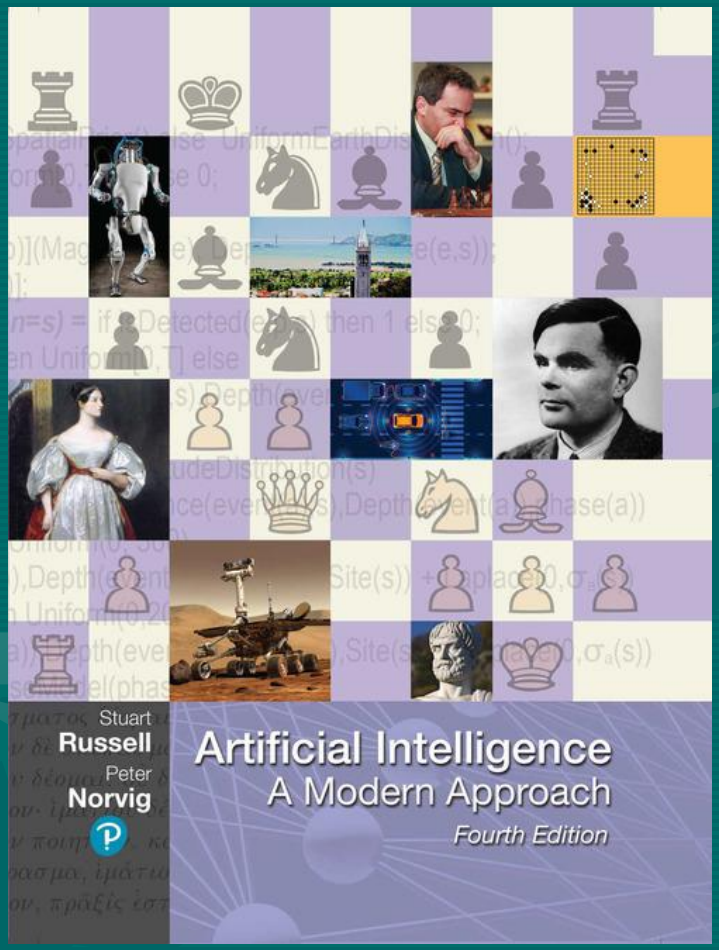
Introduction to AI

An Introduction to Artificial Intelligence

Shay Bushinsky, Fall 2022

The Course Book



Course Topics

I. Intro.
II. Agents
III. Search
IV. Game playing
V. Machine Learning

Intro. Content

- What is an Intelligent Machine?
- Typical Problems addressed by AI
- Weak AI vs. Strong AI
- AI Engine Evolution
- Subfields of AI research
- AI ethics, defects & threats
- Fiction & Creativity

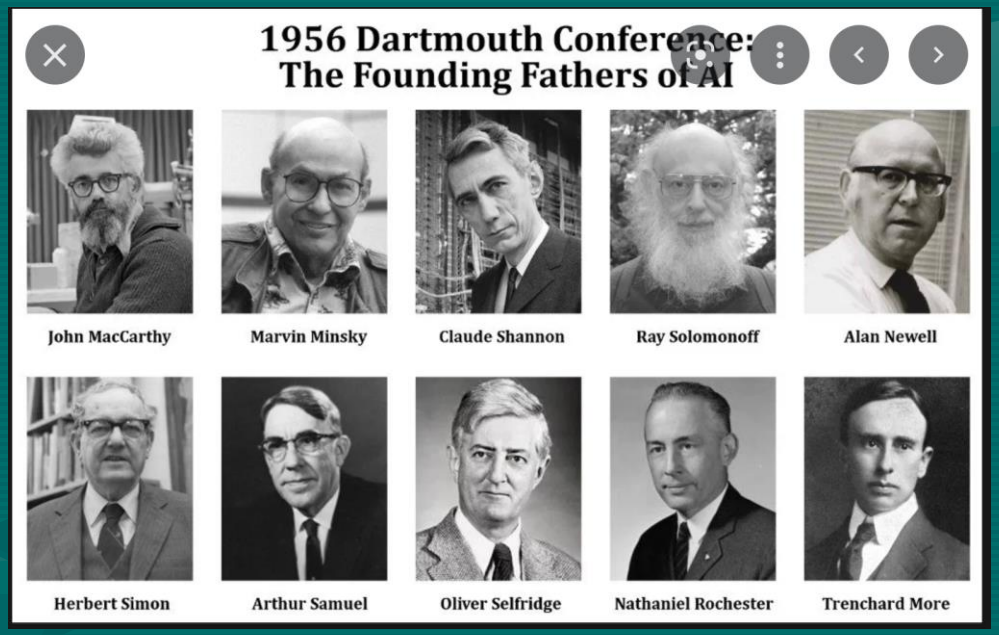
What is Intelligence?

- "The ability to acquire and apply knowledge and skills"
- 3 types: Being practical, creative, analytical
- Introspection?
- EQ?
- Evaluating:
  - Psychological tests
  - Brain Imaging (fMRI)

The founding fathers of AI

Dartmouth Summer Research Project on Artificial Intelligence

Date	1956
Duration	Eight weeks
Venue	Dartmouth College, Hanover, New Hampshire
Organised by	John McCarthy
Participants	Marvin Minsky, Nathaniel Rochester, and Claude Shannon (who proposed the workshop), with others



Typical AI Problems

- Problems that are poorly specified:
  - Unknown concise, exact problem **specification**
  - Unknown knowledge needed to **solve** the problem
  - Knowledge is **imprecise** or **inaccurate**
- – Example: Explain integration to a human
- – Non-example: Factor an integer

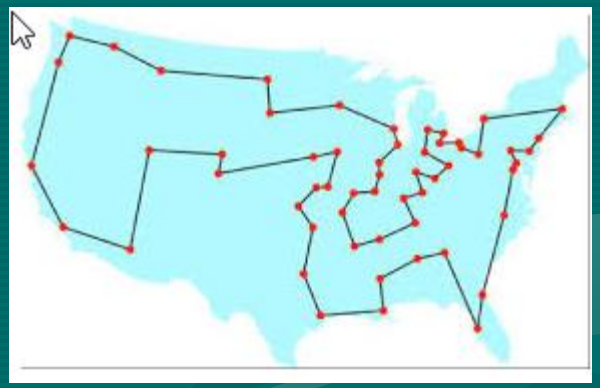
Typical AI Problems

- <u>Problems that require search:</u>

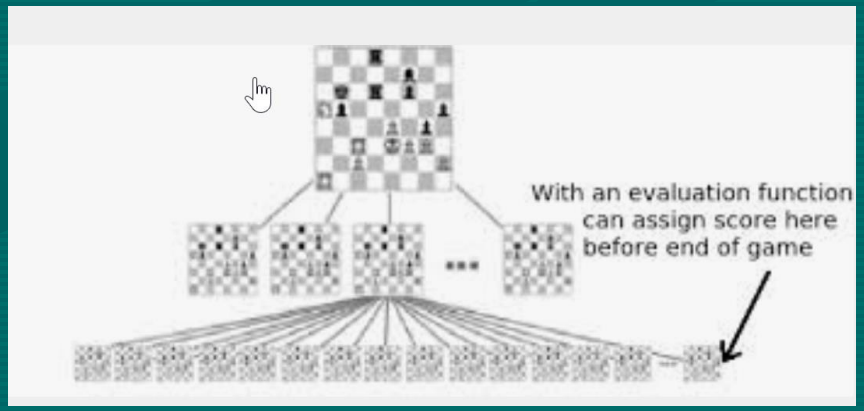
  1. No deterministic algorithm is known
  2. Must use “trial and error"

  – **NP-Hard** problems all have this property

- – Example: Schedule courses
- – Non-example: Sort a list



The traveling salesperson problem



What is an Intelligent Machine?

- Rich: Machines that can perform tasks **better than people**
- Kurzweil: A machine that can **use its resources in an optimal way** in order to achieve a goal

- Turing: it is up to the **person's judgment** to decide if he sees intelligence
- Minsky: "…AI is the science of making machines do things that would **require intelligence if done by men**"

Measuring AI

1 Think like humans "cognitive science" Ex. GPS	**2** Think rationally => formalize inference process "laws of thought"
3 Act like humans Ex. ELIZA Turing Test	**4** Act rationally "satisficing" methods

1. Main concern is that the machine would reach a result just like a human would
2. Emphasis is on sound & optimal reasoning procedure
3. Behaviorist approach
4. “Satisficing" methods, not "optimal"

(1) Thinking like a human

- Replicate how humans would solve problems
- Simulating the human reasoning:

GPS, Simon, Shaw, and Newell Means-Ends analysis (1959)

- Goal: I want to take my son to nursery school.
- Q: What's the difference between what I have and what I want?
- A: One of distance.
- Q: What changes distance? A: My automobile.
- My automobile won't work. Q: What is needed to make it work? A: A new battery. Q: What has new batteries? A: An auto repair shop. I want the repair shop to put in a new battery; but the shop doesn't know I need one. Q: What is the difficulty? A: One of communication. Q: What allows communication? A: A telephone… and so on

