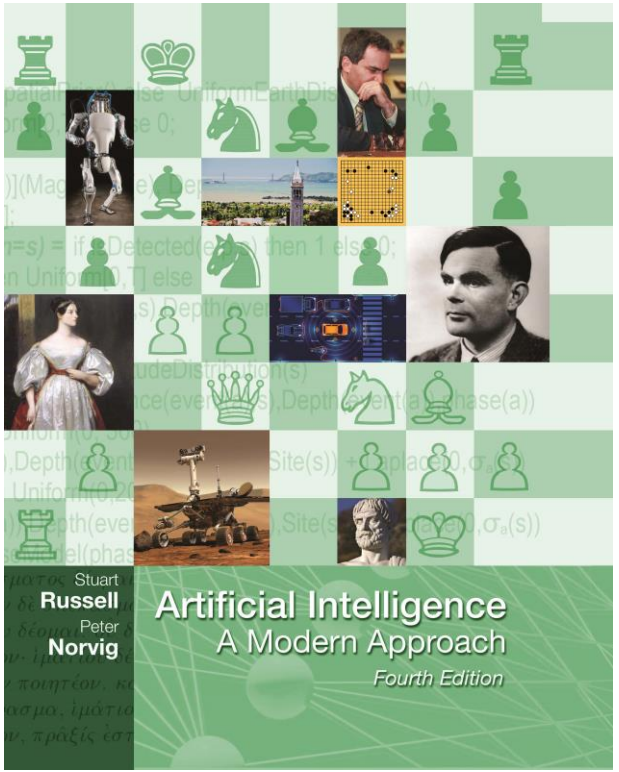
Course Description

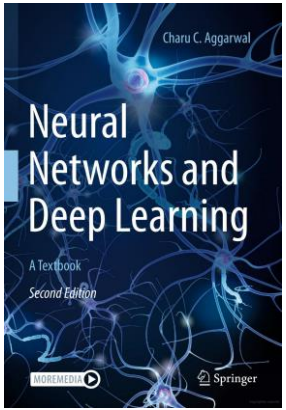
- **Main Textbook:**

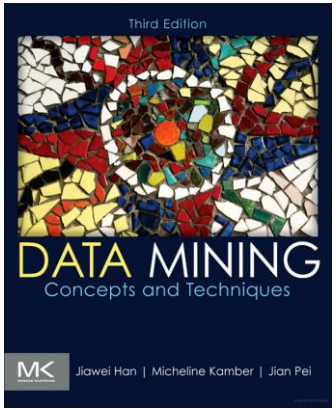
1-Artificial Intelligence; A Modern Approach - Fourth Edition

By Stuart J. Russell and Peter Norvig



- **Other textbooks:**





2-Neural Networks and Deep Learning: A Textbook by Charu C. Aggarwal

3-Data Mining: Concepts and Techniques by Jiawei Han

Course Description; Tools

- **Programming languages and Environment:**

Python Programming language in Google Colab or Kaggle notebooks. One can also use Jupyter Notebook.

We suggest to use a free web-based development environment like Google Colab which have built-in libraries.

- **Python libraries:**

Pandas, and NumPy data manipulation and analysis.

Matplotlib and Seaborn for visualizations.

Scikit-learn, TensorFlow, Statsmodels, etc. for implementing models.

✓ **Microsoft Power BI for Data visualizations.**

Course Description; Outlines

1. **Introduction to AI**
   - 1.1. What is AI?
   - 1.2. AI applications in industry
2. **Data analysis**
   - 2.1. Intro to Data Science(DS)
   - 2.2. Data / information / Knowledge Pyramid
   - 2.3. Types of data
   - 2.4. Statistical properties
   - 2.5. Data Visualization
3. **Machine Learning(ML)**
   - 3.1. Intro to ML
   - 3.2. Supervised learning
     - a) Regression
     - b) Classification
   - 3.3. Unsupervised learning
     - a) Clustering
     - b) Anomaly detection
     - c) Dimension reduction
   - 3.4. Reinforcement learning(RL)

Course Description; Outlines

4. Deep learning(DL)

- 4.1. Shallow artificial neural networks(ANNs)
- 4.2. Convolutional neural networks (CNNs)
- 4.3. Recurrent neural networks (RNNs)
- 4.4. Natural language processing (NLP)

5. Search Algorithms

- 5.1. Uninformed search algorithms (blind)
- 5.2. Informed search algorithms
- 5.3. Local search algorithms

6. Beyond ML and DL

- 6.1. Rule based expert system (ES)
- 6.2. Bayesian networks

What is Intelligence?

