SENIOR RESEARCH: SOME FINAL THOUGHTS

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How to read a research article

- What is the research problem, motivation, significance?
- What are the main findings?
- How do the authors try to convince you that these findings are valid? Experiments? Observational studies? Proofs?
- How does this work fit in the broader discipline?
- What are limitations of the work?
- How can the work be followed up on?

Writing a research paper, proposal, etc.

- Write with specificity and clarity
  - Background
  - Significance
  - Objective (should be explicitly stated)
  - Results
  - Discussion
  - Etc
- Follow instructions and do not make any spelling or grammatical mistakes!

What did you guys learn?

- Cybersecurity
  - *An Analysis of Data Deletion Methods and their Artifacts*
  - *An Analysis of Social Engineering Attacks on AI Detection Model Security*
  - *Cybersecurity Practices Among Computer Science Students vs Non-Computer Science Students*

What did you guys learn?

- Software Engineering, Web Scraping, and Databases
  - *Performance Benchmarking of Monolithic and Microservice Architectural Styles*
  - *NoSQL vs SQL Aggregate Queries: Quantitative Examination of MongoDB and SQL Performance*
  - *Effects of High Value HTML Tags on Web Scraping Efficiency*

What did you guys learn?

- Computer Simulations
  - *Performance Evaluation of Fixed-time, Heuristic, and Q-Learning Traffic Signal Control Strategies in SUMO*
- Computer Science Education
  - *Studying the Effects of Gamified Feedback on Student Learning and Confidence in a Self-Guided Learning Environment*
- Artificial Intelligence – Large Language Models
  - *Reference Hallucination Rates in Large Language Models*
  - *Can Generative AI Produce A Good Let's-Play*
  - *The Effect of Prompt Engineering Techniques on LLM Performance*

What did you guys learn?

- Artificial Intelligence & Analytics
  - *Using Weighted Bart Torvik Metrics to Achieve an Optimal Bracket Score*
  - *A Reproducible Workflow for Preliminary Reverse Engineering of Jaguar F-Type CAN Traffic for Future Powertrain Integration*
  - *Six Degrees of Wikipedia: Evaluating Separation in a Network of Articles*
  - *Interpretable Machine Learning for Predicting Energy Assistance Demand in Windham and Tolland Counties, Connecticut*

