History and Definitions

CPSC 383: Explorations in Artificial Intelligence and Machine Learning
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Outline

- History of field of AI
- Connectionist vs. Symbolic
- The state of the art

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Standing on the shoulders of ?

(not AI quite yet but maybe soon)

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Origin of AI

- The concept of a "**thinking machine**" can be dated back to ancient times, when Greek myths and legends portrayed mechanical beings endowed with intelligence.

- 17th century philosopher **René Descartes** compared the human brain with a machine
  - debated that mathematics can explain how the human brain operates.

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Pre-history

Philosophy	logic, methods of reasoning mind as physical system foundations of learning, language, rationality
Mathematics	formal representation and proof algorithms, computation, (un)decidability, (in)tractability Probability
Psychology	adaptation phenomena of perception and motor control experimental techniques (psychophysics, etc.)
Economics	formal theory of rational decisions
Linguistics	knowledge representation Grammar
Neuroscience	plastic physical substrate for mental activity
Control theory	homeostatic systems, stability simple optimal agent designs
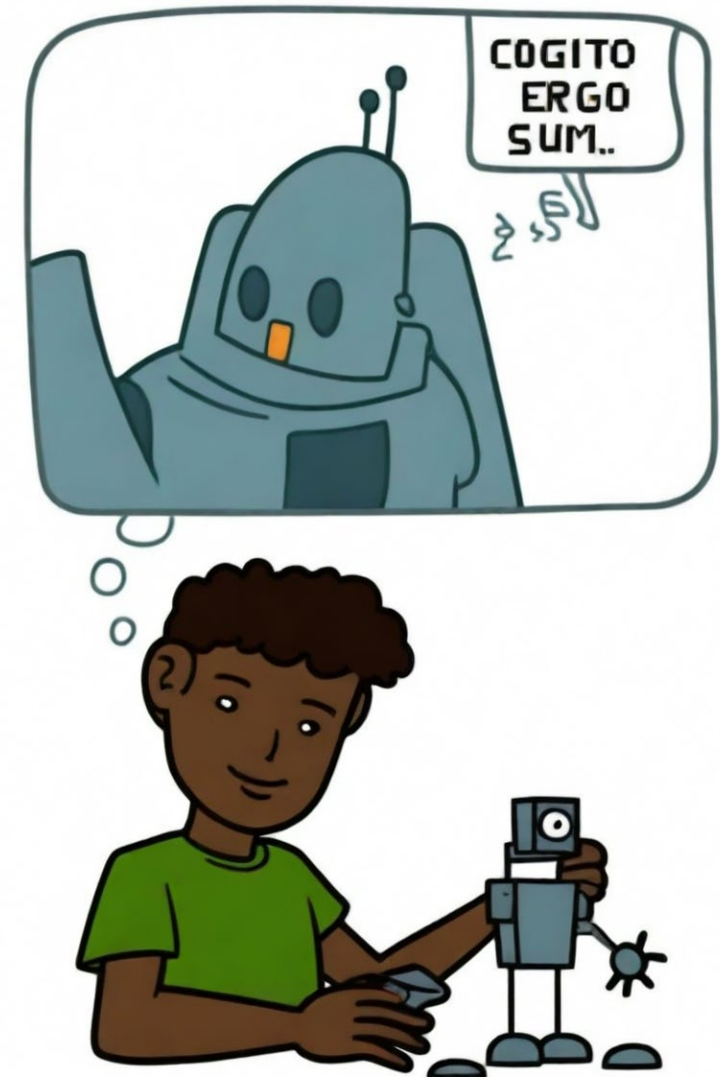
"The Analytical Engine has no pretensions whatever to originate anything. It can do whatever we know how to order it to perform. It can follow analysis; but it has no power of anticipating any analytical relations or truths."

Ada Lovelace [Mid 1800s]

(First computing AI philosopher?)

