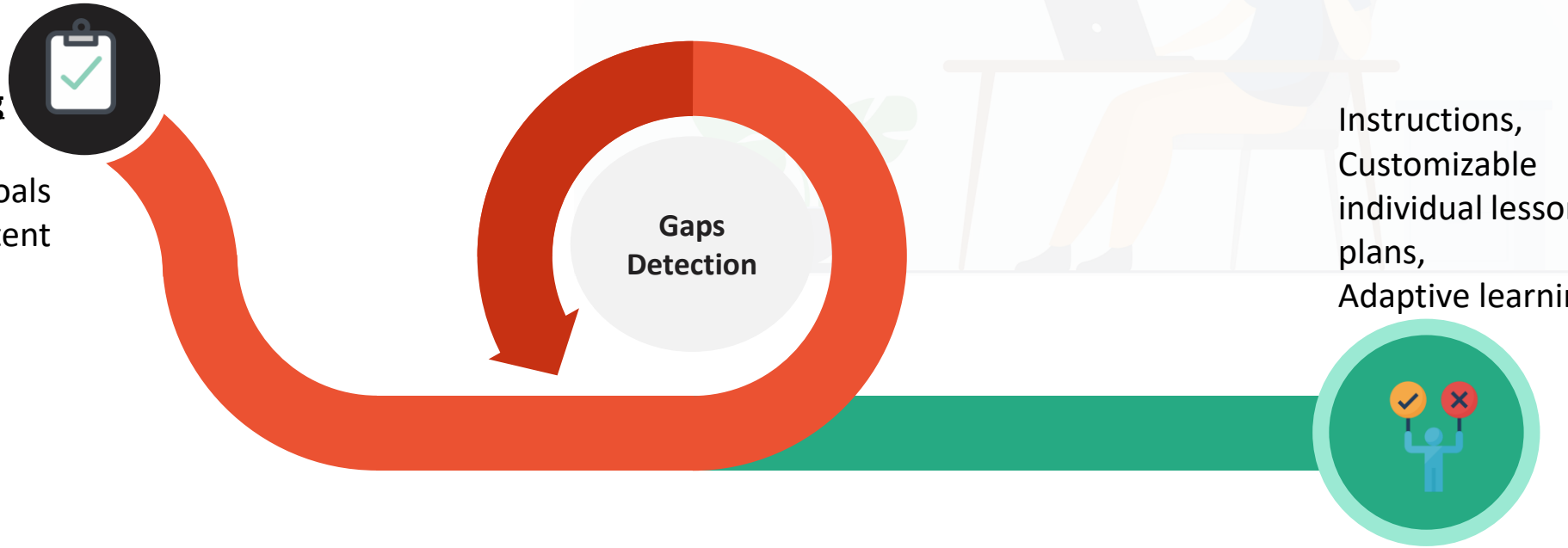
The **NLG engine** is responsible for generating content based on the model provided

Users provide specifications of the desired content, i.e., a content map of item types and topics to be generated, user-specific writing guidelines, etc

Khan, S., Hamer, J., Almeida, T., Generate: A NLG system for educational content creation, Proc. Of the 14th International Conference on Educational Data Mining, 2021.

Personalized Learning

A personalized system of education is designed to **recognize** and **analyze** the i**ndividual-specific learning abilities**, learning **requirements**, and study goals so as to customize the content



Personalized Learning

Personalized Learning Spaces

- ✓ Virtual operating medium to provide massive access
- ✓ Anyone can learn from everywhere

Recommendations

- ✓ Individualized learning plans
- ✓ Decisions upon Educational Data Mining results

Intelligent Tutors

- ✓ **Intelligent Tutoring Systems (ITSs)**
- ✓ Learning companions, **Augmented/Virtual Reality**

Interactions

- ✓ Receive feedback, analyze and understand the requirements of learners
- ✓ Predictive algorithms for selecting suitable learning choices

- Aditi Bhutoria, Personalized education and Artificial Intelligence in the United States, China, and India: A systematic review using a Human-In-The-Loop model, Computers and Education: Artificial Intelligence, Volume 3, 2022
- D. Hopkins, Personalized Learning in School Age Education, International Encyclopedia of Education (Third Edition), Elsevier, 2010, Pages 227-232

Personalized Learning: Examples

Knowji

Audio-visual vocabulary application

It is designed for language learners.