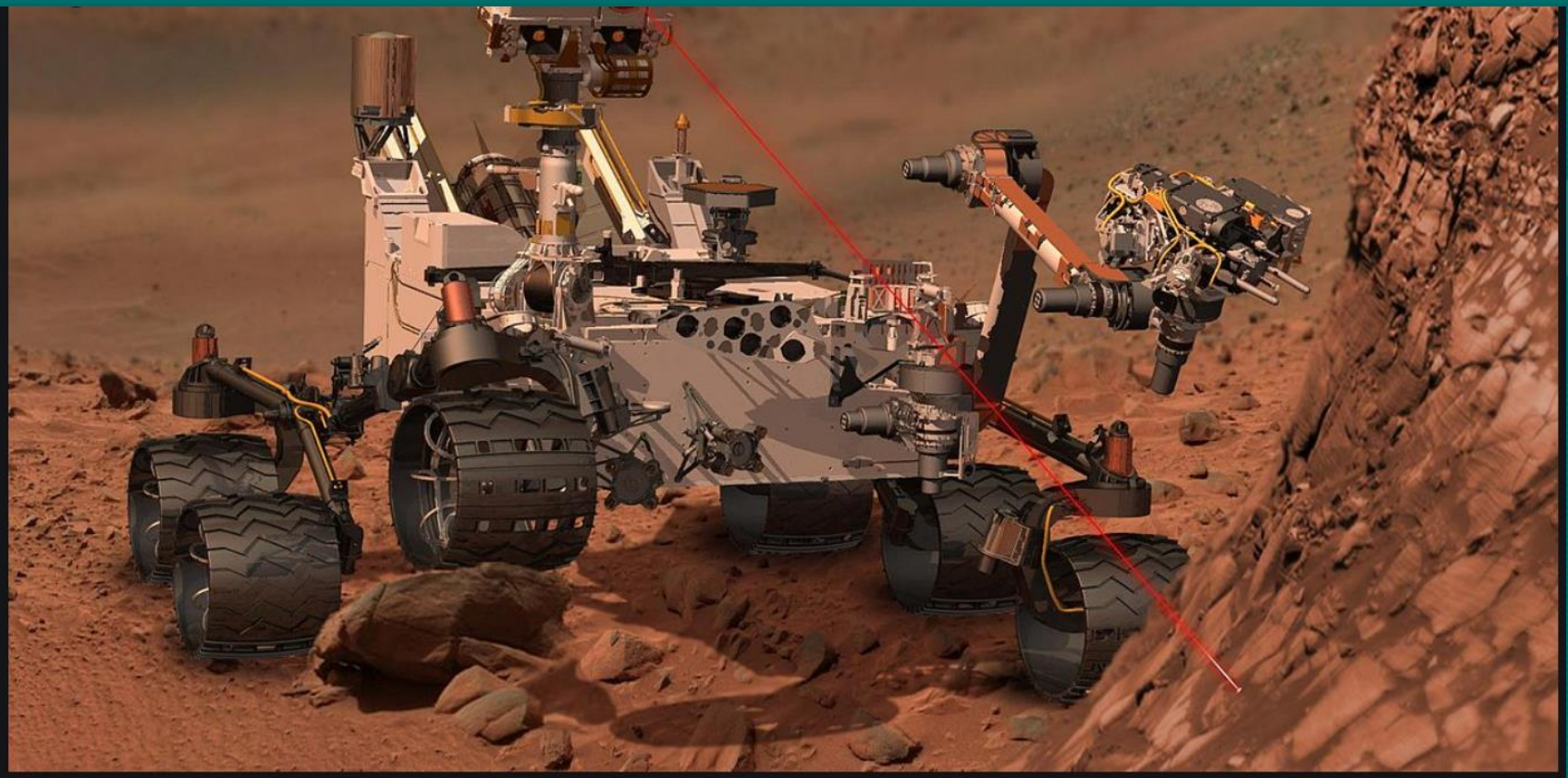
Cognitive Science

Focus on ability to: perceive, understand, correlate, learn, teach, reason, and solve problems

- Attempts to emulate human consciousness

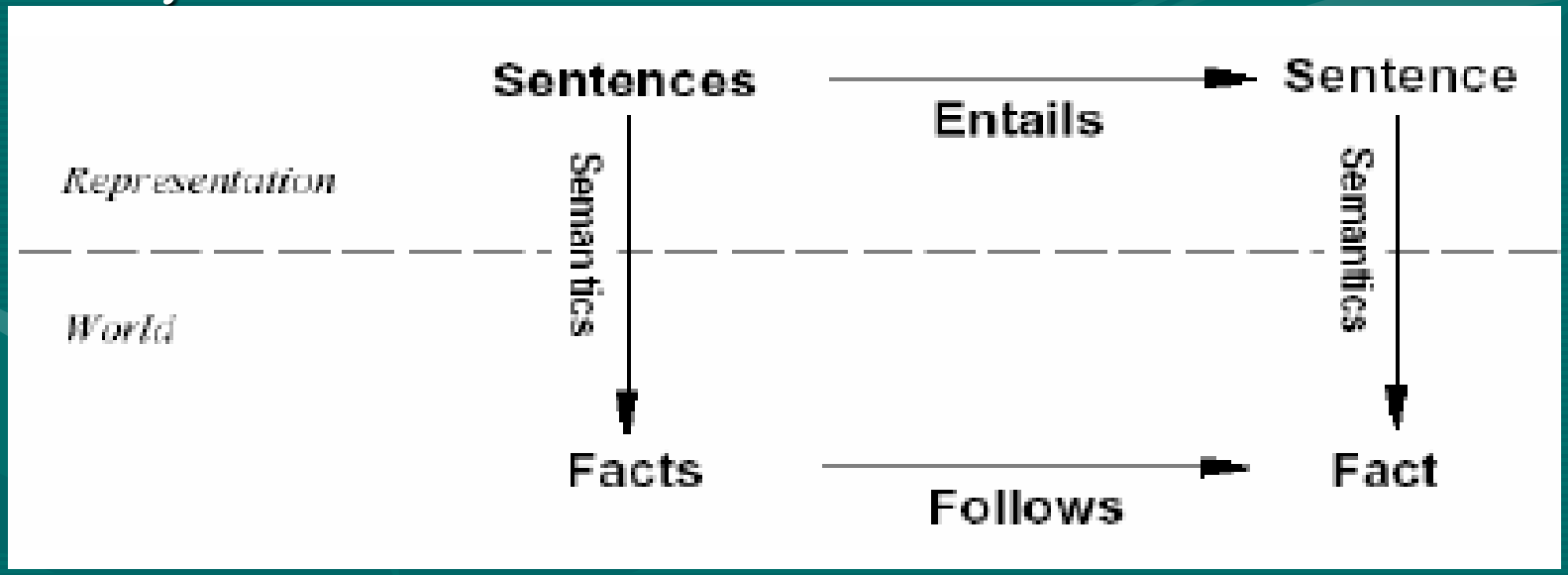
Being **self aware** of internal mental states

Cognitive AI

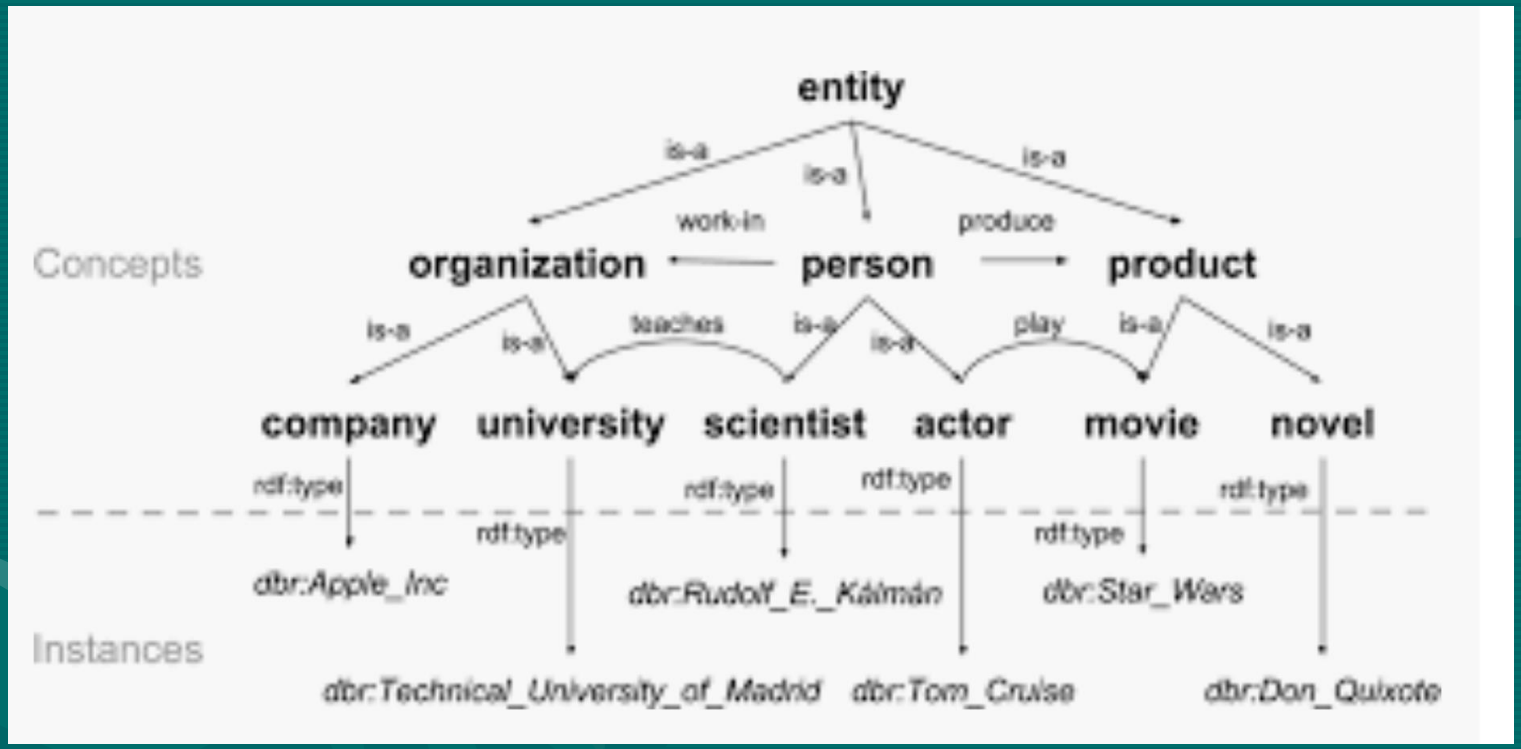


(2) Thinking Rationally

- Facts & Logic Rules – patterns of thought
- Knowledge that is less than 100% certain – fuzzy



Facts: Semantic Networks



Reasoning: Propositional Logic

p_1'	*Owns(Nono, M1)*
$\ldots$	
p_n'	*Missile(M1)*
$p_1 \wedge \ldots \wedge p_n \Rightarrow q$	*Owns(Nono , x)* $\wedge$ *Missile(x)* $\Rightarrow$ *Sells(West, Nono, x)*
Subst(θ , q)	*Sells(West, Nono, M1)*

