Code Smarter, Not Harder: Unlocking AI-Assisted Coding

Coffee, Cookies, and Coding (C3) Workshop by the Public Health Data Science and Data Equity team

Shelby Golden, M.S.

March 23rd, 2026

Background image was generated using Gemini.

Shelby Golden, M.S.

- Worked 7 years as a Molecular Biologist and Biochemist.
- Received a Masters in Applied Computational Mathematics from Johns Hopkins University in 2024.

Today's Learning Objectives

01 Foundational AI Literacy: Explain AI's evolution, distinguish system types, and define AI (~ 30 minutes)

02 Learn the tool landscape, prompting best practices, and common pitfalls (~ 15 minutes)

03 Replicate a paper using NHANES using different AI tools, practicing prompting and debugging (~ 15 minutes)

Our Choice Resources

- AI at Yale
- Yale's Data-Intensive Social Science Center (DISSC) "Artificial Intelligence and Machine Learning for Social Science Research" page for events and content lead by Nick Warren
- *Artificial Intelligence Basics: A Non-Technical Introduction* by Tom Taulli
- *The Cambridge Handbook of Artificial Intelligence* edited by Keith Frankish and William M. Ramsey
- "What is a neural network?", "... machine learning?", "... generative AI?", "... large language models (LLMs)?" from IBM
- "What is Good Old-Fashioned AI?" by Harpreet Singh Kalsi

Accessing the Codespaces

We have prepared a script outline (with solutions) for the workshop's hands-on component. To use these materials, download the codebase and complete the setup steps listed below. Participants will also need access to an LLM chatbot and the ability to configure an IDE-based AI assistant with a provider.

If you haven't already, please ensure you have a current installation of R and the new Positron Integrated Development Environment (IDE) , a VS Code-based text editor developed by the same team behind Posit (formerly RStudio) [1]. If this is your first time installing Positron or configuring the AI assistant, you will need to complete a few setup steps:

1. **OPTIONAL:** Log into your GitHub account through the Positron Accounts tab
2. Enable the "Positron Assistant," the IDE's integrated AI coding assistant
3. Connect the "Positron Assistant" to a provider of your choice (e.g., Anthropic, Amazon Bedrock, GitHub Copilot)

Below are the full steps for configuring Positron with GitHub Copilot as your AI assistant. You are welcome to use any other supported provider, and for setup instructions for other compatible providers, refer to the Positron Getting Started page. We recommend using GitHub Copilot as your provider, as it offers a free standard tier, a 30-day Pro trial, and free Pro access for qualifying faculty and students.

To access the code for this workshop, you will need Git installed on your local device, a GitHub account, and both configured. If you have not set this up yet, please follow the instructions in Configurations and Credentials first.

> ⚠ Attribution and Ownership
>
> Please note that all materials provided in this workshop, including any code added to your personal repository, belongs to DSDE. When using or referencing this material, please ensure to cite it correctly to give proper credit to the original authors.

> ⓘ Settings Used in Development

AI Assisted Coding Worked-Through Example

The Art of Shrewd AI-Assisted Programming

A common academic use case for AI-assisted coding is replicating published research. Some papers come with ready-to-run code that's easy to pick up, while others leave you hunting for clues without any code at all. A complete A-Z replication would take more time than we have in this workshop, but the provided example shows how AI-assisted coding can help you expedite your replication process.

Undoubtedly, integrating AI into your workflows can quicken your process, but it also has the potential to create new headaches or amplify problems that arise when quality checks are skipped. As a data scientist or analyst, it's essential to always scrutinize your data processing and cleaning methods to ensure accurate data preparation. For example, check that nomenclature is informative and consistent, confirm that NAs aren't standing in for zeros (or vice versa), and verify that subsetting, grouping, or processing are performed in the right order to produce your expected outcome.

An AI is not going to be much help for you in this area—at least not reliably. You cannot expect it to completely or correctly identify all the data wrangling needed for a dataset, especially if your starting raw data is messy! Be especially careful when it suggests code that runs perfectly but doesn't actually do what you need. It may even produce results that kind of look right, but after further quality checking, you might discover it missed or miscalculated something important.

The shrewd AI-assisted coder knows how to leverage AI's strengths while catching its inevitable mistakes; remeber you are the brains of the operation, not the AI. Whether you're coding with AI assistance or doing it alone, always take time to thoroughly review your data, prepare it into a complete tidy format, and run quality checks to verify your assumptions and calculations.

If you would like guidance on how to best prepare your data into a complete tidy format, review concepts of data wrangling, tidy data structures, and best practices for data inclusion and exclusion in our **"Introduction to Programming in R and Data Wrangling with `tidyverse`"** workshop.