It tracks each word's progress and can predict when users are likely to forget

CENTURY

Century Tech

It utilizes cognitive neuroscience and data analytics to construct personalized plans

Personalized plans reduce work for instructors, freeing them up to focus on other areas

The AI platform tracks student progress while pointing out knowledge gaps

It provides personal study recommendations and feedback

Knewton
A Wiley Brand

Knewton's Alta

It combines adaptive learning technology with openly available content

It provides all required content for a course or multiple courses

NUANCE

Nuance's Dragon

Adopted to dictate lesson plans, syllabi, worksheets, reading lists, etc

It achieves 99% accuracy

Intelligent Tutoring Systems

Aim 1
Provide sophisticated instructional advice better than conventional computer-aided instruction

Aim 2
Develop and test models about the cognitive processes involved in instruction

The 'intelligence' comes from the application of AI in four interacting components

ITS

An intelligent tutoring system (ITS) is a computer system that aims to provide immediate and customized instruction or feedback to learners, usually without requiring intervention from a human teacher

P. Sedlmeier, Intelligent Tutoring Systems, International Encyclopedia of the Social & Behavioral Sciences, Pergamon, 2001, Pages 7674-7678

Intelligent Tutoring Systems

Architecture

Knowledge Base

It contains declarative (knowing what) and procedural (knowing how) knowledge

Student Model

It represents the student's current state of knowledge, concepts, and skills acquired either fully or partially
It also includes the representation of skills and needs

Pedagogical Module

It determines the presentation method, the balance of tutor and student control;
How to deal with student errors, e.g., when to interrupt and what to say

User Interface

The best solution would be for the student to communicate with the ITS in natural language
This, unfortunately, is not possible to date
Solutions to this problem include multiple choice selection, and the almost exclusive use of graphical interfaces

ITSs: Examples

CARNEGIE LEARNING

MATHia

- It gives a math experience providing the real-time feedback and assessments to students
- It is designed to provide individual student support and insightful data

ASSISTments

- It is a formative assessment math platform that provides real-time feedback for students and actionable learning data for teachers

toppr

- It uses machine learning to process student responses
- It provides personalized questions and adjusts the speed of presentation to optimize the experience for each student

area9 LYCEUM

- It recreates learning content and delivers it on a platform which uses a 'continuous self-assessment'
- User's confidence in the provided responses are adopted as part of the adaptive process