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Ride the wave

- 1940-1950: Early days
  - 1943: McCulloch & Pitts: **Early neural network ideas**
  - **1950: Turing's "Computing Machinery and Intelligence"**

- 1950—74: Excitement: Look, Ma, no hands!
  - 1950s: Early AI programs
  - **1956: Dartmouth Conference: "Artificial Intelligence" adopted**
  - 1969-79: Early development of knowledge-based systems

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GPS

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no not that one

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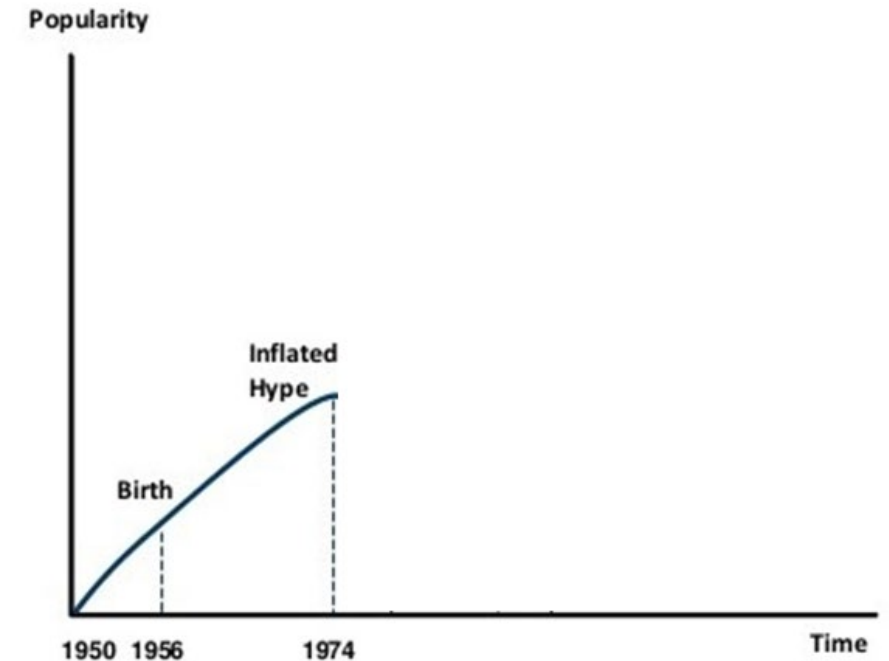
General Purpose Problem Solvers

Goals: Develop computer programs that show an intelligent behavior and that can serve as companion to human beings.

Example: the **GPS** program (General Problem Solver) "describe problem in logic and it will solve it using logical inferences"

Result: Complete failure and enormous negative reaction in media (and elsewhere)

Problems: One knowledge representation scheme with one knowledge processing mechanism not enough + search spaces are enormous.