“AI is often thought of as a black box, and so am I.”

Examination of Biotechne:
Does AI think, or only imitate human thought?

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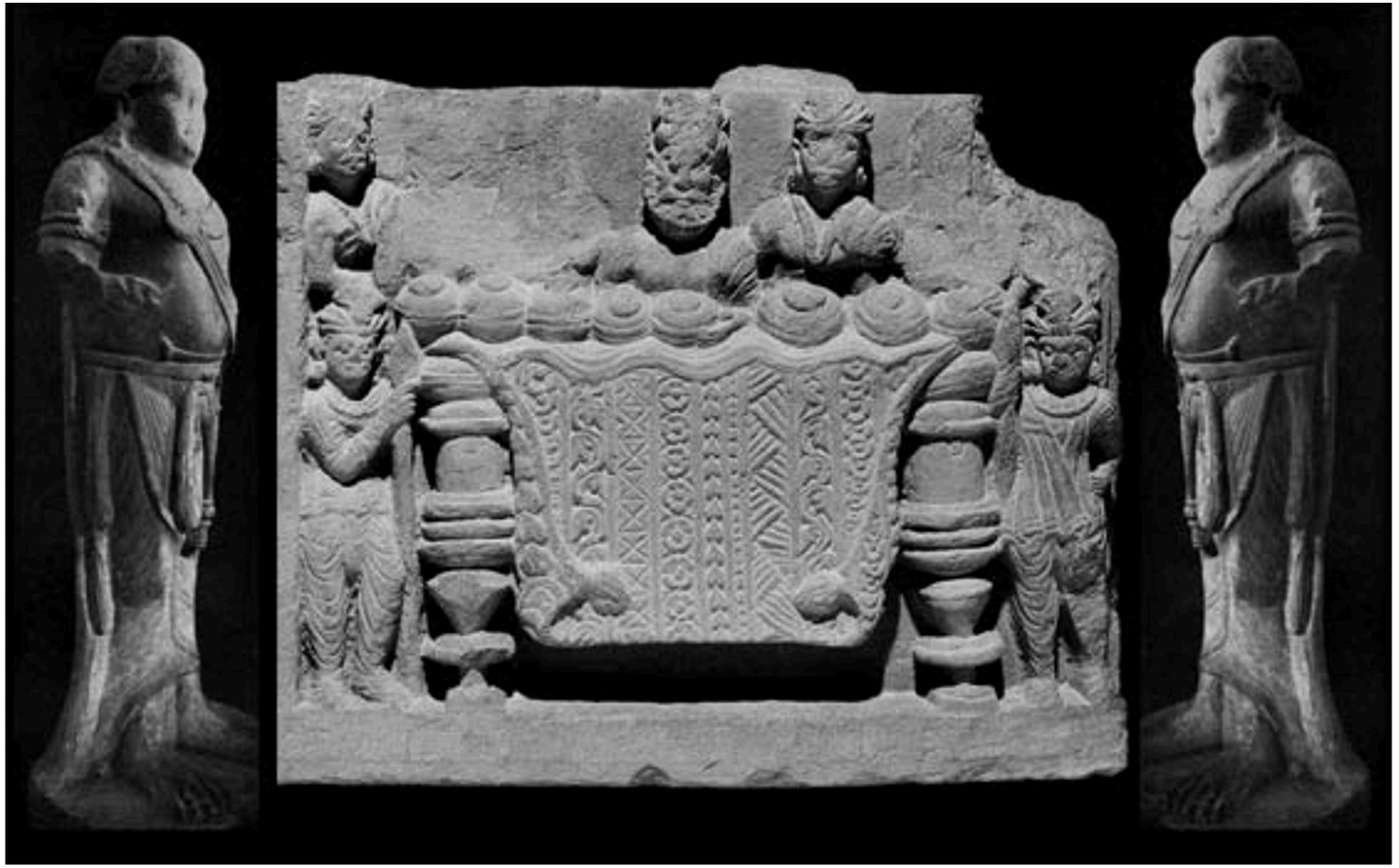
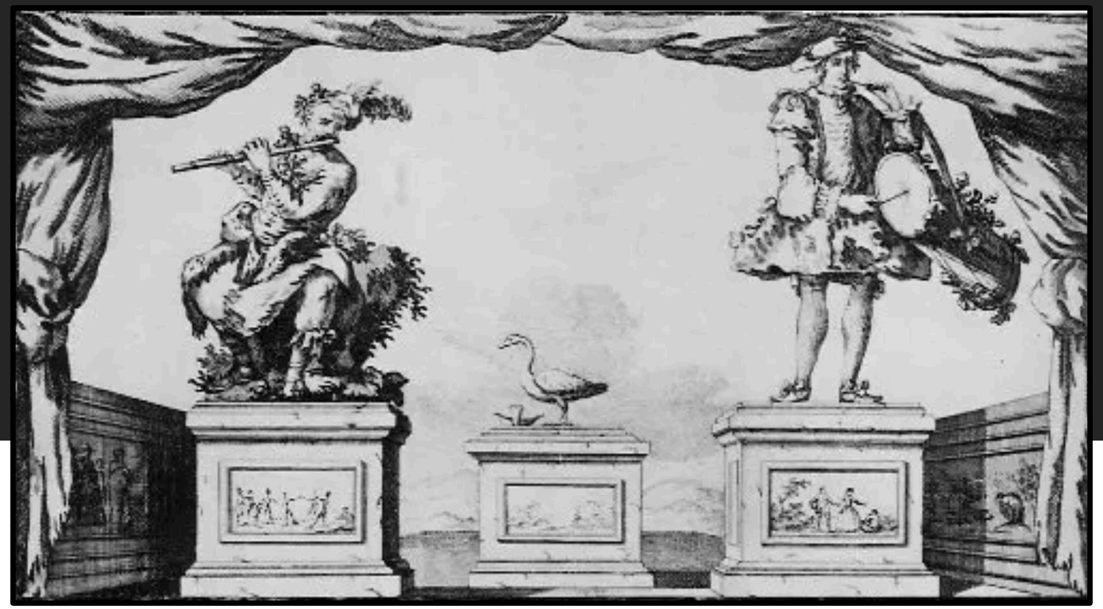
“Imagination is the spirit that unites myth and science.” - Professor Adrienne Mayor