Uncertainty: Bayesian Networks

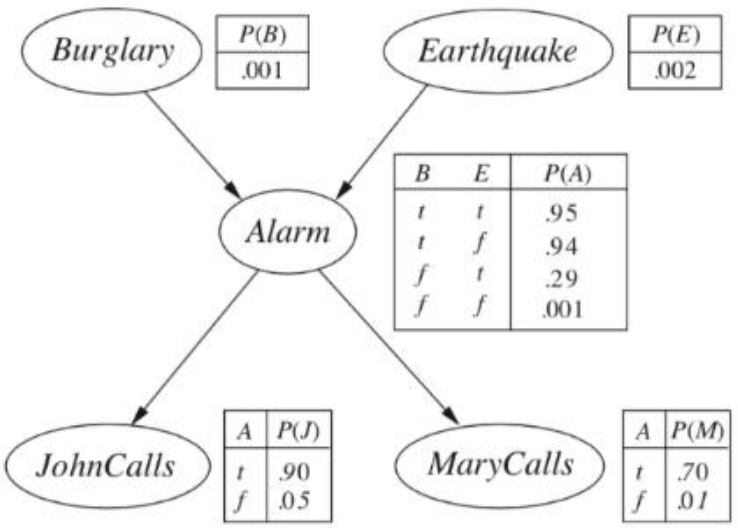
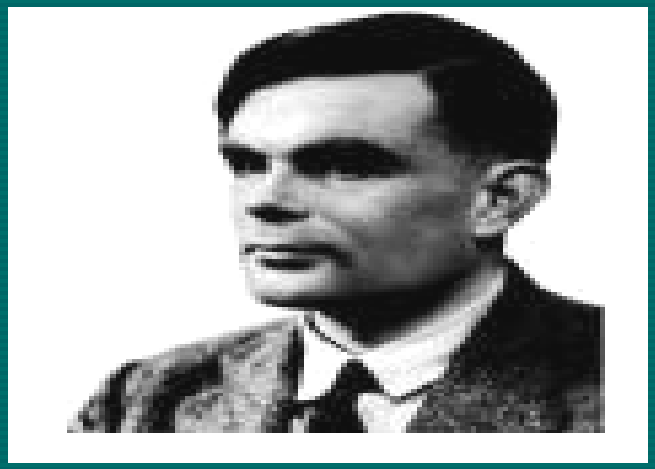
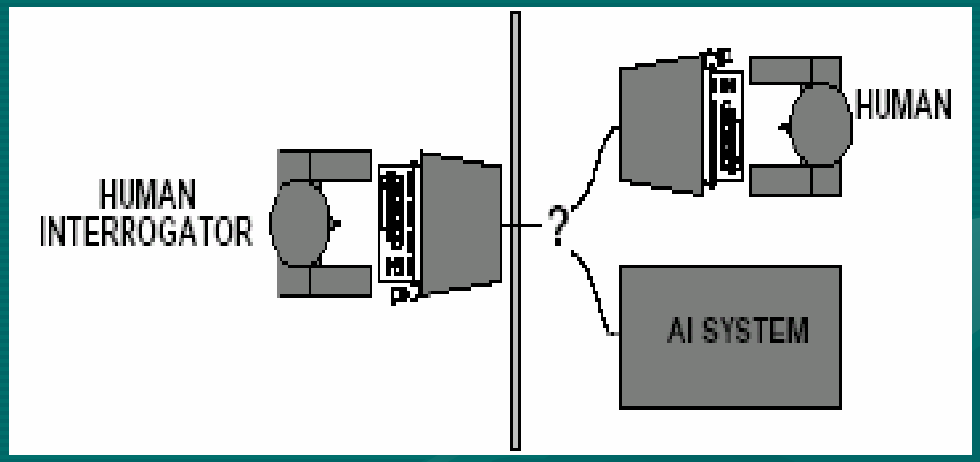


Figure 14.2 A typical Bayesian network, showing both the topology and the conditional probability tables (CPTs). In the CPTs, the letters B, E, A, J, and M stand for *Burglary*, *Earthquake*, *Alarm*, *JohnCalls*, and *MaryCalls*, respectively.

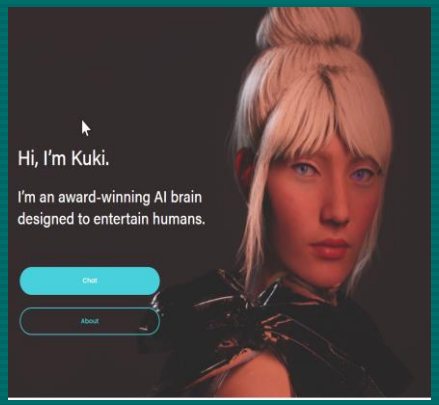
$$\underbrace{P(A \mid B)}_{\text{Probability of } A \text{ given } B} = \frac{\overbrace{P(A \cap B)}^{\text{Probability of } A \text{ and } B}}{\underbrace{P(B)}_{\text{Probability of } B}}$$

(3) Acting like a human
The Turing Test





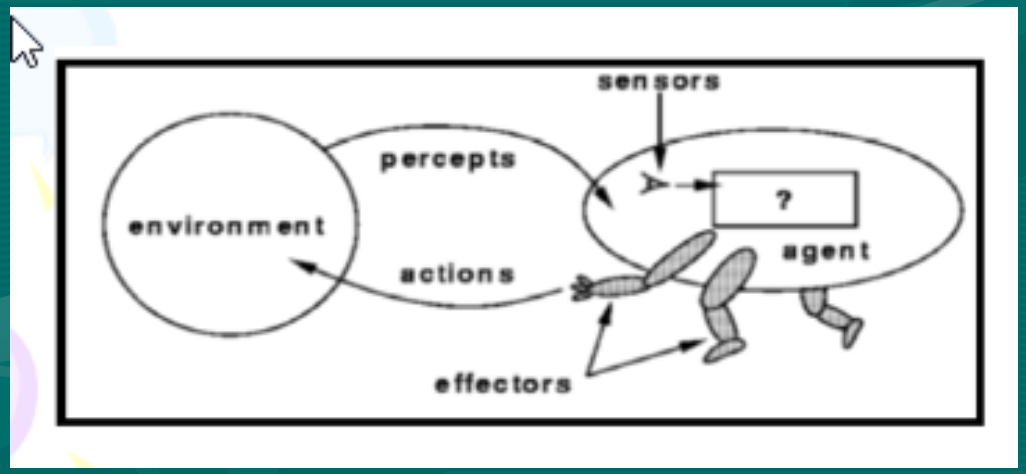
- Alan Turing (1950) – rather than passing a long list of Intelligence test, Turing designed a test where a machine disguises to a human



- The AI System = "Agent"

An agent skill set

- 1. NLP, representation, reasoning, ML
- Extra: object manipulation, vision



(4) Acting Rationally

- **Satisficing** is a decision-making strategy that aims for a satisfactory or adequate result, rather than the optimal solution

- Instead of putting maximum exertion toward attaining the ideal outcome, satisficing focuses on **pragmatic effort** when confronted with tasks

“Satisficing” Methods:

- Do the “right thing”
- Achieve goal under uncertainty

- Deep Junior’s rooks…

Garry Kasparov verses Deep Junior ches…

Approach critic

- **Rational**: Correct inference is just one of many mechanisms…
- **Cognitive**: The goal of the cognitive approach is to create actual **thinking machines** – is it necessary?
- Detaching from human thought…Can we do better? The basis of the **engineering approach**: to formulate better methods than human's

The Weak/Strong AI hypotheses

- **Weak AI** is the hypothesis that a **powerful enough computer** could simulate any aspect of the human mind
- **Strong AI**—is the hypothesis that "the **brain** is a digital computer, and the **mind** is a computer program"
- According to this view, if a programmer types the right program, then that program would emulate (be equivalent to) a human mind

Strong AI

- Key points defining software as “strong AI”:

1. Mimics human brain
2. Emulating actions of the human brain
3. Consciousness

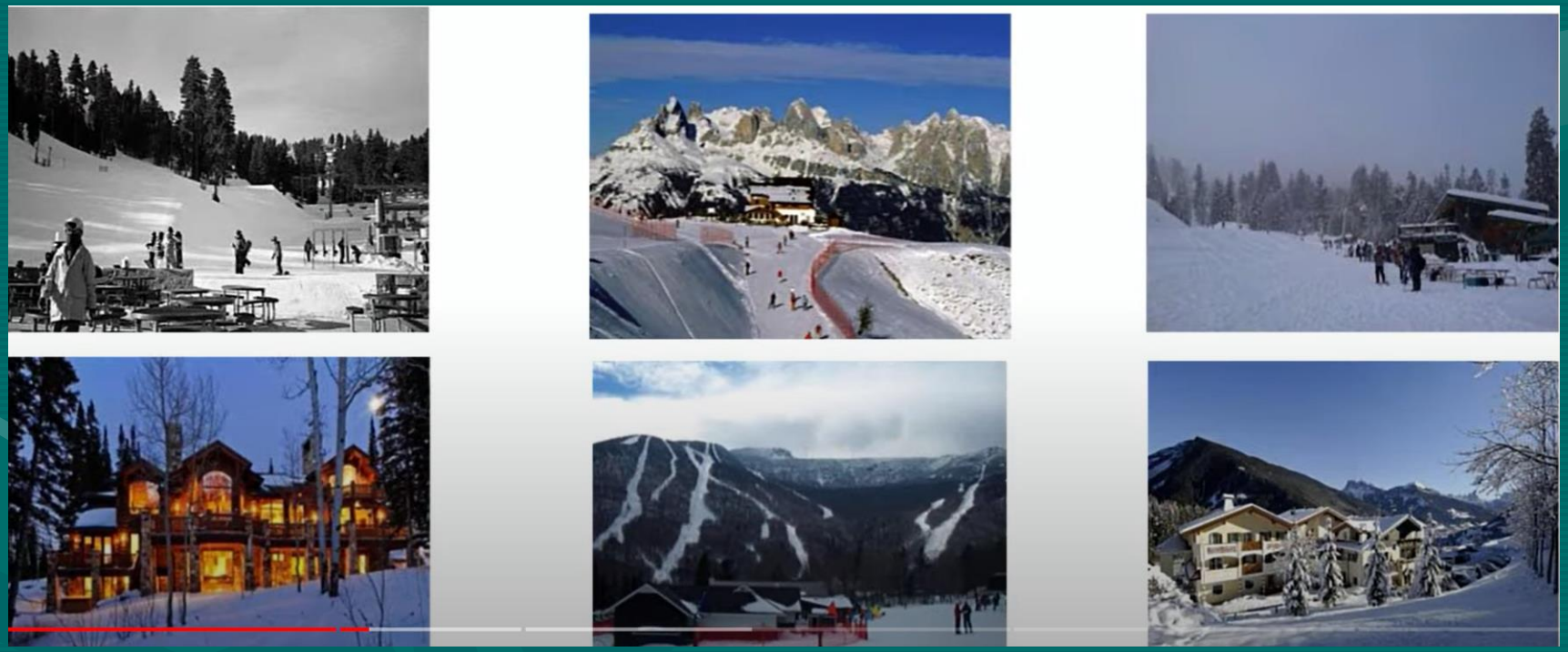
Reactive AI engines - 2000

PATTERN RECOGNITION SYSTEMS

THE MACHINE LEARNING REVOLUTION

FINDING PATTERNS IN DATA

Classification

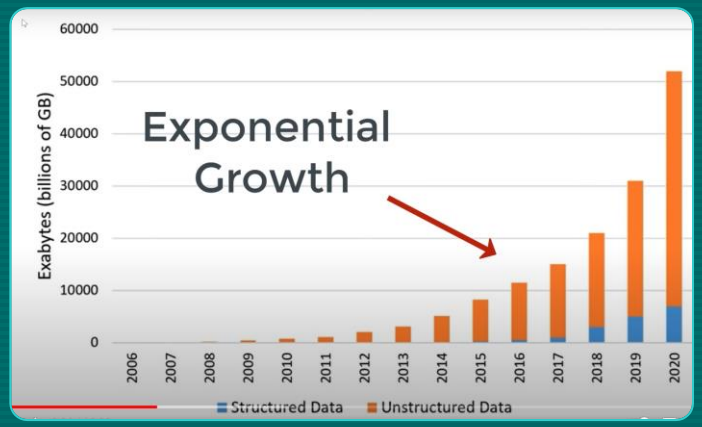


Prediction Models

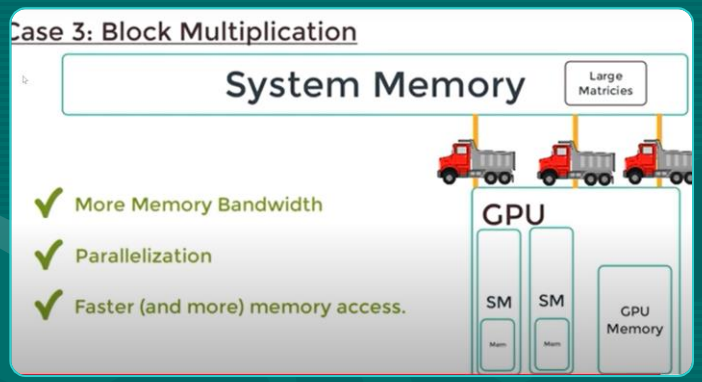
Features

Ranking movies	House Price Estimation	Dog Breed Classification	Sky Resort Identification
genera	Sq Meter	purr	snow
actors	Number of rooms	tail	House shapes
Other's rankings	floor	ears	surfers
	area	tongue	