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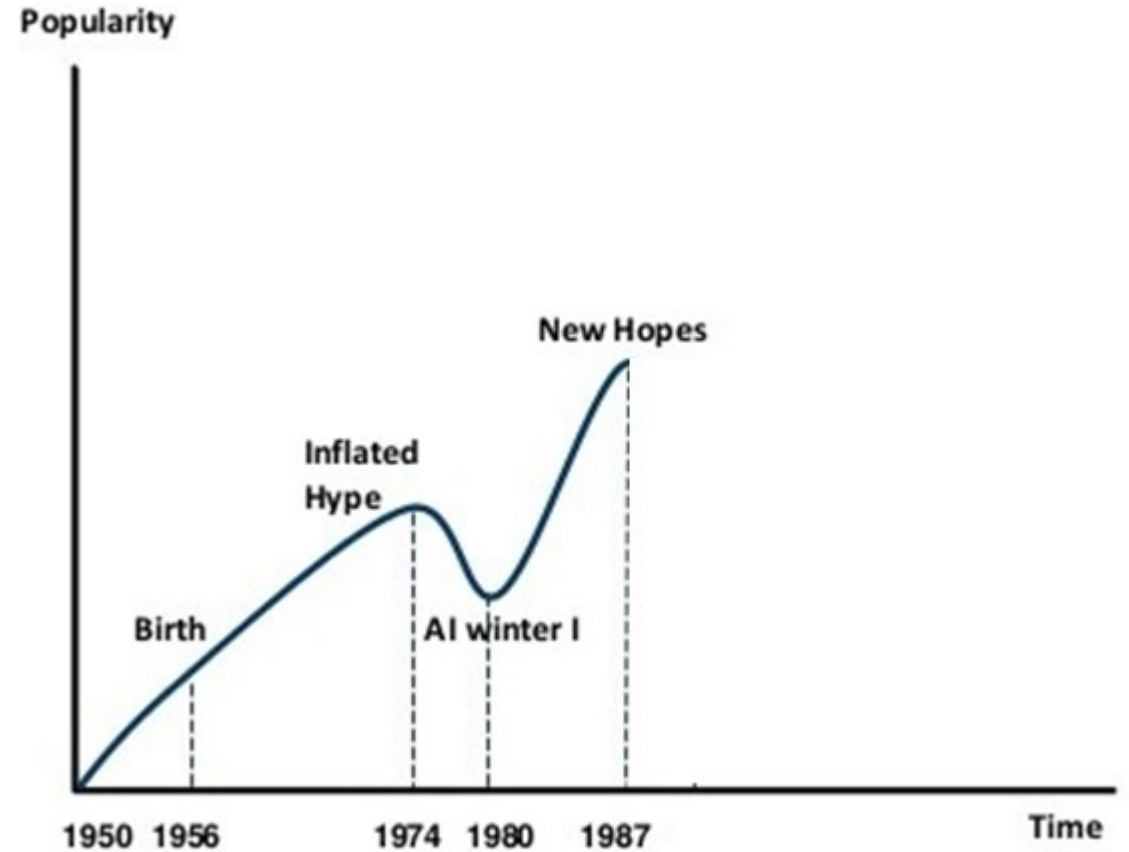# AI Winter

We're number one!

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Failure and New Hopes

- 1974—80: AI Winter I

- 1970—90: Knowledge-based approaches
  - 1969—79: Early development of knowledge-based systems
  - 1980—88: **Expert systems industry booms**

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Bubbling

Goals: Select a field in AI and an application area and "make it work"

Examples:

- Natural language understanding and dictating
- Expert systems for configuration and diagnosis in small application areas
- Playing a game
- Scoring high in intelligence tests

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Expert Systems: We did it mom

Result: It (**expert systems**) worked within the expectations

Expert systems – develop one knowledge representation and solution for one specific problem at a time

Problems:

- Very different methods used in different fields

- Application areas very specialized

- Systems resemble "idiot savante" (person without any interest outside his/her field)