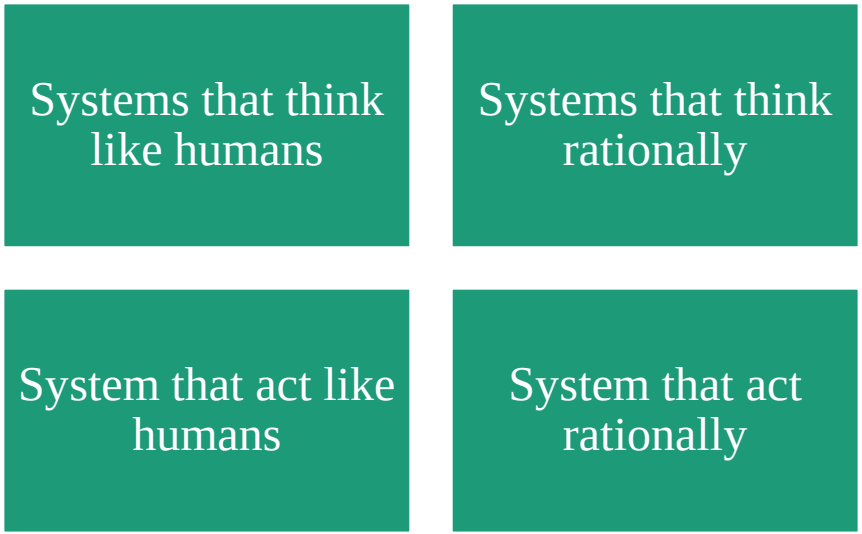
For thousands of years, we have tried to understand how we think and act—that is, how our brain can perceive, understand, predict, and manipulate a world far larger and more complicated than itself.

Some have defined intelligence in terms of fidelity to **human performance**, while others prefer an abstract, formal definition of intelligence called **rationality**—loosely speaking, doing the "right thing."

Some consider intelligence to be a property of **internal** thought processes and reasoning, while others focus on intelligent behavior, an **external** characterization.

What is Artificial Intelligence(AI)?

- From these two dimensions—human vs. rational and thought vs. behavior—there are **four possible combinations**.



- **Artificial intelligence** is the development and study of computing systems that address a problem associated with some form of intelligence.

Thinking humanly

- This is the cognitive modeling approach.

- If we say that a program thinks like a human, we must have some way of determining how humans think. We can learn about human thought in three ways:
  1. **introspection**—trying to catch our own thoughts as they go by;
  2. **psychological experiments**—observing a person in action;
  3. **brain imaging**—observing the brain in action.