CS and the Future: Random Thoughts

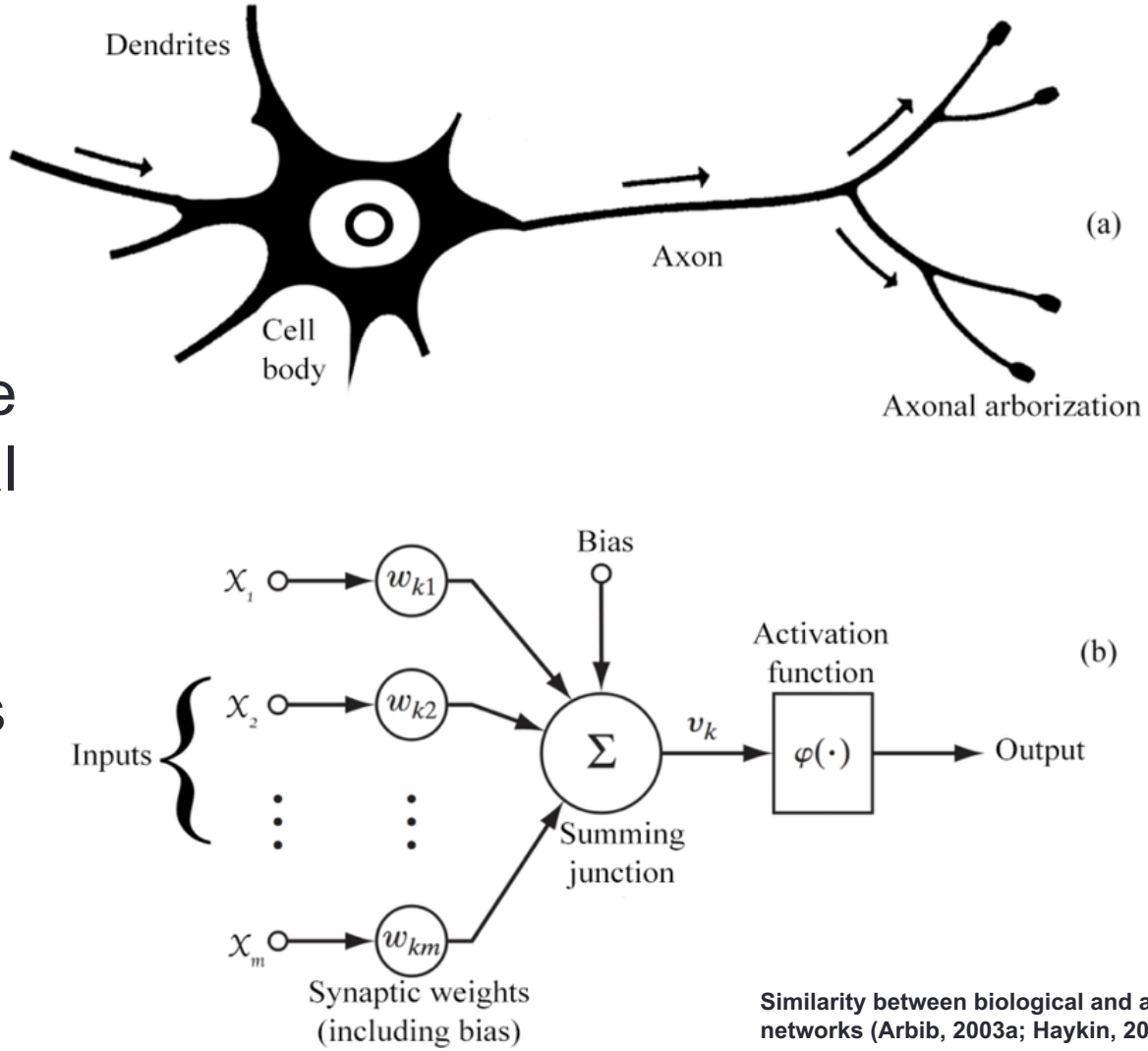
- What digital privacy rights do we have?
  - Do we have the "right to be forgotten?"
    - https://www.theguardian.com/world/2019/nov/28/german-court-backs-murderers-right-to-be-forgotten-online
- Supreme Court cases:
  - Cell phone searches require a warrant (Riley vs. California)
    - http://www.cnn.com/2014/06/25/justice/supreme-court-cell-phones/
  - A warrant is needed to access cell phone location information (Carpenter v. U.S.)
    - https://www.newyorker.com/news/daily-comment/in-carpenter-the-supreme-court-rules-narrowly-for-privacy
  - Are geofence warrants constitutional? Stay tuned
    - https://www.reuters.com/legal/government/us-supreme-court-weighs-lawfulness-geofence-warrants-crime-probes-2026-04-27/

CS and the Future: Random Thoughts

- "Software is eating the world"
  - Marc Andreessen, 2011 (venture capitalist and co-founder of Netscape)
- "Software is eating the world, but AI is going to eat software"
  - Jensen Huang, 2017, CEO of Nvidia

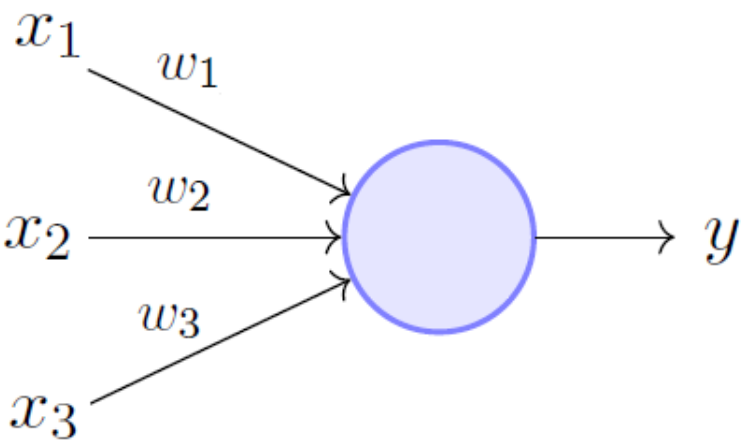
- Applications of AI
  - AI in Medicine: https://www.weforum.org/stories/2025/03/ai-transforming-global-health/
  - AI in cybersecurity: https://www.forbes.com/sites/daveywinder/2024/11/05/google-claims-world-first-as-ai-finds-0-day-security-vulnerability/
  - AI for coding:
  - https://www.businessinsider.com/google-ai-generated-code-75-gemini-agents-software-2026-4

- Artifical neural networks (ANNs) are inspired by biological neural networks
- A neuron receives inputs, and *fires* if its inputs exceed a threshold



Similarity between biological and artificial n networks (Arbib, 2003a; Haykin, 2009b).