The rise of Deep Learning



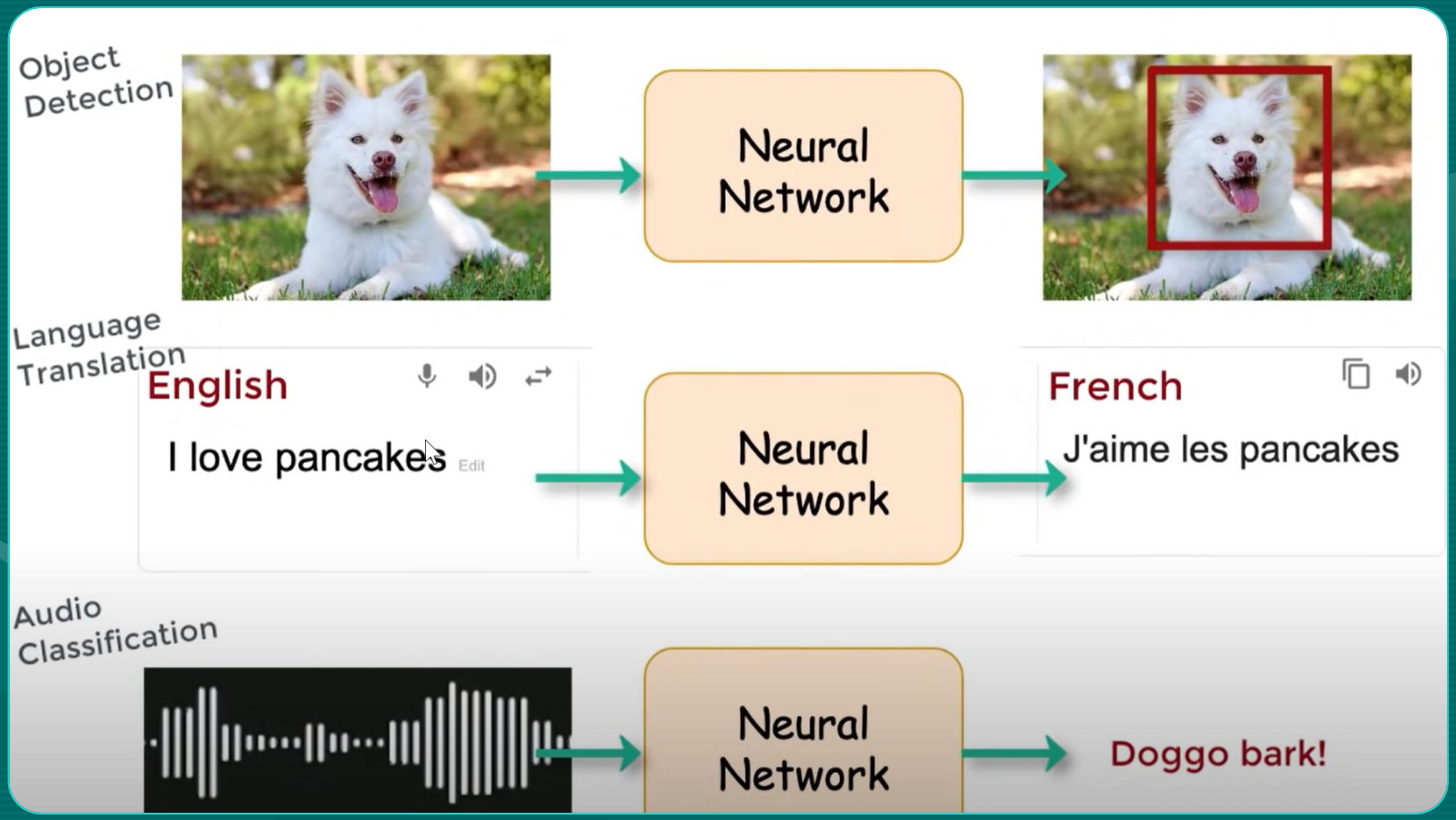
- MEMORY



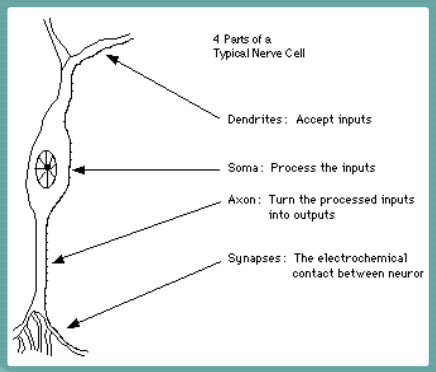
- CPU
  GPU / TPU

Internet growth rate: 3000%

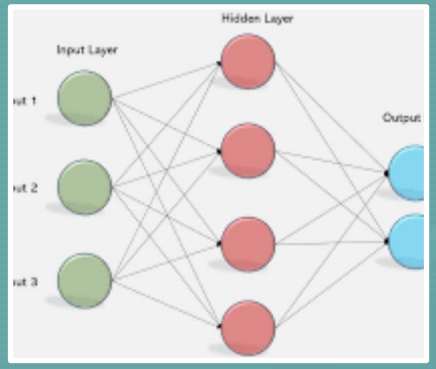
A universal approximator



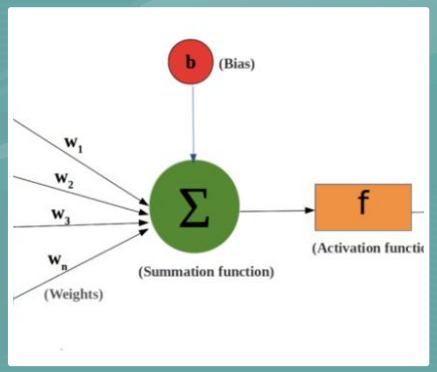
Neural Networks



נוירון

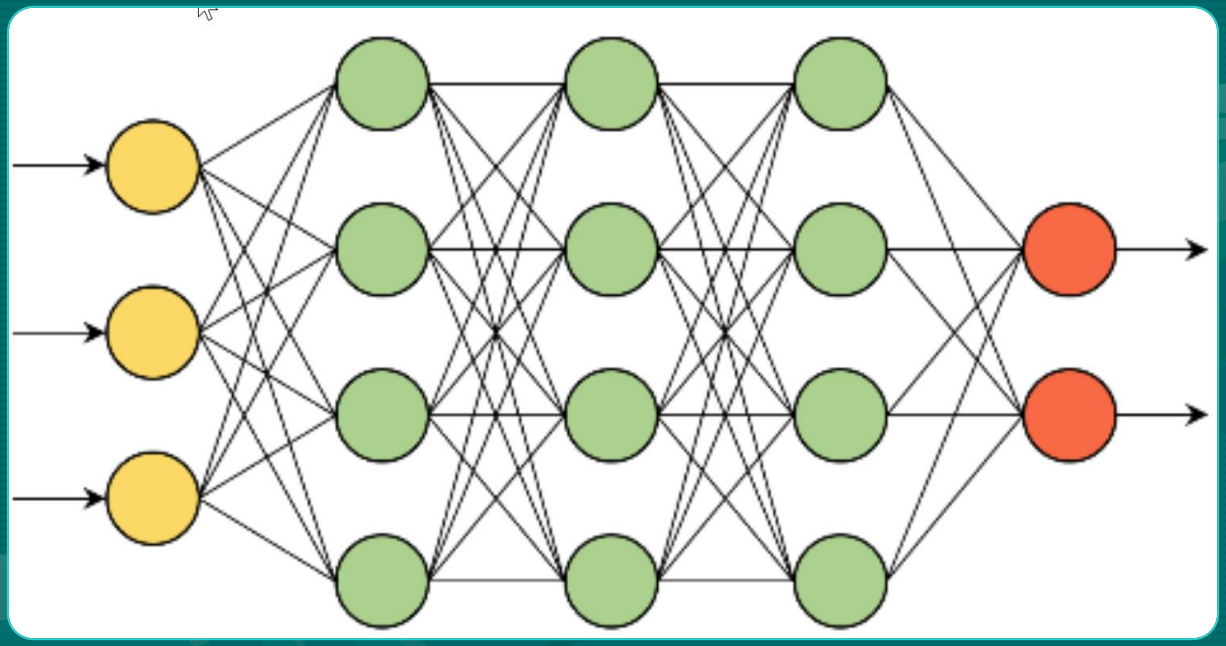


MLP



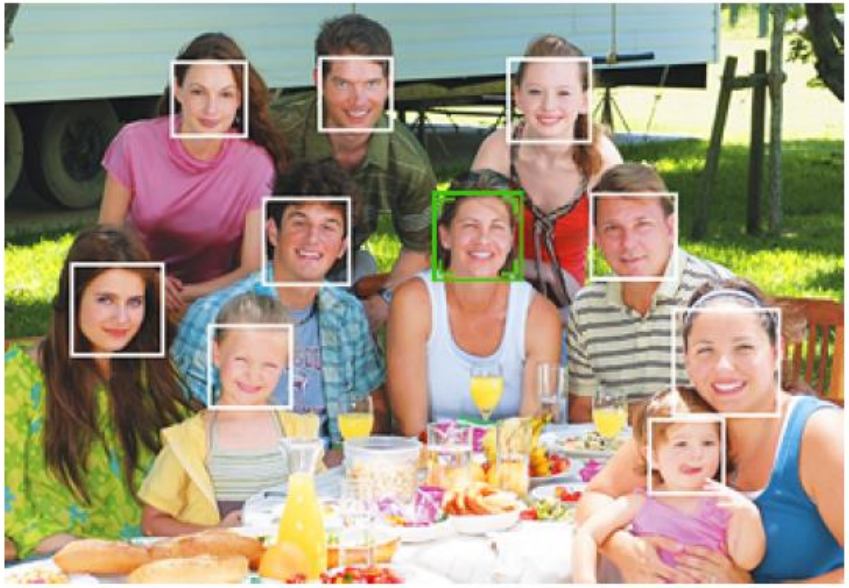
משקול קשרים

DNN



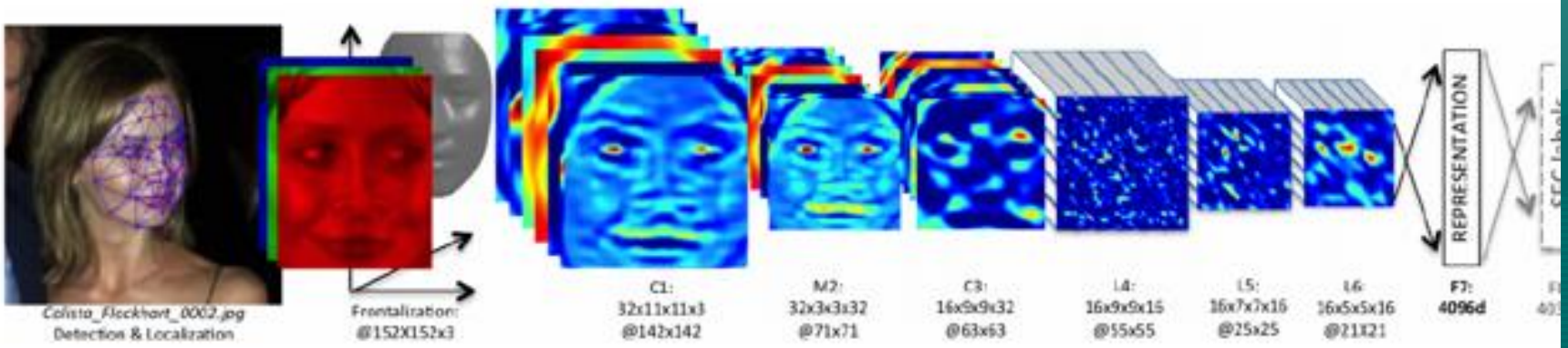
CNN success story

Face identification



Hierarchal Classification

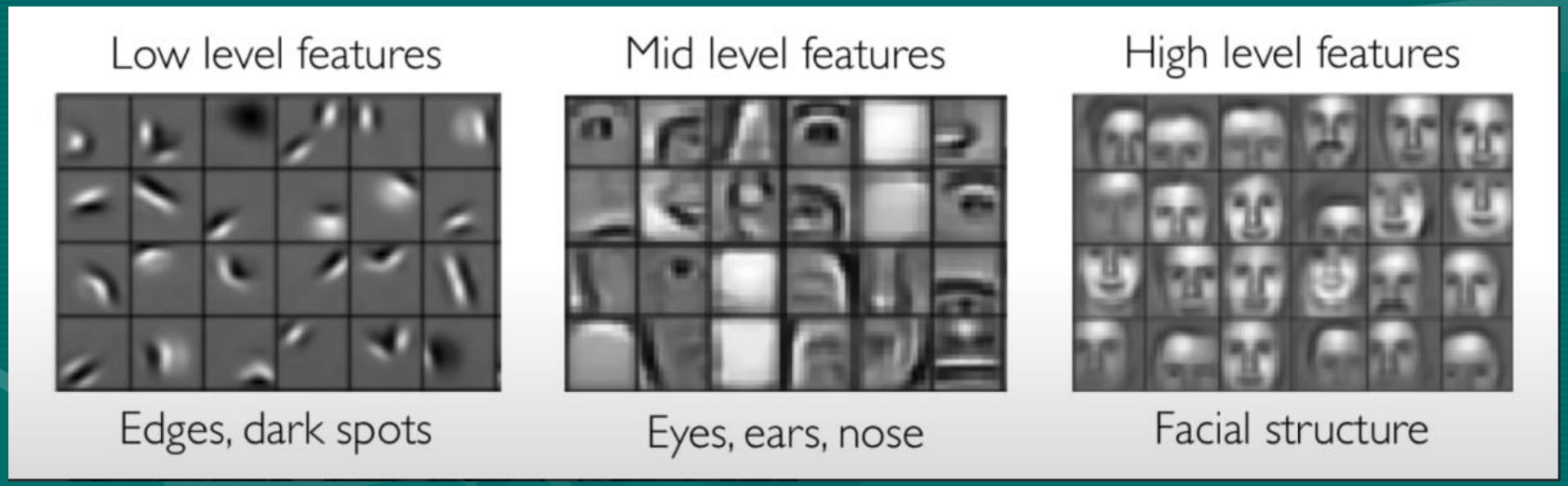
- Examples: linear classifiers, deep neural networks

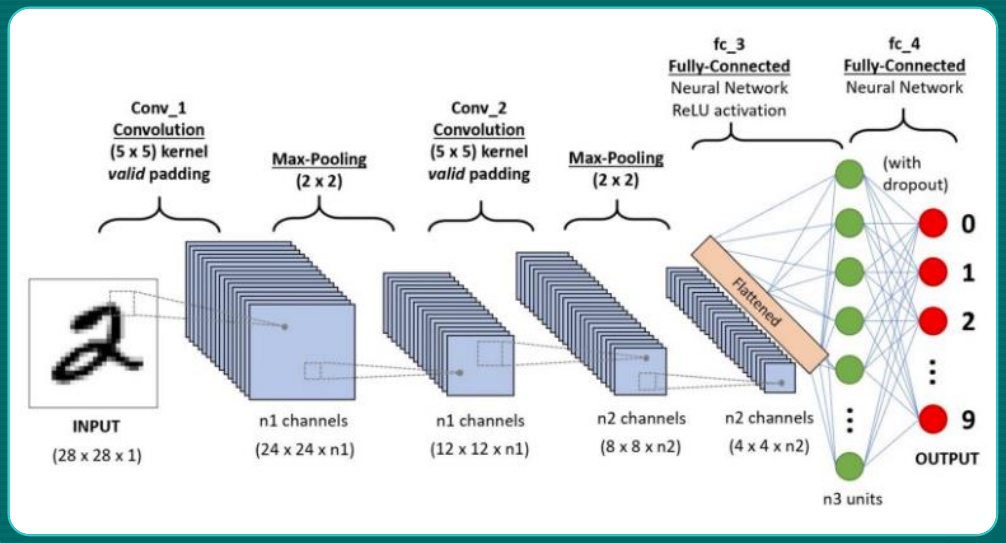


- Most common models in machine learning

- Fully feed-forward (no backtracking)