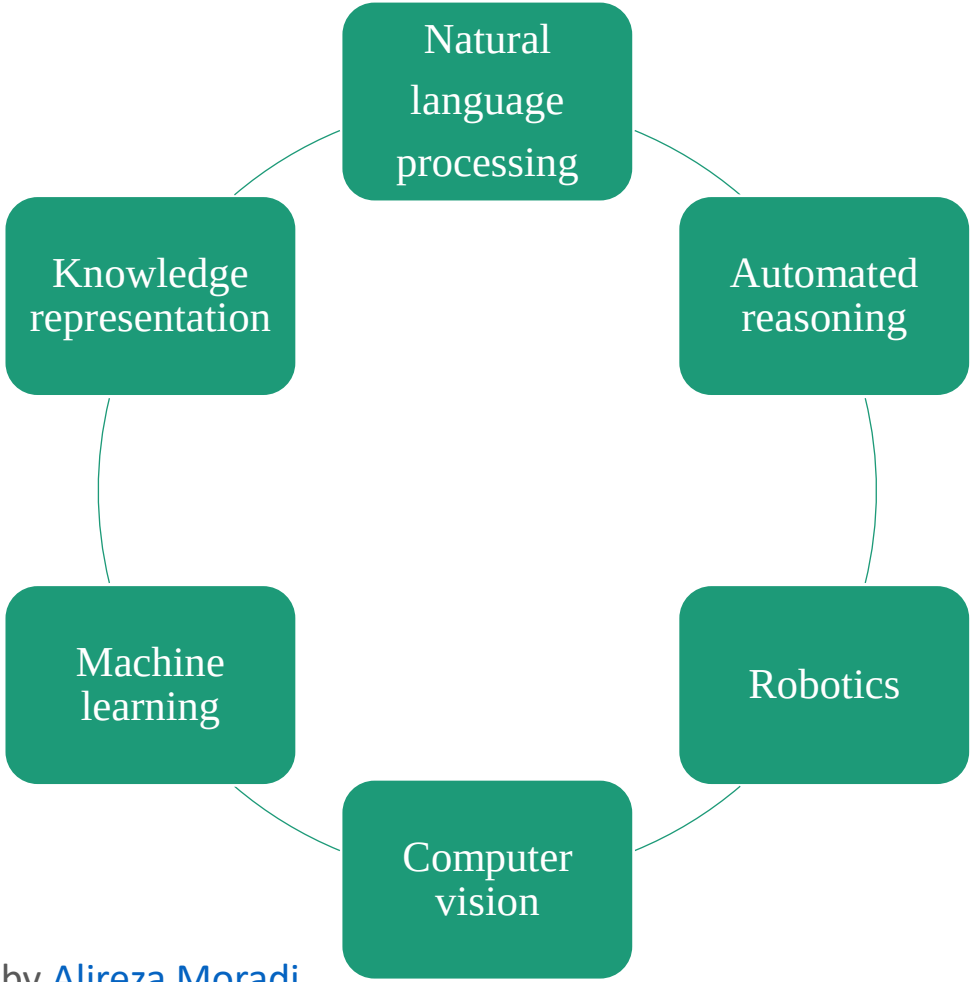
- Once we have a sufficiently precise theory of the mind, it becomes possible to express the theory as a computer program.

- The interdisciplinary field of cognitive science brings together computer models from AI and experimental Cognitive science techniques from psychology to construct precise and testable theories of the human mind.

Acting Humanly

- This is the Turing test approach, proposed by Alan Turing (1950).

- To say a computer agent is acting humanly, it would need to process these capabilities:



Thinking rationally

- This is the "laws of thought" approach.

- These laws of thought were supposed to govern the operation of the mind; their study initiated the field called **logic**.

- An example of a logic rule is like :

if A=>B and B=>C then A=>C

There is a canonical example starts with Socrates is a man and all men are mortal and concludes that Socrates is mortal.

- We simply don't know the rules of, say, politics or warfare in the same way that we know the rules of chess or arithmetic. The **theory of probability** fills this gap, allowing rigorous reasoning with uncertain information.

Acting rationally

- **Agent:**

An agent is just something that acts. E.g., humans

- **Computer agents:**

Of course, all computer programs do something, but computer agents are expected to do more; operate under autonomous control, perceive their environment, persist over a prolonged period, adapt to change, and create and pursue goals.

- **Rational Agent:**

A rational agent acts to achieve the best outcome or, when there is uncertainty, the best expected outcome.

- Recall that **rationality** is doing the right thing.

Acting rationally

- The rational-agent approach to AI has prevailed throughout most of AI's history. This is also the **current paradigm** and is popular enough to be called the standard model.

- In a nutshell, AI has focused on the study and construction of agents that do the right thing.

- We need to make one important refinement to the standard model to account for the fact that **perfect rationality**—always taking the exactly optimal action—is not feasible in complex environments. The computational demands are just too high.

- **limited rationality**—acting appropriately when there is not enough time to do all the computations one might like.

Fields and knowledge areas in AI

Artificial Intelligence (AI) is an interdisciplinary field that draws knowledge and techniques from various domains. Here are some of the key fields and knowledge areas that are used in AI:

- Philosophy
- Cognitive psychology
- Computer science
- Computer engineering
- Probability theory
- Statistics
- logic
- linear algebra
- Optimization
- Neuroscience
- Control theory
- Economics
- Decision theory
- Operation research(OR)
- Game theory
- Algorithm design
- Ethics
- human–computer interaction