- Hard problems still a problem

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AI Winter^2

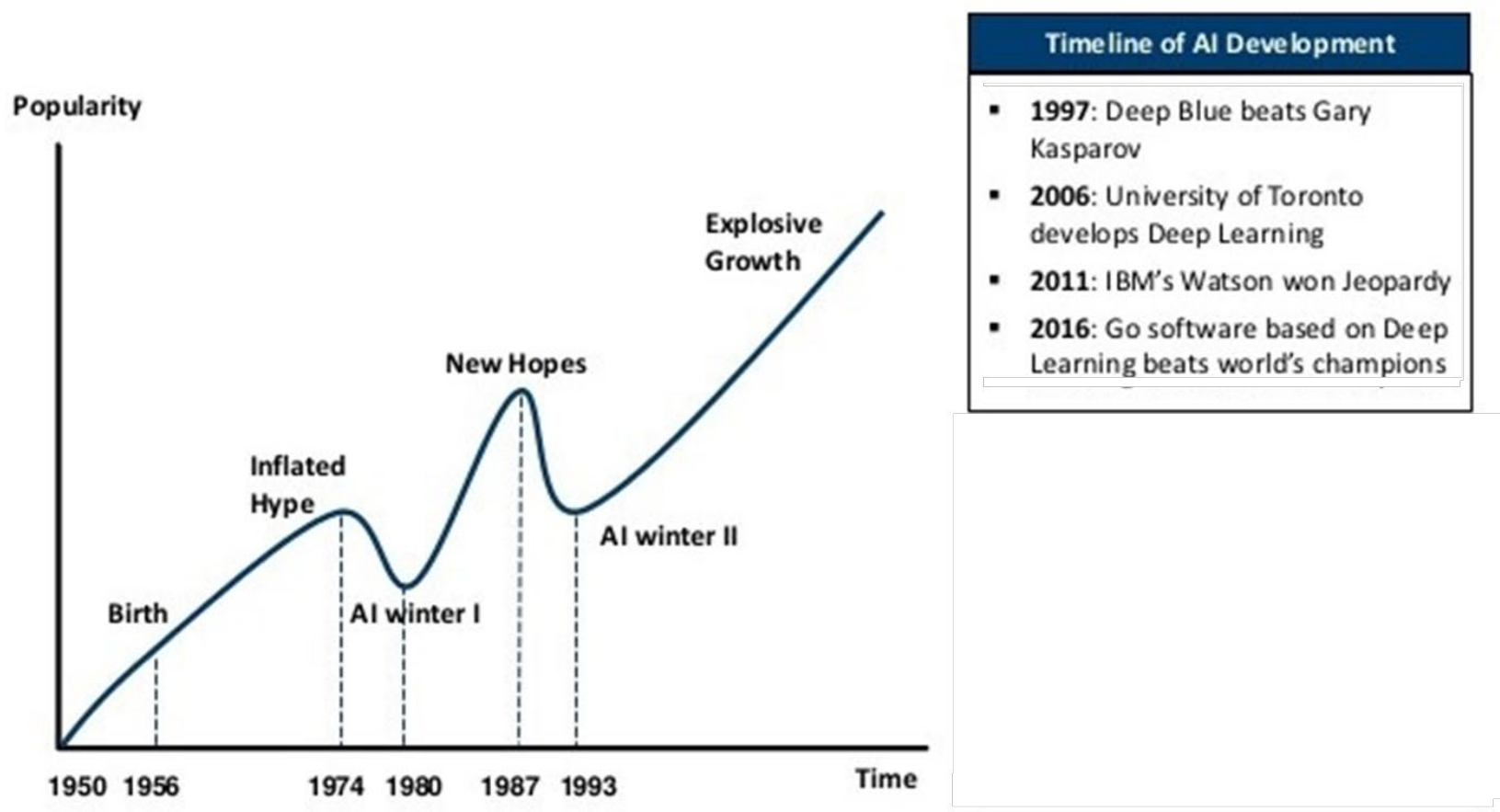We're number two!

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Failure Mark II and but an awakening

- AI Winter II
  - 1987—93: Expert systems industry busts "AI Winter"

- 1990—: Statistical approaches
  - **Agents and learning systems… "AI Spring"**
    - Resurgence of probability, focus on uncertainty
  - **Connectionist 'Machine Learning' ascendence**
  - Willingness to use AI in marketing again

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Artificial Intelligence (AI) in Computer Science

AI HAS A LONG HISTORY OF BEING "THE NEXT BIG THING"...

Timeline of AI Development

- **1997**: Deep Blue beats Gary Kasparov
- **2006**: University of Toronto develops Deep Learning
- **2011**: IBM's Watson won Jeopardy
- **2016**: Go software based on Deep Learning beats world's champions

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Connectionist vs Symbolic

Connecting the symbols?