Emerging Features



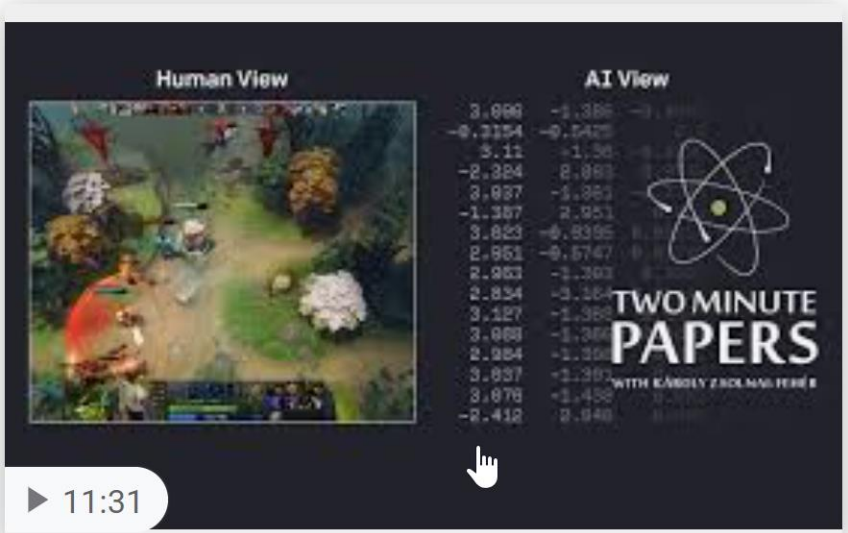


CNN Hierarchal Networks

Game Playing

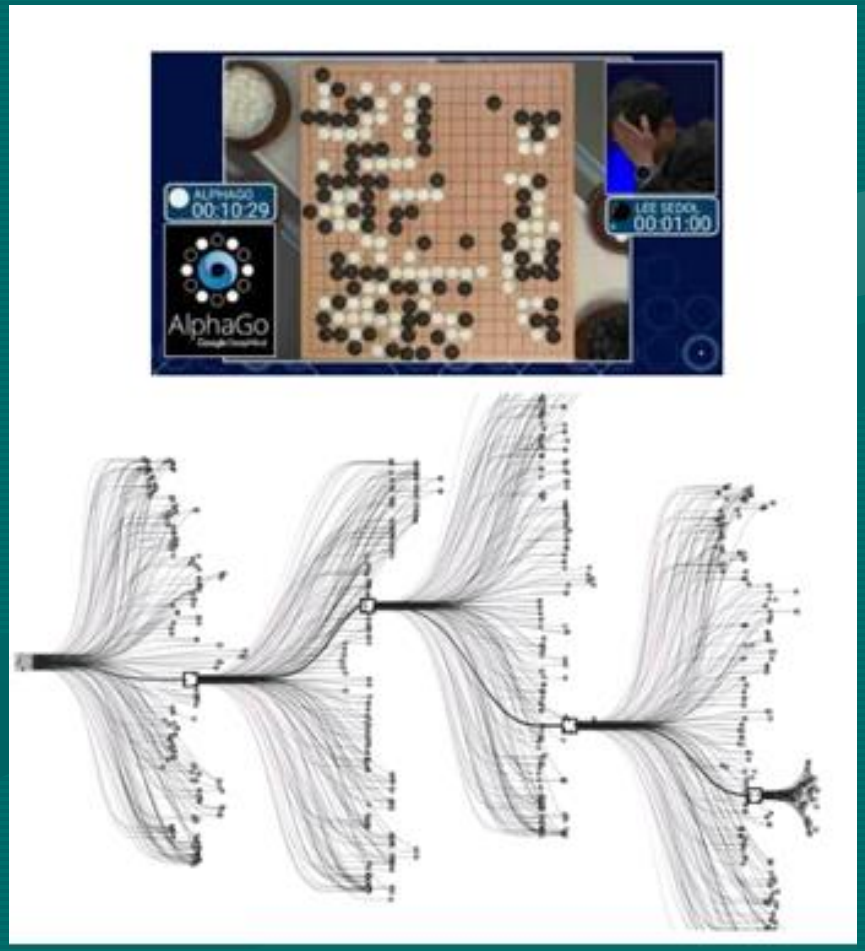
- Computer programs beat world's best players in **go, chess, checkers, backgammon** and **poker**. 1950-2020

- Dota 2 is a multiplayer online battle arena (MOBA) video game



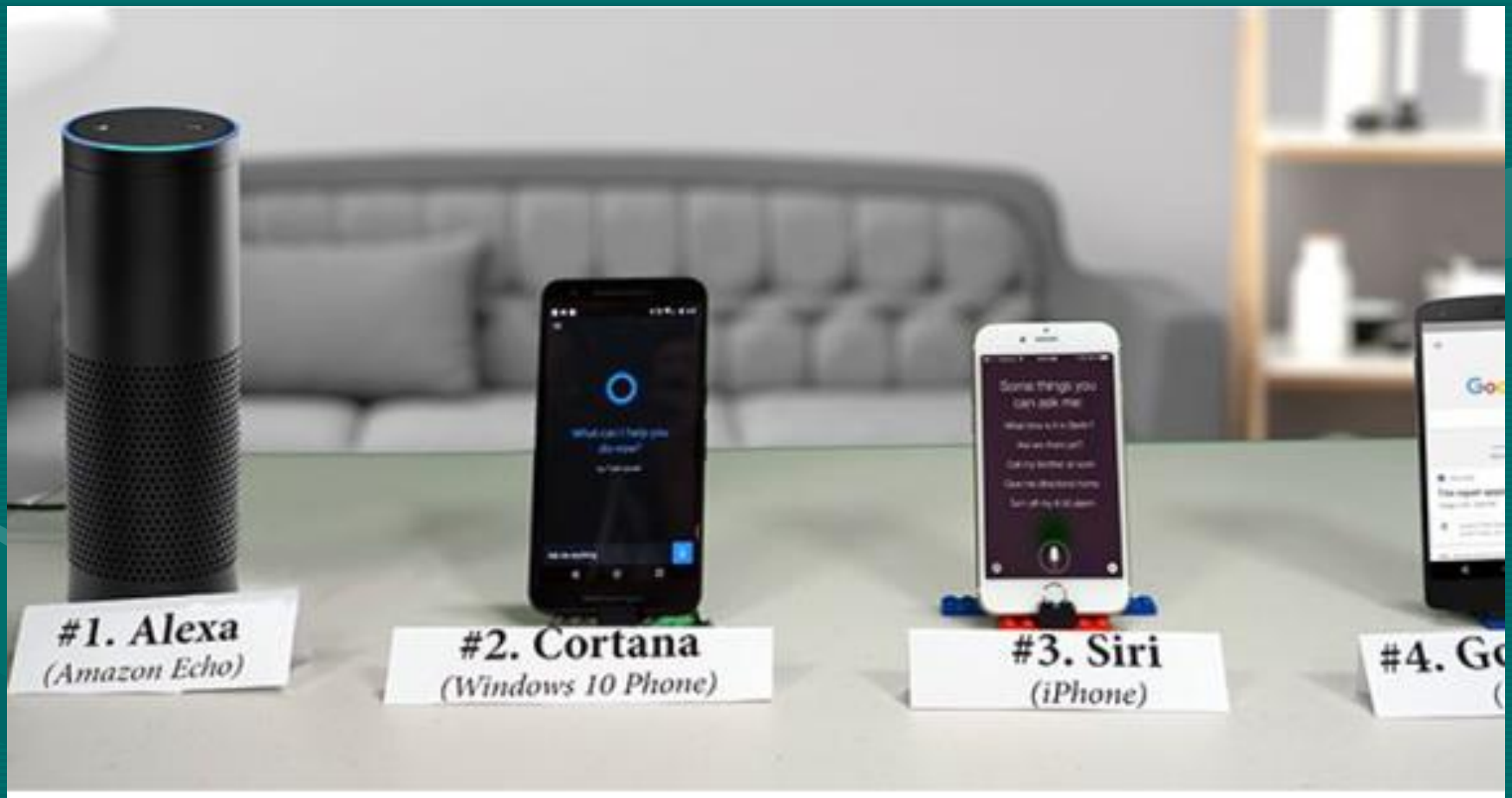
OpenAI Five Beats World Champion DOTA2 ...
youtube.com

Alpha Go & Alpha Zero

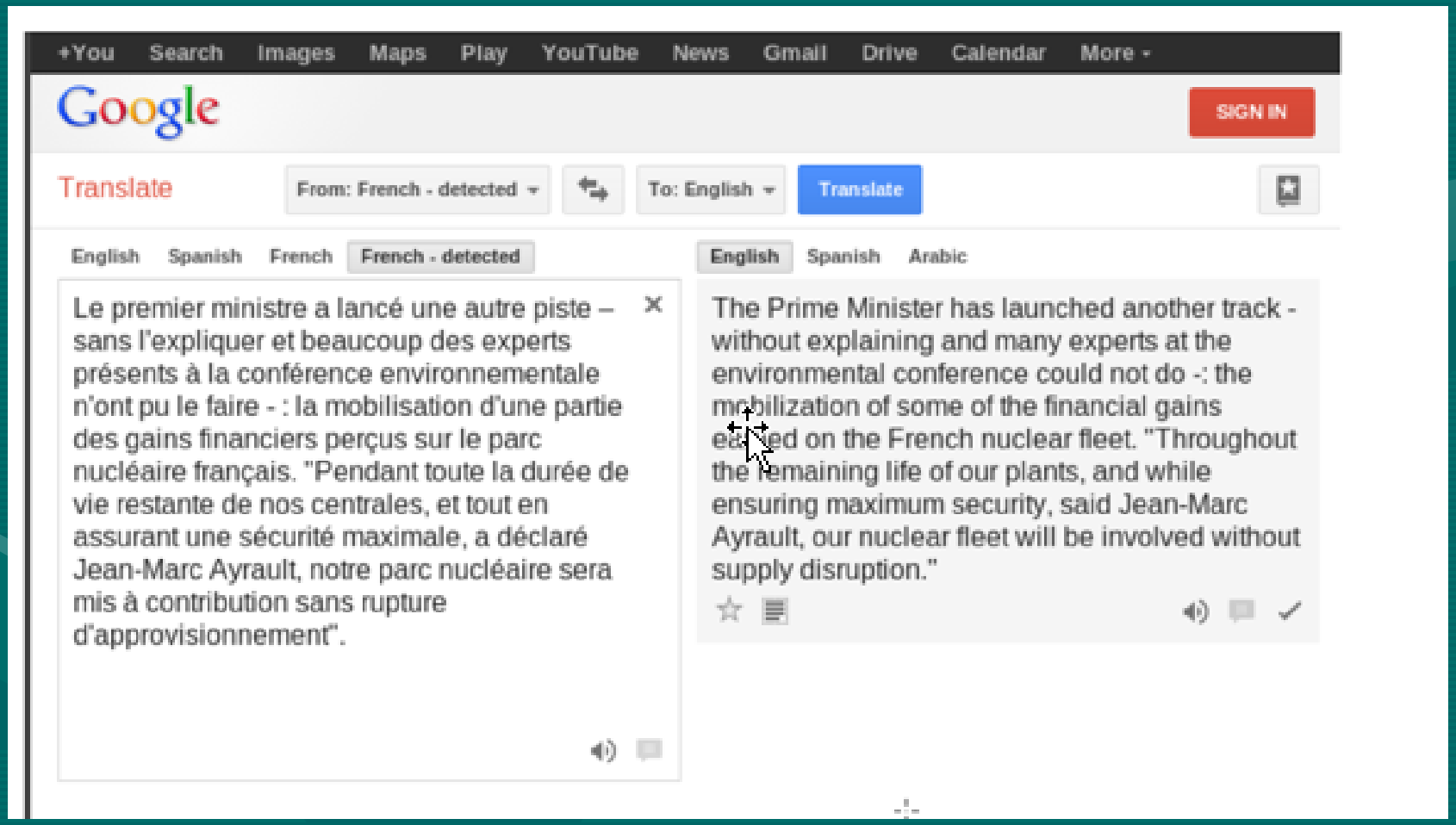


Autonomous vehicles

Speech Recognition



Machine Translation



Reading comprehension

In meteorology, precipitation is any product of the condensation of atmospheric water vapor that falls under gravity. The main forms of precipitation include drizzle, rain, sleet, snow, graupel and hail... Precipitation forms as smaller droplets coalesce via collision with other rain drops or ice crystals within a cloud. Short, intense periods of rain in scattered locations are called "showers".