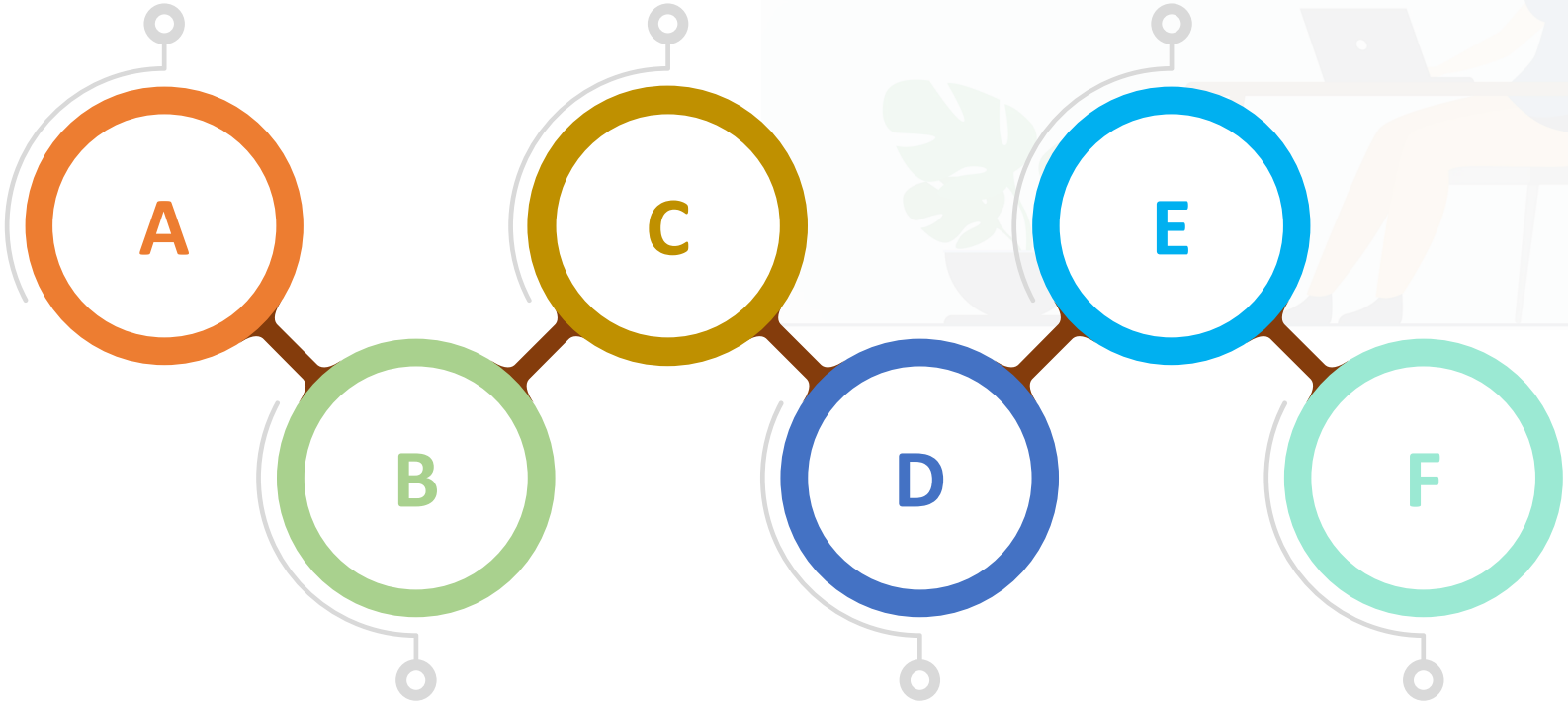
A relevant book is: Charles Fadel Wayne Holmes, Maya Bialik, Artificial Intelligence In Education: Promises and Implications for Teaching and Learning, 2019

Conversational AI

Conversational AI delivers intelligent tutoring by observing the pattern of content consumption

Increases Student Interactions

The virtual chat assistance can provide immediate answers to any student's query



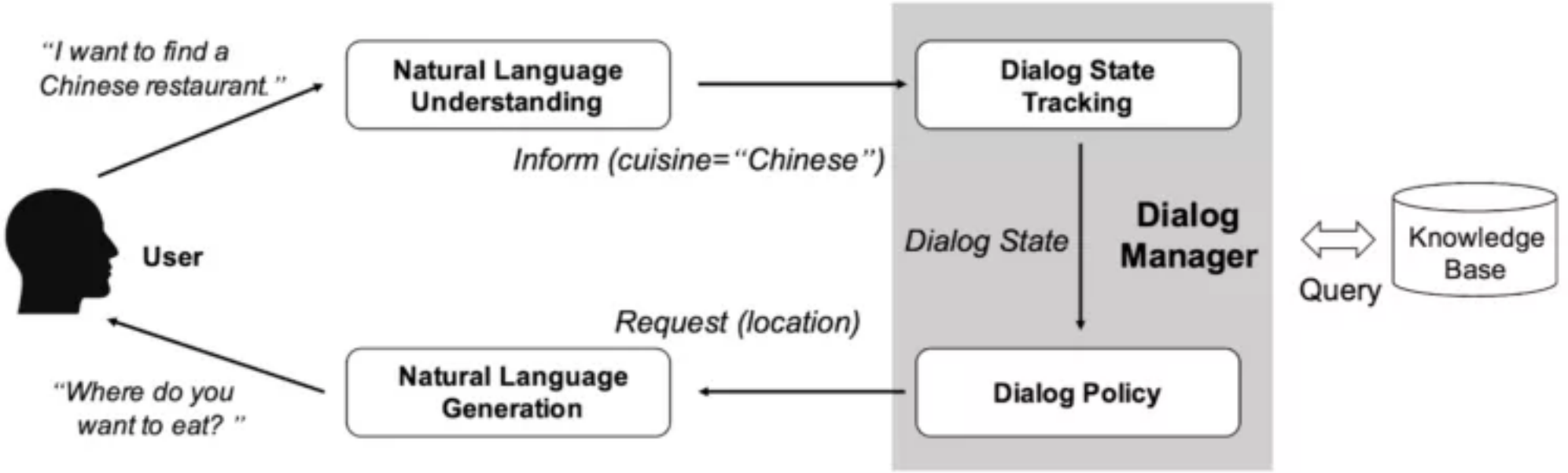
Chatbots are an example of how AI in education consumes data to inform itself and provide assistance

