Sea EU – Marine Data Literacy Course
Application of AI to Oceanography

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Overview

Artificial Intelligence

What is Artificial Intelligence?

- Artificial Intelligence involves the development of "agents" that are capable of doing things that people normally associate with intelligence.

- AI techniques are increasingly utilised to solve problems that can not be solved using a purely "procedure based approach".
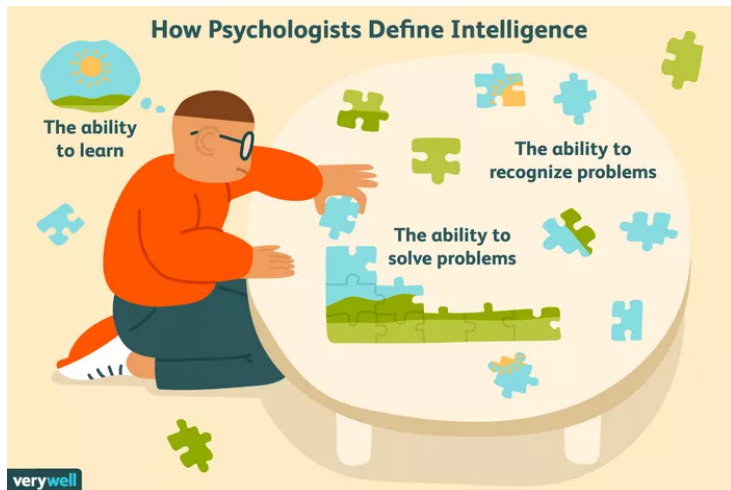
- But what constitutes intelligence?

Figure 1: from: https://www.verywellmind.com/theories-of-intelligence-2795035

Problems that require "Intelligence"

- Perceiving the environment.
    - Scene analysis; understanding speech/audio, understanding written text; ...
- Communicating with humans
- Learning, and learning how to learn
- Acquiring knowledge (including general knowledge)
- Representing knowledge
- Reasoning with information/knowledge to derive new knowledge
- Interacting with the environment
- Planning/Problem Solving

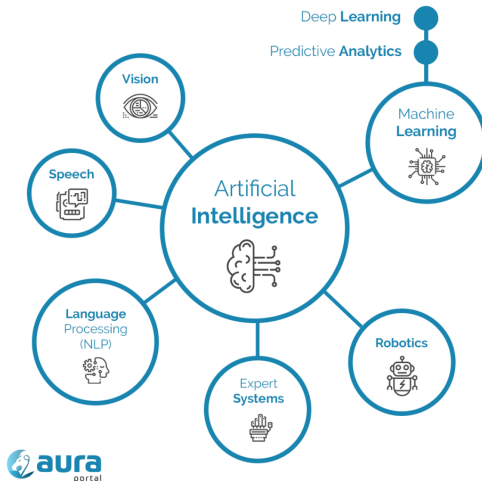Figure 2: From: https://www.auraquantic.com/what-is-hyperautomation/

Typical AI Applications

- Prediction

- Business Intelligence

- Big Data and Data Mining

- Decision Support

- Diagnosis

Typical AI Applications

- Recommender Systems

- Robotics

- Route planning/timetabling/scheduling

- Fraud Detection

- Information Retrieval (for multimedia systems)

- NLP / Machine Translation

Philosophical Approaches to AI

Systems that think like humans Machines with minds, in the full and literal sense (Strong AI)	**Systems that think rationally** The study of mental faculties through the use of computational models. The study of the computations that make it possible to perceive, reason, and act. (Logic)
Systems that act like humans The study of how to make computers do things that, at the moment, people are better. The art of creating machines that perform functions that require intelligence when performed by people. (Turing Test)	**Systems that act rationally** Computational intelligence is the study and design of intelligent agents. Intelligent behaviour in artifacts (Weak AI)

Figure 3: Adapted from:
`http://www.math.uaa.alaska.edu/~afkjm/cs405/handouts/intro.pdf`

Strong vs *Weak* AI

- **Artificial General Intelligence** – intelligence of a machine/robot that is able to perform any intellectual task that a normal human can do.
    - Also known as **Strong AI** and **Full AI**

- **Applied AI** –intelligent systems that perform reasoning to accomplish specific tasks.
    - Does not simulate the full scale of human cognitive abilities.
    - E.g. Game playing

Tests for General AI

- **Turing Test** – ability to communicate with a human who will not realise that the other end is a robot/machine

- **Coffee Test** – machine/robot needs to be able to enter a home and brew coffee.