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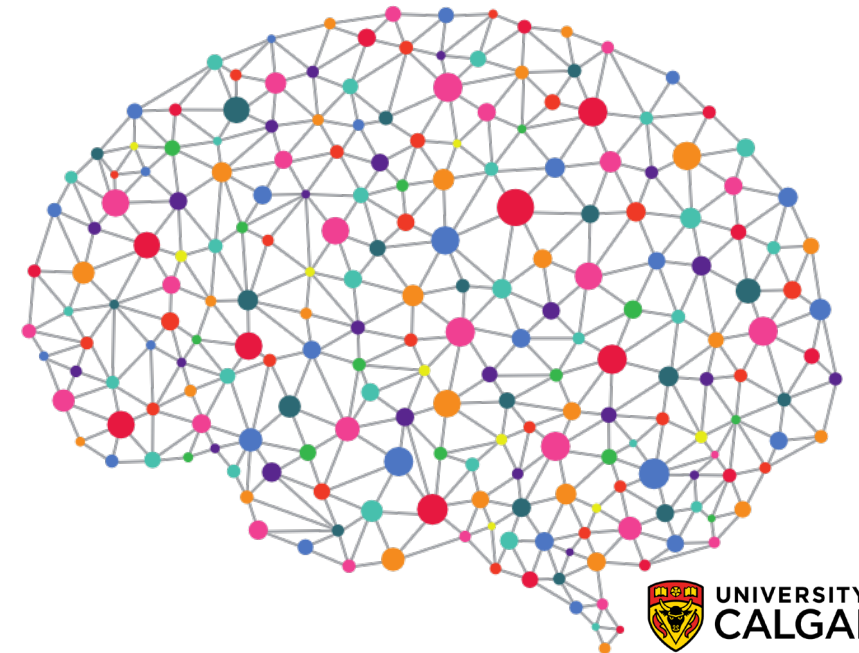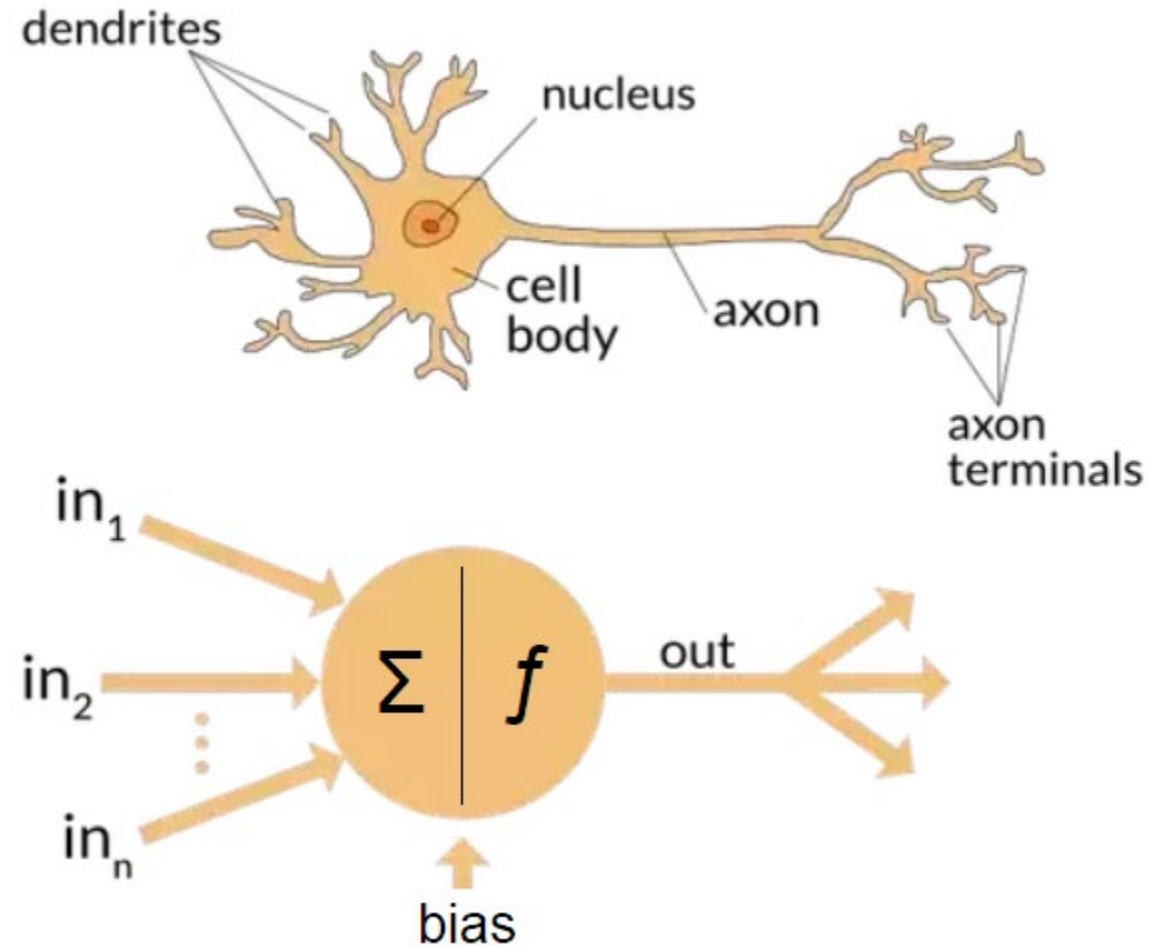
Connectionist?