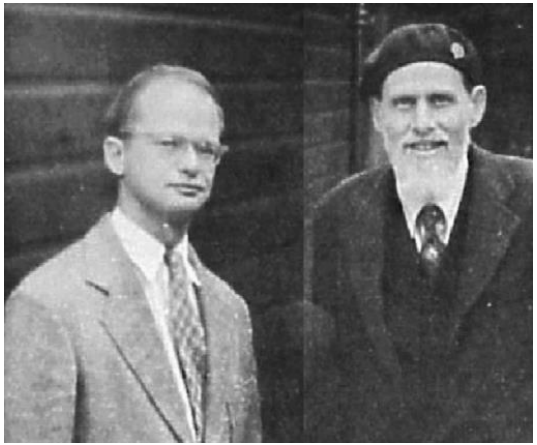
AI history

- The first work that is now generally recognized as AI was done by Warren McCulloch and Walter Pitts (1943).

- They proposed a model of artificial neurons in which each neuron is characterized as being “on” or “off,” with a switch to “on” occurring in response to stimulation by enough neighboring neurons.

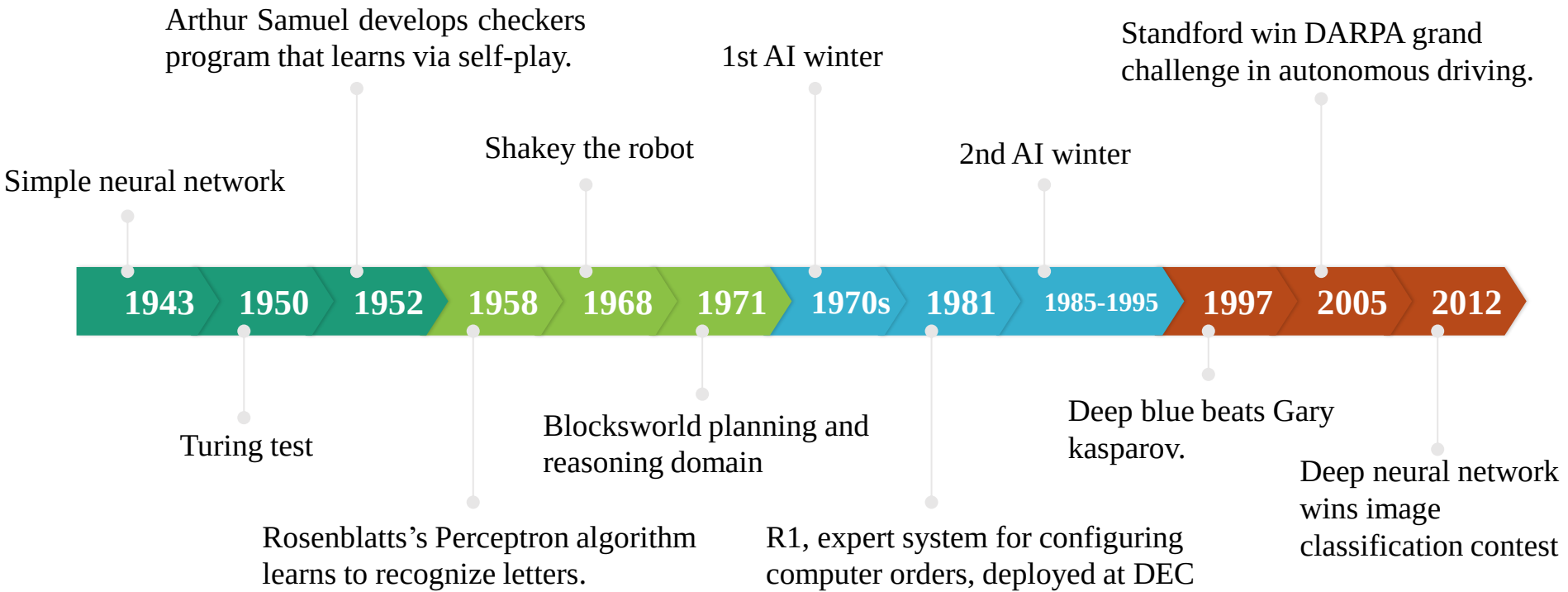
- Suitably defined networks could **learn**.

- Two undergraduate students at Harvard, Marvin Minsky (1927–2016) and Dean Edmonds, built the first neural network computer, SNARC, in 1950. They used SNARC to simulate a network of 40 neurons.



