* how studies of the human mind and brain have let to inspiration for computer science and vice versa
* develop connections between understanding of human minds and artificial mind.
* We take a cognitive scientific approach here: Mind can be considered an information processor. At least some mental operations bear similarity to the way information is processed in a computer.
* Santiago Ramón y Cajal: neuroscientist, pathologist, and histologist specializing in neuroanatomy and the central nervous system
* Information processing requires that some aspect of the world be represented and then operated on or computed.   
  So, we will think about **mental representations**, which show similarities to feature extraction we have discussed before.
* **Reason** is the capacity of consciously making sense of things, applying logic, and adapting or justifying practices, institutions, and beliefs based on new or existing information.
* We are going to think about how we get to mental representations of things we see; we’ll discuss visual perception.
* Based on that we will touch upon theories of mind from different perspective: the cognitive approach and the network approach.
* Cognitive science is the interdisciplinary, scientific study of the mind and its processes.
* Including language, perception, memory, attention, reasoning, and emotion.
* Sees contributions from multiple fields, including philosophy and its newest offshoot, experimental philosophy, psychology, cognitive psychology, neuroscience, the connectionist or network approach, evolution, linguistics, the scientific study of emotions and social behavior, Al, robotics, and more.
* We will look at few aspects of this, that related to Machine Vision.`

# Mental Representations

* "thinking can best be understood in terms of representational structures in the mind and computational procedures that operate on those structures.“
* Computational models require a mathematically and logically formal representation of a problem
* At least some mental operations bear similarity to the way information is processed in a computer.
* Computations are processes that act on or transform representations.
* Information processing requires that some aspect of the world be represented and then operated on or computed.
* Analogue codes retain the main perceptual features of whatever is being represented, so the images we form in our minds are highly similar to the physical stimuli. They are a near-exact.
* A representation is symbolic if it stands for something else.
* The thing a symbol stands for in the world is called its referent.
* The fact that symbols are "about" these things is called intentionality.
* The propositional theory claims that mental representations are stored as propositions (underlies the relationship between concepts) rather than as images.
* How to build these representations (or codings)? We will look at some ideas in the context of the visual system in a minute.

# Reasoning

**Reasoning** is associated with the acts of thinking and cognition and involves using one's intellect.

**Reason** is the capacity of consciously making sense of things, applying logic, and adapting or justifying practices, institutions, and beliefs based on new or existing information.

example of inductive reasoning: Premise: The sun has risen in the east every morning up until now. Conclusion: The sun will also rise in the east tomorrow.

example of deductive reasoning: Premise 1: All humans are mortal. Premise 2: Socrates is a human. Conclusion: Socrates is mortal.

Analogical reasoning is a form of inductive reasoning from a particular to a particular. It is often used in case-based reasoning, especially legal reasoning

Analogical reasoning is a weaker form of inductive reasoning from a single example, often leads to wrong conclusions.

Abductive reasoning starts with observations and seek most likely explanations. Yields a plausible solution but does not verify it

Many more: causal reasoning, reasoning by similarity

Scientific methods: hypothesis posing and testing, finding analogies, complexity analysis

# Vision

Now let’s think about how we get to mental representations of images.

**Visual cortex** is the largest system in the human brain and is responsible for processing the visual image.

**Visual perception** is the ability to interpret the surrounding environment using light.

Theories and observations of visual perception have been the main source of inspiration for computer vision or machine vision.

**Visual system** comprises the sensory organ (the eye) and the part of the central nervous system

Optic chiasm: point where the information coming from both eyes is combined and then splits according to the visual field.

**Lateral geniculate nucleus (LGN)** is a 6-layer sensory relay nucleus. E.g. layer 1 is concerned with depth and motion, others with colors and edges.   
See https://en.wikipedia.org/wiki/Visual\_system#Lateral\_geniculate\_nucleus

**Primary visual cortex** receives information from LGN; here selection of visual input information by attention starts. Neurons respond selectively to lines of specific orientations, or combinations of lines. These are believed to support edge and corner detection; as well as basic information about color and motion.

Further downstream the visual pathway there is the **Visual association cortex**, where neurons respond selectively to complete object (e.g., a figure drawing), and neurons in visual association cortex may respond selectively to human faces, or to a particular objects

The occipital lobe is one of the four major lobes of the cerebral cortex in the brain of mammals.

The occipital lobe is the visual processing center of the mammalian brain containing most of the anatomical region of the visual cortex

# Memory

Without memory, a human, animal, or machine could not learn. We need to retain information over time.

There are three major types of memory: sensory, working, and long-term.