- Inspired by the Human Brain.

- The human brain has about 86 Billion neurons and requires 20% of your body's energy to function.

- Connectionist method
  - Make network, train, hope result is useful
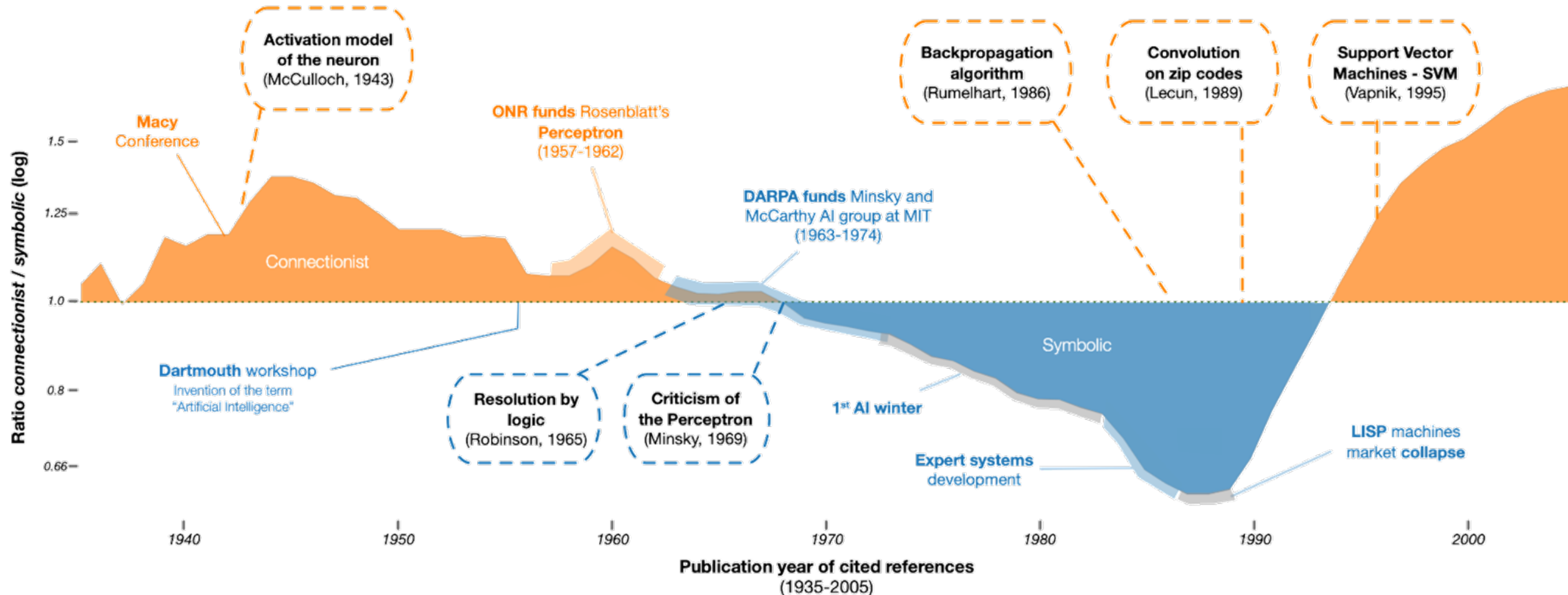
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Neuron Model of Connections