What causes precipitation to fall?
gravity

What is another main form of precipitation besides drizzle, rain, snow, sleet and hail?
graupel

Where do water droplets collide with ice crystals to form precipitation?

Image generation

From the early days of AI – big developments recently

NLP, NLU & NLG

Eliza (Weizenbaum, 1964-1968): a simple program that induced delusion

- Human: Well, my boyfriend made me come here.
- ELIZA: Your boyfriend made you come here?
- Human: He says I'm depressed much of the time.
- ELIZA: I am sorry to hear you are depressed.
- Human: It's true. I'm unhappy.
- ELIZA: Do you think coming here will help you not to be unhappy?

The Eliza Effect

- The tendency to unconsciously assume computer behaviors are analogous to human behaviors
- The effect is named for the 1966 chatterbot ELIZA, developed by MIT computer scientist Joseph Weizenbaum.

NLU All beginnings are difficult…

Example: machine translation

The spirit is willing but the flesh is weak.

↓

(Russian)

↓

The vodka is good but the meat is rotten.

1966: ALPAC report cut off government funding for MT, first AI winter

LEARNING ASSOCIATIONS

SEMANTIC UNDERSTADNING

Word context is determined according to <u>word order</u>

- Muki's **dog** is cute
- Muki looks like a **dog**

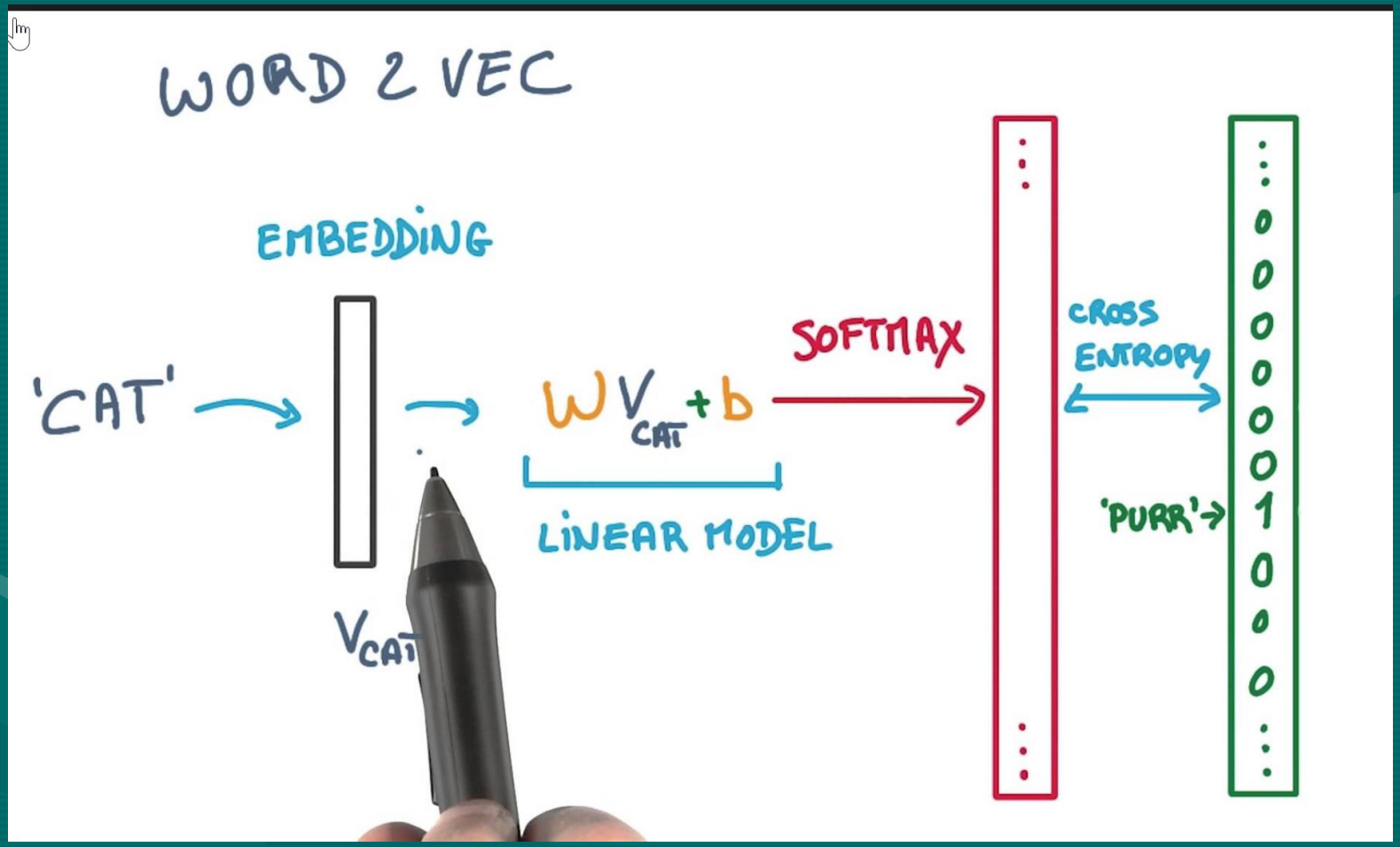
Word context is determined according to <u>world knowledge</u>

- **Tom Cruise** played in mission impossible
- The **actor** played in dozen more movies

Word Embeddings

- Represent words as a real-valued vector in some abstract space
- Goal: find representations that capture multiple degrees of similarity
- The skip-gram model:
- Maximize the average log probability of predicting surrounding words

Word2Vec: Predict the target from its context and vice versa



Analogies Artifacts

Differences in vectors capture relations:

$$\theta_{\text{france}} - \theta_{\text{french}} \approx \theta_{\text{mexico}} - \theta_{\text{spanish}} \text{ (language)}$$

$$\theta_{\text{king}} - \theta_{\text{man}} \approx \theta_{\text{queen}} - \theta_{\text{woman}} \text{ (gender)}$$

$$\theta_{\text{king}} - \theta_{\text{man}} + \theta_{\text{woman}} \approx \theta_{\text{queen}}$$

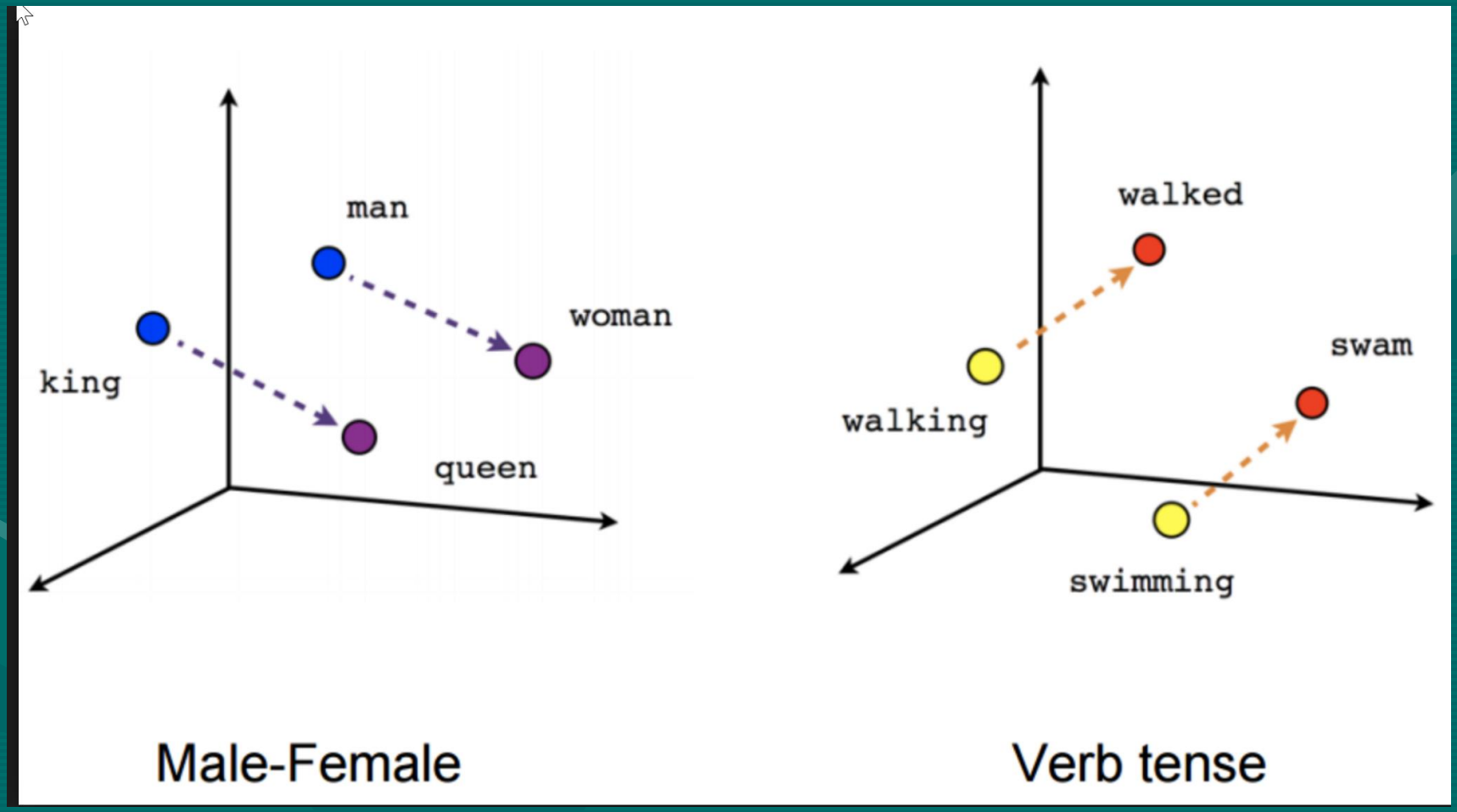
Data as a social mirror:

$$\theta_{\text{computer programmer}} - \theta_{\text{man}} + \theta_{\text{woman}} \approx \theta_{\text{homemaker}}$$