- **Robot College Student Test** – machine needs to be able to enrol at a college, take classes and exams, and obtain a degree.

- **Employment Test** – machine is given an economically important job and it performs at least as well as a human would.

Machine Learning

Conventional Programming

- A program is the set of instructions for a computer to perform a particular task.
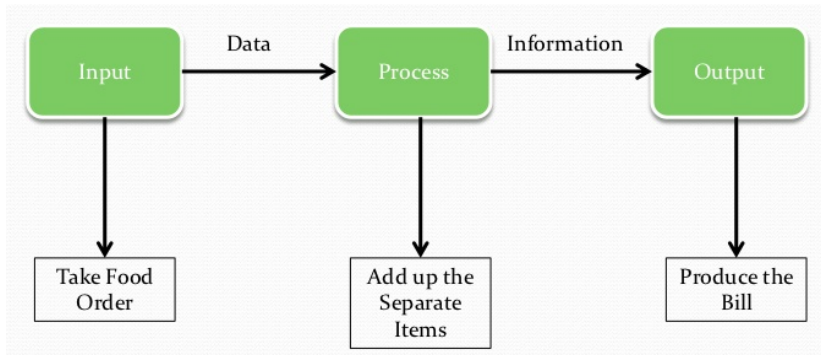- Consider the scenario below:

Figure 4: Adapted from: `https://pt.slideshare.net/shiplakeict/data-and-information-input-process-and-output/9`

Limitations of Conventional Programming

- In the previous scenario, the system needs to be programmed to add items together.

- Imagine if we do not know how to instruct the computer to solve certain problems
    - Detect spam from incoming mail
    - Identify fraudulent transactions.
    - What are the pre-conditions leading to a certain result?
    - Recommend *interesting* items to a user.
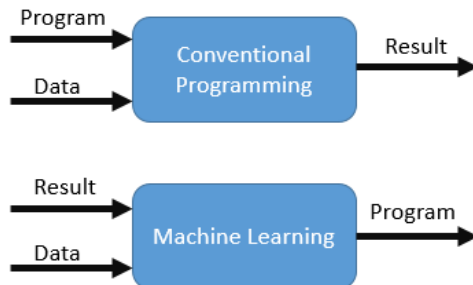
- This is where Machine Learning (ML) comes in.

Machine Learning

Figure 5: From: https://medium.com/@rstefanus16/
conventional-programming-vs-machine-learning-a3b7b3425531

- The machine 'learns' the model by itself.

Figure 6: Adapted from:
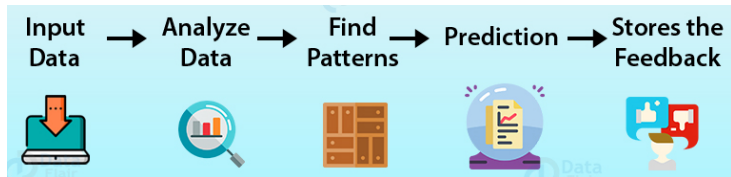`https://data-flair.training/blogs/machine-learning-tutorial/`

Machine Learning Types

Figure 7: Adapted from:
https://data-flair.training/blogs/machine-learning-tutorial/