- Developed to mimic the human neural system (in the brain) and its processing capabilities

- Simple components, the intelligence is in the connections

Connectionist vs Symbolic AI

Cardon, D., Cointet, J.-P. & Mazieres, A. (2018). Neurons spike back. The invention of inductive machines and the artificial intelligence controversy. *Réseaux*, 36(211), 173-220.

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A short history of Neural Networks

- 1957: Perceptron (Frank Rosenblatt): one layer network neural network
- **First AI Winter (General problem solvers)**
- 1988: Backpropagation (faster training)
- 1989: ALVINN: autonomous driving car
- 1989: (LeCun) Handwritten ZIP codes on mail
- **Second AI Winter (Expert systems)**
- 2012: Convolutional neural networks (vision)
- 2010: Deep learning
- 2017: Transformers (Like Chat-GPT)
- 2020s: LLM and Generative AI enabling
  - (near-human capabilities for image recognition, speech recognition, and language translation)

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Current

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Current
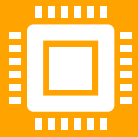
After second AI Winter computer science made a lot of progress on taking the specialized system on the symbolic side and generalizing their ideas

On the other side our computing power reached the point that connectionist became powerful again

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Post AI Winter II (1990s ->)

New developments and Applications :

- Multi-Agent Systems:
  - Cooperation concepts to bring together the many specialized systems to tackle harder tasks

- The Internet
  - Requires agents for "intelligent" routine tasks that are specialized and limited

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Post AI Winter II (2000s ->)

- Service-based computing:
  - Offer functionality at your web site and allow others to use it
    (☞ describe service and how to access it, best in a form understandable by a program)

- Self-X Systems:
  - Started as IBM's (and now others) code for learning/adaptive systems
  - Sees more and more areas within CS that want to include learning/adaptation into their concepts and systems
  - Self-organization, self-healing, …

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Post AI Winter II (2010s ->)

- Machine Learning:
  - Not new but resurgence
  - Good at seeing patterns in images, classifying things with many parts (text), filtering by pattern, chat systems, modeling complex things like, voice recognition, etc.
  - Currently most research is deep learning neural networks

- Deep Learning:
  - Machine learning with large neural networks, LLMs

- Areas in AI grow together:
  - Personal assistants like Alexa: restricted natural language understanding, machine learning, (intelligent) search techniques in the Internet and use of service-based computing
  - Watson: dedicated knowledge representation for an application area, machine learning to add to represented knowledge (often using natural language understanding) and restricted inference mechanisms

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Current

- Popular areas: Deep learning (neural networks), machine learning (AI for finding patterns), digital assistants (connect symbolic systems), service architectures, internet of things, self-automation, etc.

- Things likely less close than you have been sold: universal self-driving cars (visual identification has a lots of weaknesses), machine intelligence (?), true generic systems (we've generalized but there's usually a lot more specificity under the hood than you think)

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Future

AI - The Future ? (I)

- Specialized agents (avatars) helping and representing users (in the new digital world, i.e. moving Siri/Alexa/... forward)
    - Agentic AI

- "Command-and-Control" systems for management
  ☞ Management by exception

- Cooperating intelligent robots in disaster areas and hostile environments represent humans acting out of save environments

- Automation of trade and commerce
  ☞ Management by Policies

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AI - The Future ? (II)

In general AI enhances what a human being can do intellectually (assistants)

Still hard problems:

- Achieving necessary flexibility to interact with human beings in real world
- Find concepts to combine the methods of the different fields
- Common sense reasoning

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Next... Agents

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