Perceptron



$$\begin{cases} 0 \text{ if } \sum w_i x_i < b \\ 1 \text{ if } \sum w_i x_i \geq b \end{cases}$$

$$\sum w_i x_i = w_1 x_1 + w_2 x_2 + w_3 x_3$$

A perceptron consists of a single neuron that ”fires” if the sum of its weighted inputs exceeds a threshold (i.e., the bias term, b)

Image from: https://towardsdatascience.com/what-is-a-perceptron-210a50190c3b

Perceptron

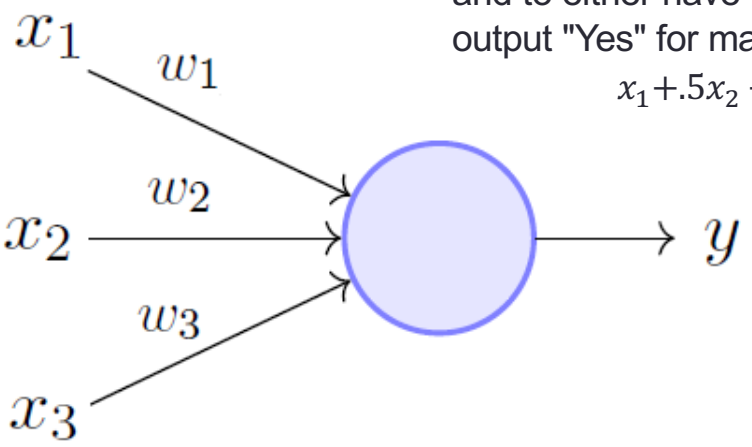
If we expect mammals to be warm-blooded and to either have fur *or* hair, then we might output "Yes" for mammal if, e.g.

$$x_1 + .5x_2 + .5x_3 > 1.3$$

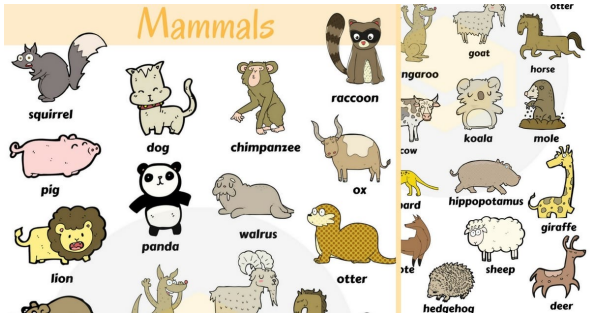
Warm-blooded (Y = 1, N = 0)

Fur (Y = 1, N = 0)

Hair (Y = 1, N = 0)



Mammal (Yes or No)



Input	Score	Output (Mammal?)
Warm-blooded, no fur, no hair	1	No (score is NOT > 1.3)
Not warm-blooded, hair only	0.5	No (score is NOT > 1.3)
Warm-blooded, fur, no hair	1.5	Yes (score is > 1.3)

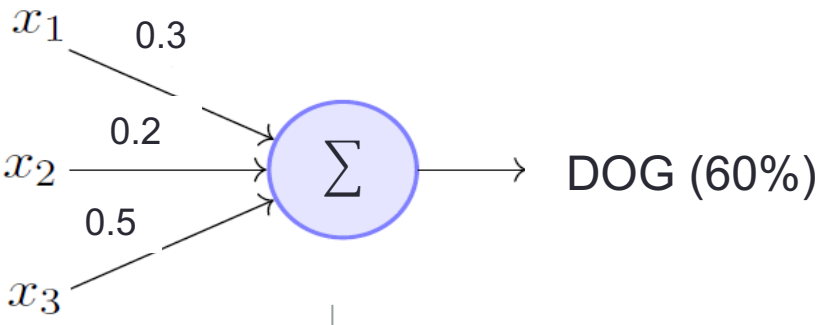
Image from: https://towardsdatascience.com/what-is-a-perceptron-210a50190c3b

Machine Learning (Neural Networks)