**Iconic memory** holds a brief visual representation of whatever it is you have just seen.

Whereas iconic memories are fragile, decay rapidly, and are unable to be actively maintained, visual short-term memories are robust to subsequent stimuli and last over many seconds.

**Working memory** holds the contents of one's thoughts in immediate awareness to allow for reasoning and problem solving. It is capable of retaining only 7 ± 2 items on average for less than a minute without rehearsal. There are auditory, visual, and semantic codes

Short term memory is part of working memory that simply stores information for a short while, while working memory retains the information in order to manipulate it.

There are several different types of **long-term memory**.

**Explicit** memory is for declarative knowledge, which deals with facts (semantic) or events (episodic). This is demonstrated verbally and is a part of **conscious** awareness.

**Implicit** memories hold procedural knowledge, which is a skill or action. This information is subconscious and is demonstrated by doing.

# Theories of mind

How do we get to an artificial mind, that is capable to reason given images?

Now we have some ingredients: mental representations, reasoning

It is not known whether mental states are physical states.

Emergence implies that it may not be fully explained by an understanding of its component parts.

At least some mental operations bear similarity to the way information is processed in a computer.

The evolutionary purpose of the brain is to predict the future, in admittedly limited ways, so as to change it.

Mind as a computer metaphor

Cognitive psychology is the scientific study of mental processes such as "attention, language use, memory, perception, problem solving, creativity, and thinking.  
Here we limit the discussion to the perception of visual stimuli.

Pattern recognition is the ability to identify objects in the environment.

The major theories of visual pattern recognition are template matching, feature detection, recognition by components, feature integration, and computational.

Template matching is hard to generalize.

Problem with feature detection: in real-life, recognition seems to be steered by conceptually driven processes, in which context an higher level knowledge aid recognition.

Attention may be thought of as a concentrated mental activity that is allocated among alternative information sources.

Attention can be selective or focused on one source. It can also be divided between sources or shifted among them.

Preattentive processing is all that is required to locate a target that differs in one way from distractors.

Focused attention is needed to locate a target that differs in more than one way from surrounding distractors

# Neuroscience

Study of nervous system structure and function and attempt to relate these findings to cognitive processes.

The cerebral cortex is the outer layer of neural tissue of the cerebrum of the brain.

**Neocortex** is involved in higher order functions such as sensory perception, generation of motor commands, **spatial reasoning**, conscious thought, and in humans, language.

A **neuron** can be considered the functional unit of the brain, as it receives messages from other neurons and can also send messages.

Knowledge on the physical function of the brain is obtained using brain imaging, e.g. fMRI, PET

Possibly two visual system-processing streams:

The dorsal pathway handles information regarding location and motion.

The ventral pathway is concerned with object recognition.

# How to define AI?

Main goal is to create technology that allows computers and machines to function in an intelligent manner.

To mimic "cognitive" functions that humans associate with the human mind, such as "learning" and "problem solving“

**Intelligent agent**: any device that perceives its environment and takes actions that maximize its chance of successfully achieving its goal

AI is founded on the assumption that human intelligence "can be so precisely described that a machine can be made to simulate it“? Or is AI whatever hasn't been done yet?

The **strong AI** view is that it may be possible someday to engineer a complex system that is conscious.   
In contrast, the **weak AI** view advocates that consciousness is either nonphysical or that it is physical but too difficult to engineer.

The cognitive capabilities of current architectures are very limited, and there are numerous challenges to simulate the human mind

Machine perception is the ability to use input from sensors such as cameras to deduce aspects of the world.

Computer vision is usually ambiguous; a giant, fifty-meter-tall pedestrian far away may produce the same pixels as a nearby normal-sized pedestrian, requiring the AI to judge the relative likelihood and reasonableness of different interpretations, for example by using its "object model" to assess that fifty-meter pedestrians do not exist.

# Reinforcement learning

Reinforcement learning is one of three basic machine learning paradigms, alongside supervised learning and unsupervised learning.

Reinforcement learning (RL) is an area of machine learning concerned with how software agents ought to take actions in an environment in order to maximize the notion of cumulative reward.

Reinforcement learning differs from supervised learning in not needing labelled input/output pairs be presented, and in not needing sub-optimal actions to be explicitly corrected.

Instead the focus is on finding a balance between exploration (of uncharted territory) and exploitation (of current knowledge).

# Can machines think?

One need not decide if a machine can "think"; one need only decide if a machine can act as intelligently as a human being. This approach to the philosophical problems associated with artificial intelligence forms the basis of the Turing test.

Zombie consciousness: The only way to know that a person/machine thinks, is to be that person/machine