Warren McCulloch and Walter Pitts

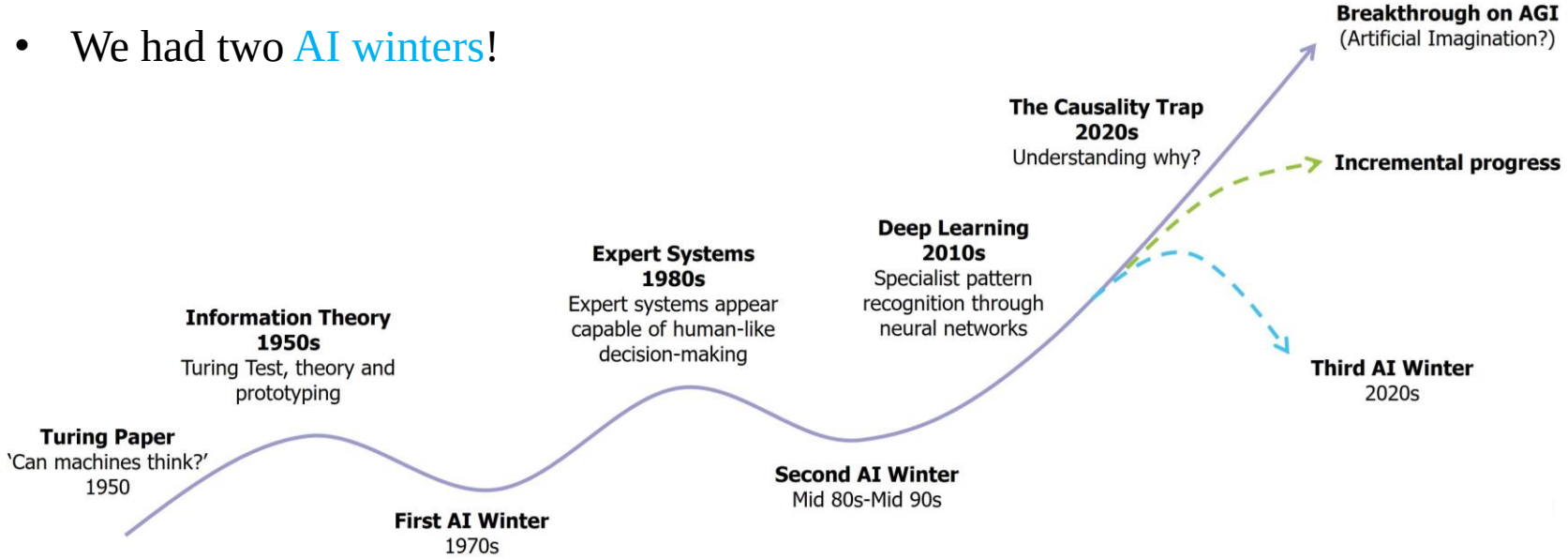
AI history; Continue



AI history; Continue

- The history of AI has had cycles of success, misplaced optimism, and resulting cutbacks in enthusiasm and funding. There have also been cycles of introducing new, creative approaches and systematically refining the best ones.

- We had two AI winters!



AI history; Continue

Phases of AI history:

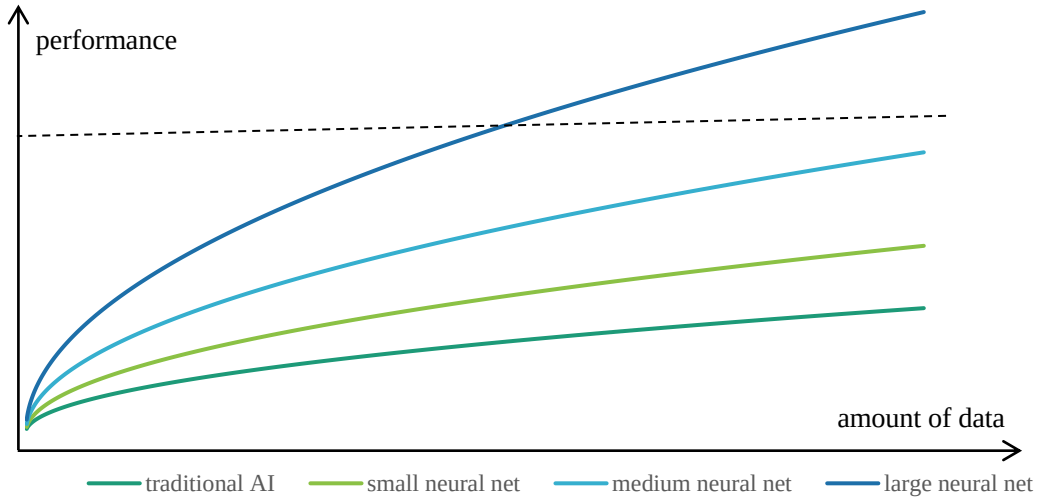
- The inception of artificial intelligence (1943-1956)
- Early enthusiasm, great expectations (1952-1969)
- A dose of reality (1966-1973)
- Expert systems (1969-1986)
- The return of neural networks (1986-present)
- Probabilistic reasoning and machine learning (1987-present)
- Big data (2001-present)
- Deep learning (2011-present)