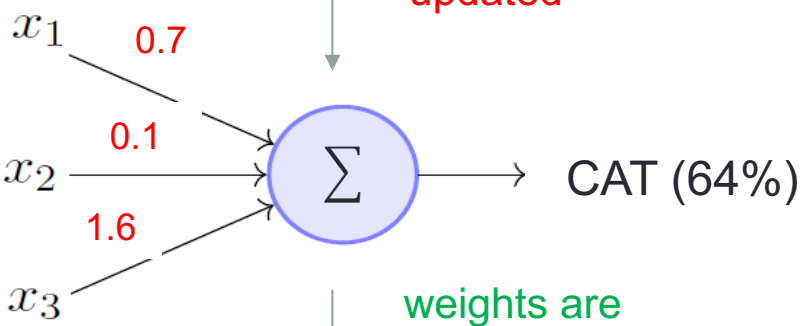
Input

Output

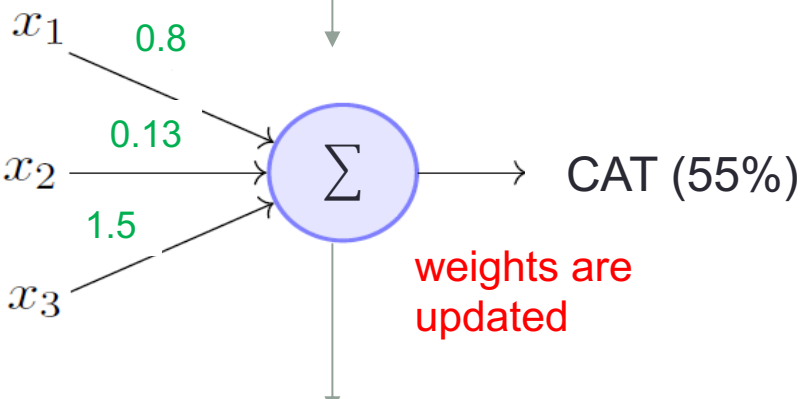
Training



weights are updated



weights are updated



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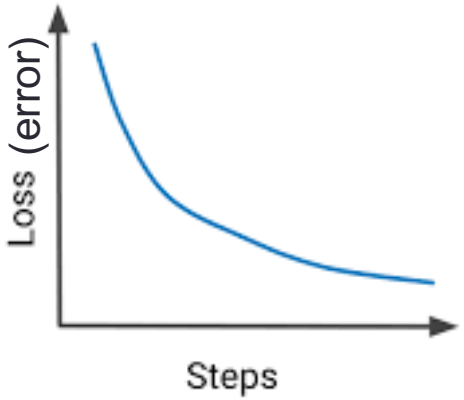
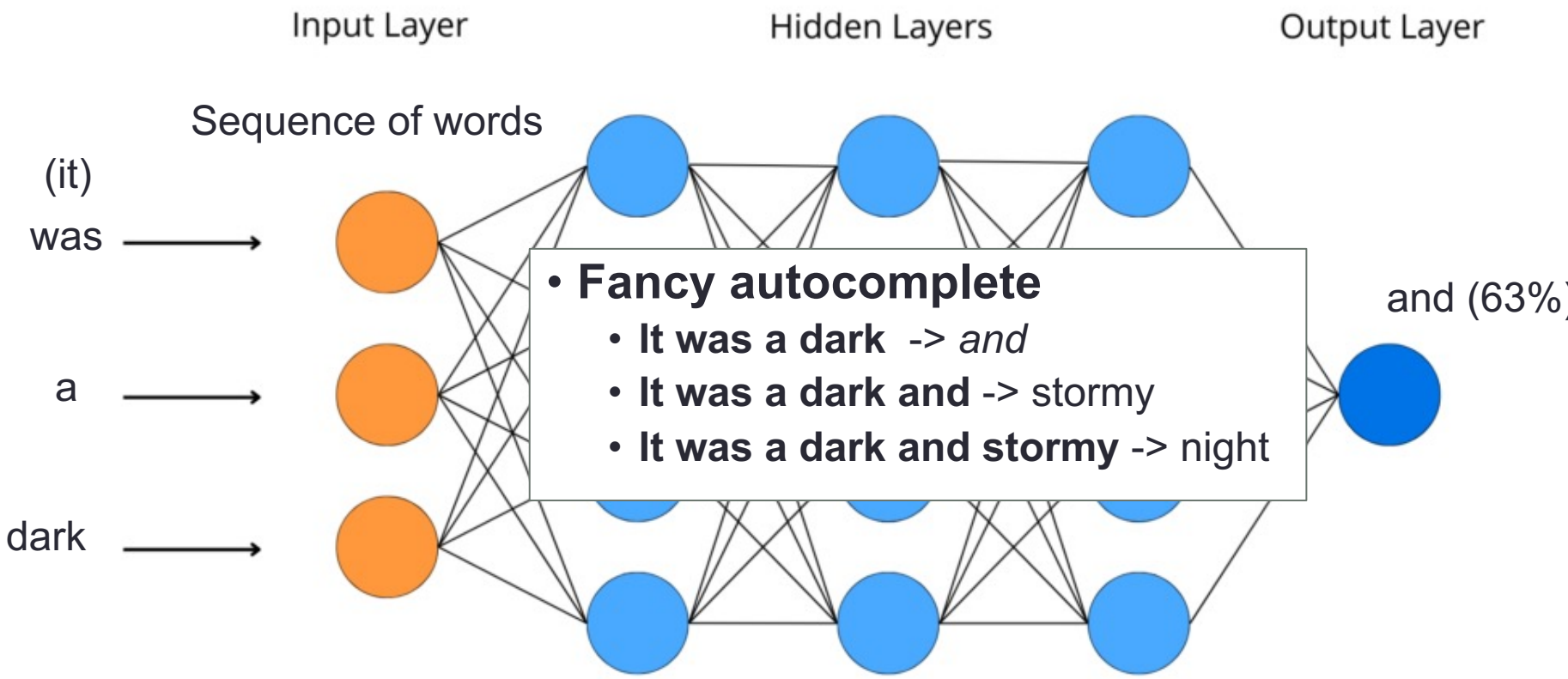