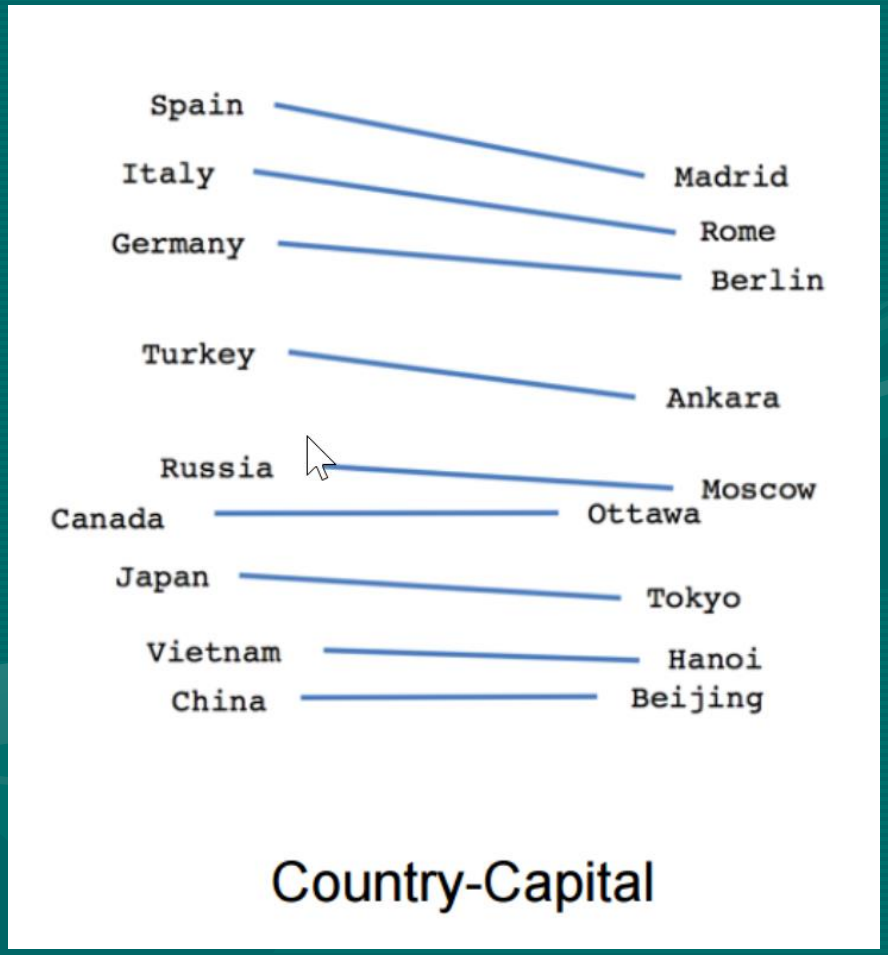
$$\theta_{\text{doctor}} - \theta_{\text{father}} + \theta_{\text{mother}} \approx \theta_{\text{nurse}}$$

$$\theta_{\text{feminism}} - \theta_{\text{woman}} + \theta_{\text{man}} \approx \theta_{\text{convervatism}}$$

Word2Vec Projections



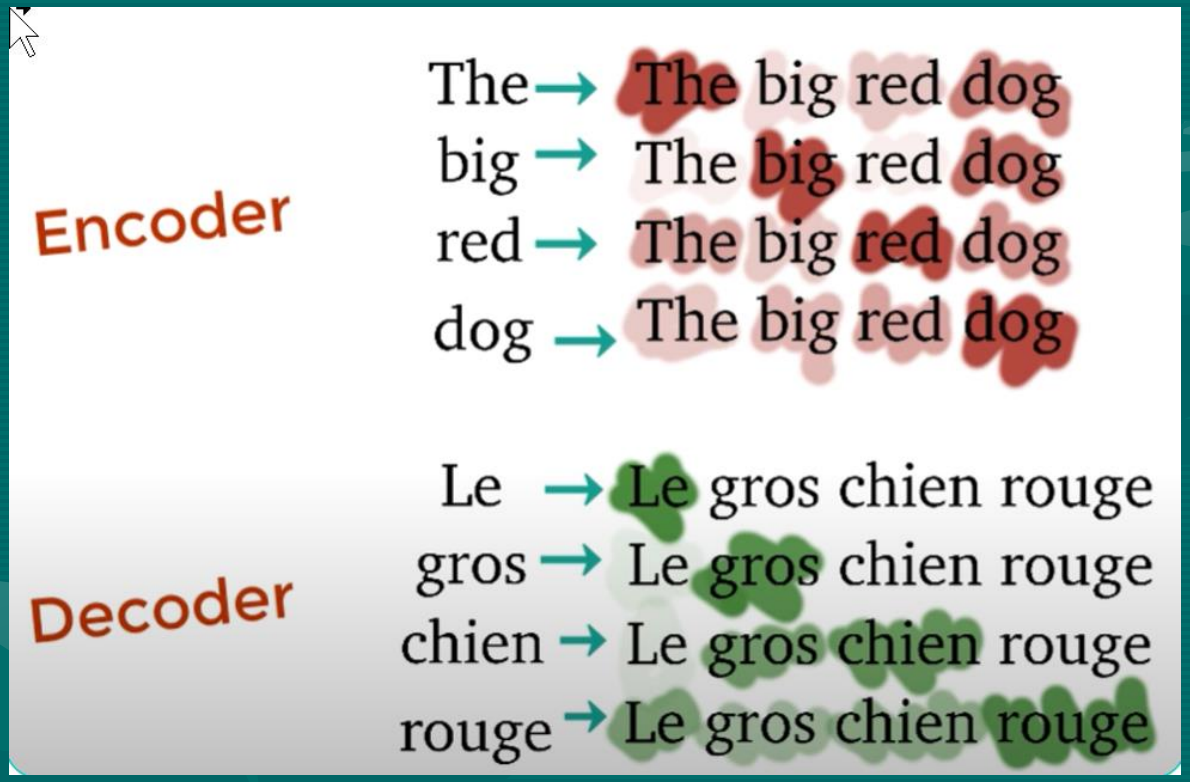
Word2Vec Yields Semantic connectivity



The Transformer deep learning model

- Transformers are designed to handle sequential data
- Allowing faster learning by parallelization.
- **Attention mechanism**: let a model directly look at, and draw from, the state at any earlier point in the sentence.
- Advantage: does not need to process the beginning of it before the end.

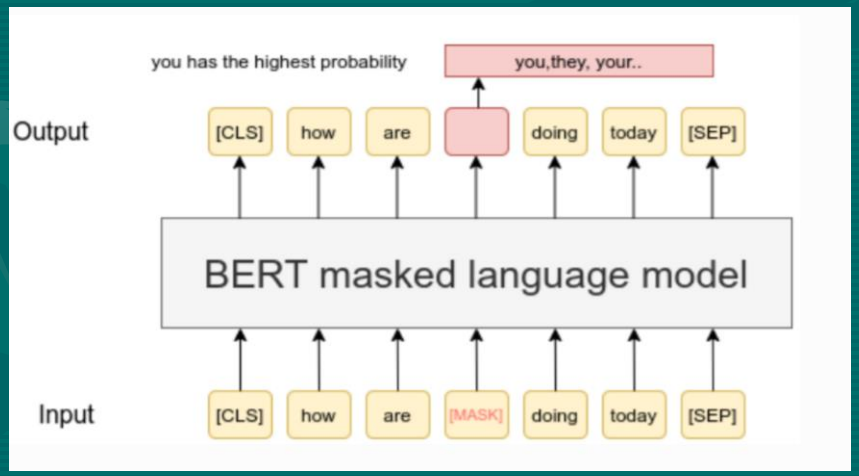
Language Translation



The Transformer model (Google, Dec. 2017)

- A Smart predictor of text – priming & bootstrapping

1. User inputs text snippet
2. The transformer prints its prediction for the next paragraph
3. Uses its prediction as the next input
4. Loop…



2020 NLG engine / Language Model

GPT-3: GENERATIVE PRE-TRAINED TRANSFORMER:

Behind GPT-3

- An unsupervised learner;
- Researchers fed it a large corpus of the internet, from popular Reddit posts to Wikipedia to news articles to fan fiction.
- Simple train task: guess what words are most likely to come next, given a certain initial prompt.

GPT-3 was released on May 2020

- Compose short stories, songs, press releases, technical manuals, directions & tweets
- Text in style of specific writers
- Multilingual – Language translation
- Produce HTML (‘generate a button that looks like a watermelon”)
- Questions & Answers

GPT-3 Q & A Example

- Human: How many eyes does a giraffe have?

  GPT-3: A giraffe has two eyes.
- Human: How many eyes does my foot have?

  GPT-3: Your foot has two eyes.
- Human: How many eyes does a spider have?

  GPT-3: A spider has eight eyes.
- Human: How many eyes does the sun have?

Language Generation

Poem Generation

- Dr. Seuss poems - Elon Musk:

"But then, in his haste,
he got into a fight.
He had some emails that he sent
that weren't quite polite.
The SEC said, "Musk,
your tweets are a blight."

Code Generation

- https://www.youtube.com/watch?v=rqSmqejnJMY&ab_channel=Josode