Trends in AI

- We saw that AI field has adopted several stories about itself. first the bold idea that intelligence by a machine was even possible, then that it could be achieved by encoding expert knowledge into logic, then that probabilistic models of the world would be the main tool, and most recently **machine learning** and **deep learning** are prevailing.

- Performance with amount of data diagram

- Trend: More Data, more Complex Models, and Higher Resource Consumption



Trends in AI

As the problems that AI deals with became more complex, the field moved from Boolean logic to **probabilistic reasoning**, and from hand-crafted knowledge to **machine learning from data**. This has led to improvements in the capabilities of real systems and greater integration with other disciplines.

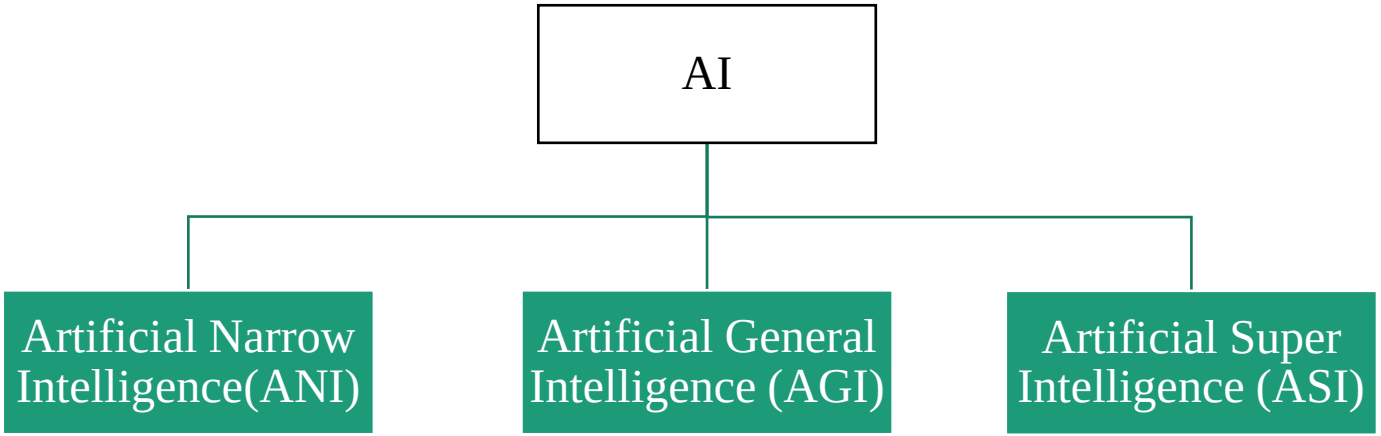
AI was founded in part as a rebellion against the limitations of existing fields like control theory and statistics, but in this period, it **embraced the positive results of those fields**.