ChatGPT

Dataset	Quantity (tokens)	Weight in training mix	Epochs elapsed when training for 300B tokens
Common Crawl (filtered)	410 billion	60%	0.44
WebText2	19 billion	22%	2.9
Books1	12 billion	8%	1.9
Books2	55 billion	8%	0.43
Wikipedia	3 billion	3%	3.4

GPT-3: 175 billion parameters
GPT-4: 1.3 trillion parameters (estimate)
Human brain: 100 – 1000 trillion synapses

T. Brown *et al.*, "Language Models are Few-Shot Learners," in *Advances in Neural Information Processing Systems*, Curran Associates, Inc., 2020, pp. 1877–1901.



Fine-tuning from human feedback

Table 2: Illustrative prompts from our API prompt dataset. These are fictional examples inspired by real usage—see more examples in Appendix A.2.1.

Use-case	Prompt
Brainstorming	List five ideas for how to regain enthusiasm for my career
Generation	Write a short story where a bear goes to the beach, makes friends with a seal, and then returns home.
Rewrite	This is the summary of a Broadway play: """ {summary} """ This is the outline of the commercial for that play: """

L. Ouyang *et al.*, "Training language models to follow instructions with human feedback," *Advances in Neural Information Processing Systems*, vol. 35, pp. 27730–27744, Dec. 2022.

Impact of technology

- Welcome to the Internet: https://www.youtube.com/watch?v=k1BneeJTDcU
- Something (seemingly) happened to young people in the early 2010s that triggered a surge of anxiety and depression? https://www.anxiousgeneration.com/research/the-evidence
- Misinformation on FB gets 6x as much engagement as posts from reputable news sources
  - https://www.businessinsider.com/facebook-study-misinformation-six-times-more-engaged-with-than-news-2021-9

Impact of technology

- “Our attention is a limited resource. When we pay attention to one thing, we’re not paying attention to something else. This fact of life has been deeply complicated by technology.” https://www.humanetech.com/youth/the-attention-economy

- “It would be a shame if brilliant technology were to end up threatening the kind of intellect that produced it” ~Edward Tenner
  - https://www.nytimes.com/2006/03/26/opinion/searching-for-dummies.html

AI as a tool in CS

- “I’d say maybe 20%, 30% of the code that is inside of our repos today and some of our projects are probably all written by software” ~ Satya Nadella, Microsoft CEO[1]
- “New Junior Developers Can’t Actually Code…The future isn’t about whether we use AI—it’s about how we use it. And maybe, just maybe, we can find a way to combine the speed of AI with the depth of understanding that we need to learn.” ~ Namanyay, software developer[2]
- “The future is about using AI as a tool”[3]

1. https://www.cnbc.com/2025/04/29/satya-nadella-says-as-much-as-30percent-of-microsoft-code-is-written-by-ai.html
2. https://nmn.gl/blog/ai-and-learning
3. https://www.forbes.com/councils/forbestechcouncil/2024/12/02/why-ai-wont-replace-programmers-a-comparison-with-robots/

Peter Drucker