Machine Learning Applications in Oceanography
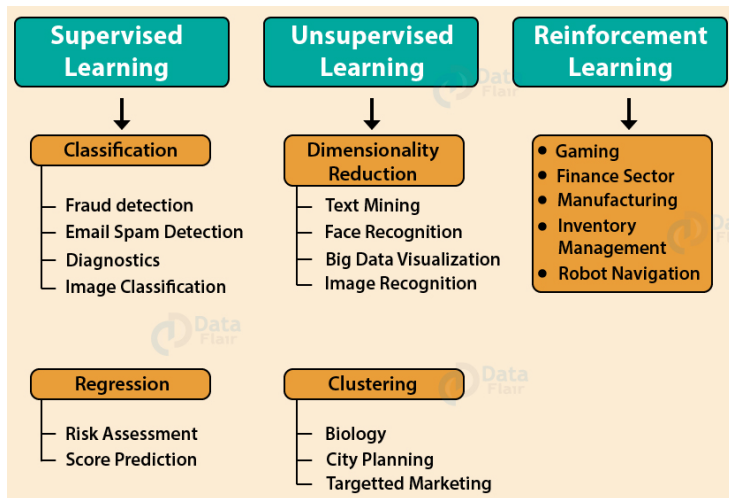
- Clustering
  - Identifying different zones (spatial clustering)
  - Identifying regimes (temporal clustering)

- Prediction/Regression
  - Gap filling
  - Short term forecasting

Big Data and Data Mining

Data Mining

- Analysing data from different perspectives to extract *useful* information.

- Discovery of new knowledge, and useful and meaningful relationships between data items from sources that do not explicitly contain that knowledge

- The discovered information can be used to increase profit, increase public interest, test out hypotheses etc.

Figure 8: From: https://www.quora.com/How-big-is-the-Big-data

https://www.youtube.com/watch?v=EH3bp5335IU

Big Data/Data Mining Applications in Oceanography

- Trend Detection
  - Discovery of pollution sources.

- Anomaly Detection
  - Detection of anomalous ship routes
  - Identifying extreme events

- Association Rule Mining
  - Identify how different variables/events are associated with each other.
  - Teleconnection Discovery

The Data Mining Process

Process Steps in Data Mining

1. Data Acquisition – downloading, aggregation, ...

2. Pre-Processing – converting the data into a logical representation.

3. Knowledge Discovery – the logical representation is analysed and new useful knowledge is discovered.

4. Validation of Discovered Knowledge – using measures such as frequency filters, support and confidence metrics.

5. Data Visualisation.

Main Challenges Involved

- Efficiency, especially when applied to the World Wide Web.
  - In some cases, the possible search space must be reduced drastically to be able to perform some mining techniques that may be computationally expensive.

- Problems in the original data set.
  - noise/errors in dataset
  - missing data due to cloud cover / interference

- Correctness of extracted relationships.

Figure 9: Screenshot from: `https://observablehq.com/@d3/gallery`

Applying AI to Oceanography

Data Availability for AI

- AI requires huge amounts of data

- Today, one can find:

    - Huge volumes of freely available data

    - Different types of data – models, observations, remote-sensed data

    - Data covering long periods of time (over 50 years)

    - Global or regional datasets

    - Data in high temporal and spatial resolution

    - Real time data

Use Case Example - SOSeas app

- https://marine.copernicus.eu/services/use-cases/
  soseas-assessment-tool-predicting-dynamic-risk-drowning-b

- Aims to reduce drowning and maritime accidents

- Uses AI to forecast risk assessment on beaches.

Figure 10: from: https://marine.copernicus.eu/services/use-cases/
soseas-assessment-tool-predicting-dynamic-risk-drowning-beaches

Some other AI Applications in Oceanography

- Text Mining
    - Identify events and relations from publications.
    - Extract organisation activity from reports.

- Personalised Recommendation
    - Identify the information/datasets required by a user at that time.

- Computer Vision
    - Sand type / organisation identification from images.

Conclusions

Conclusions

- What is Artificial Intelligence
  - What renders something intelligent
  - *Strong* vs *Weak* Intelligence

- Machine Learning
  - Conventional Programming vs Machine Learning
  - Supervised vs Unsupervised Learning

- Data Mining and Big Data
  - What is Data Mining and Big Data
  - The Data Mining Process
  - Problems and Challenges

- Applying AI to Oceanography
  - Available oceanographic data
  - AI Applications

Final points

- Importance of the sea around us, especially for small islands

- Data Economy – data represents value

- AI can help exploit the available data to render the ocean safer, clean, more sustainable and more valuable.