Ease everyday tasks, e.g., tasks allocation, rank tests, track project assignments, help teachers offer individually tailored messages, etc

The entire feedback process can be made interesting using conversational forms and automated replies

Conversational AI

Chatbot Architecture



- AI-enabled chatbots rely on NLP to scan users' queries and recognize keywords to determine the right way to respond
- Chatbots could also benefit from ML integration and so can self-improve through repeated interaction with users' data (as new training data) to expand the knowledge base and improve the relevancy and accuracy of their responses

https://research.aimultiple.com/chatbot-architecture/

Conversational AI: Examples

Cognii
Artificial Intelligence for Education

- Conversational technology assists students form open-format responses and improve critical thinking skills
- The virtual assistant provides one-on-one tutoring and real-time feedback customized to each student

HubSpot

- HubBot has the capability to answer basic questions per a pre-loaded script
- HubBot can also book meetings, integrate with the existing HubSpot CRM, and track communications
- It is geared to automate conversations

mongoose

Mongoose harmony is an intelligent chatbot and virtual assistant that is designed specifically for higher education

Ivy.ai

- Ivy is specifically designed for universities and colleges
- It assists in application forms, enrollment, tuition costs, deadlines, and more
- A unique feature is the ability to plan recruitment campaigns

IBM

IBM's Watson utilizes a technology referred to as Watson Conversation Service to expedite student responses, download and provide documents when needed, and answer subject-specific questions

aws

Amazon's QnABot prioritizes the idea that students should have quick access to institutional answers
Amazon's QnABot makes it easy to add features and functionality and even provide a platform for students to offer feedback

MSc
Educational Applications with STEM
Epistemology

(http://stem.cs.uth.gr - in Greek)

Curriculum

Semester 1

Course 1: Educational Applications using the STEM interdisciplinary approach; Types and indicators of assessment in STEM

Course 2: Computational Thinking in STEM Education; Computational Pedagogy; Physical quantities related to climate change and STEM epistemology

Course 3: Design of material in computational environments; Basic electronic and sensors used in STEM education; Engineering design process; Physical computing

Course 4: Digital objects and repositories; Virtual and Augmented Reality; Gamification

Semester 2

Course 1: Methodology of education research; Descriptive and inductive statistics

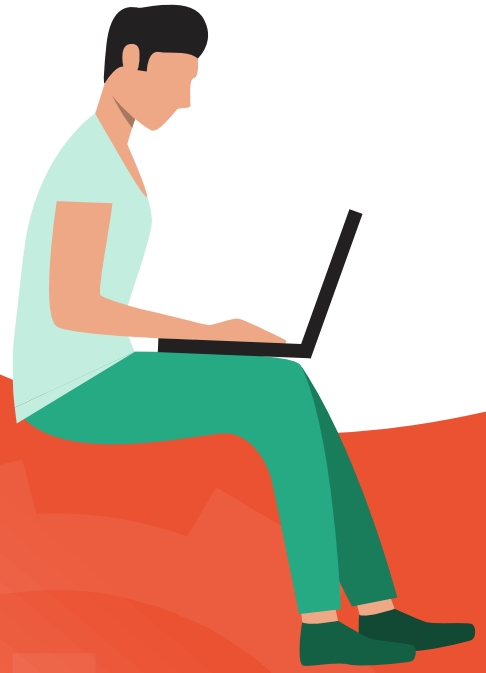
Course 2: Internet of Things (IoT) in Education; Principles and applications

Course 3: Artificial intelligence in Education

Course 4: STEM and Arts; Epistemology and applications

Semester 3

Master Thesis



THANK YOU

More Publications, Datasets, Presentations can be found at:

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http://www.iprism.eu

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