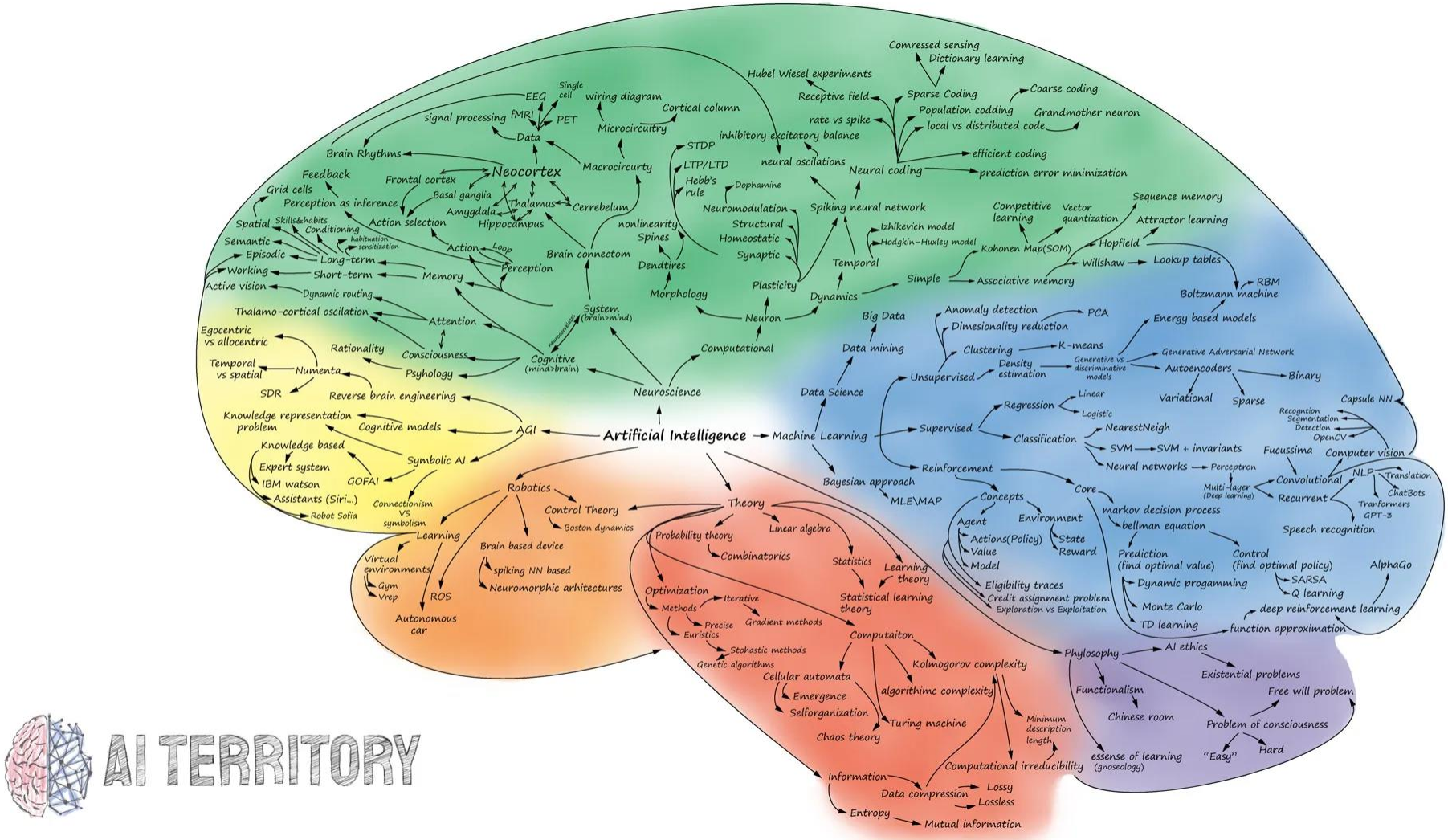
Artificial General Intelligence(AGI) is another trend that we will explain next slide.

Branches of AI

AI currently encompasses a huge variety of subfields, ranging from the **general** (learning, reasoning, perception, and so on) to the **specific**, such as playing chess, proving mathematical theorems, writing poetry, driving a car, or diagnosing diseases.

AGIs can do almost anything a human can, ASIs is the stage of Artificial Intelligence when the capability of computers will surpass human beings.





AI TERRITORY

Branches of AI; Continue

- There are a lot of branches in AI. As this is an engineering course for industrial engineers, we are concerned with modeling and implementations. The main tool is computing systems, unlike cognitive sciences that also utilize other resources. This course concentrates on machine learning, AGI , and AI theory.

- Another famous taxonomy of AI (also with an engineering perspective):

1. Machine learning
2. Neural networks(Deep learning)
3. Robotics
4. Expert systems
5. Fuzzy logic
6. Natural language processing
7. Knowledge representation
8. Computer vision