Gods and Robots: Myths, Machines, and Ancient Dreams of Technology *Figure 9.5* by Professor Adrienne Mayor. Accessed March 15th, 2026.

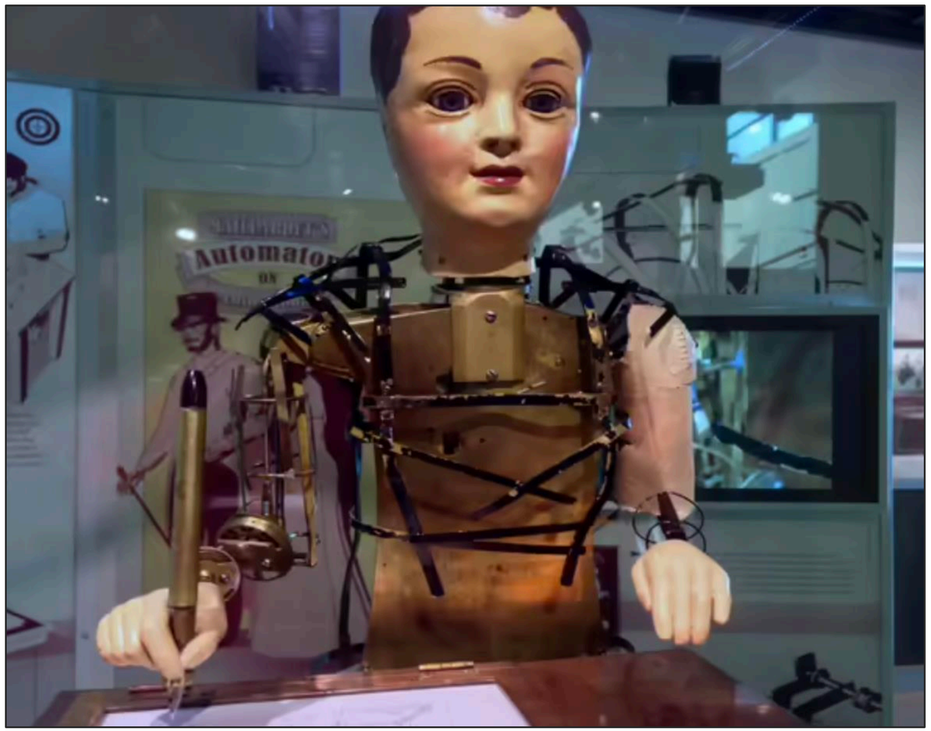
TALOS - Ray Harryhausen and the Argonauts by Matthew Teevan. Accessed March 15th, 2026.

“The story of AI is an exhilarating saga.., yet it is also the story of a slow but steady acquisition of knowledge about how humans think.” – Daniel Crevier

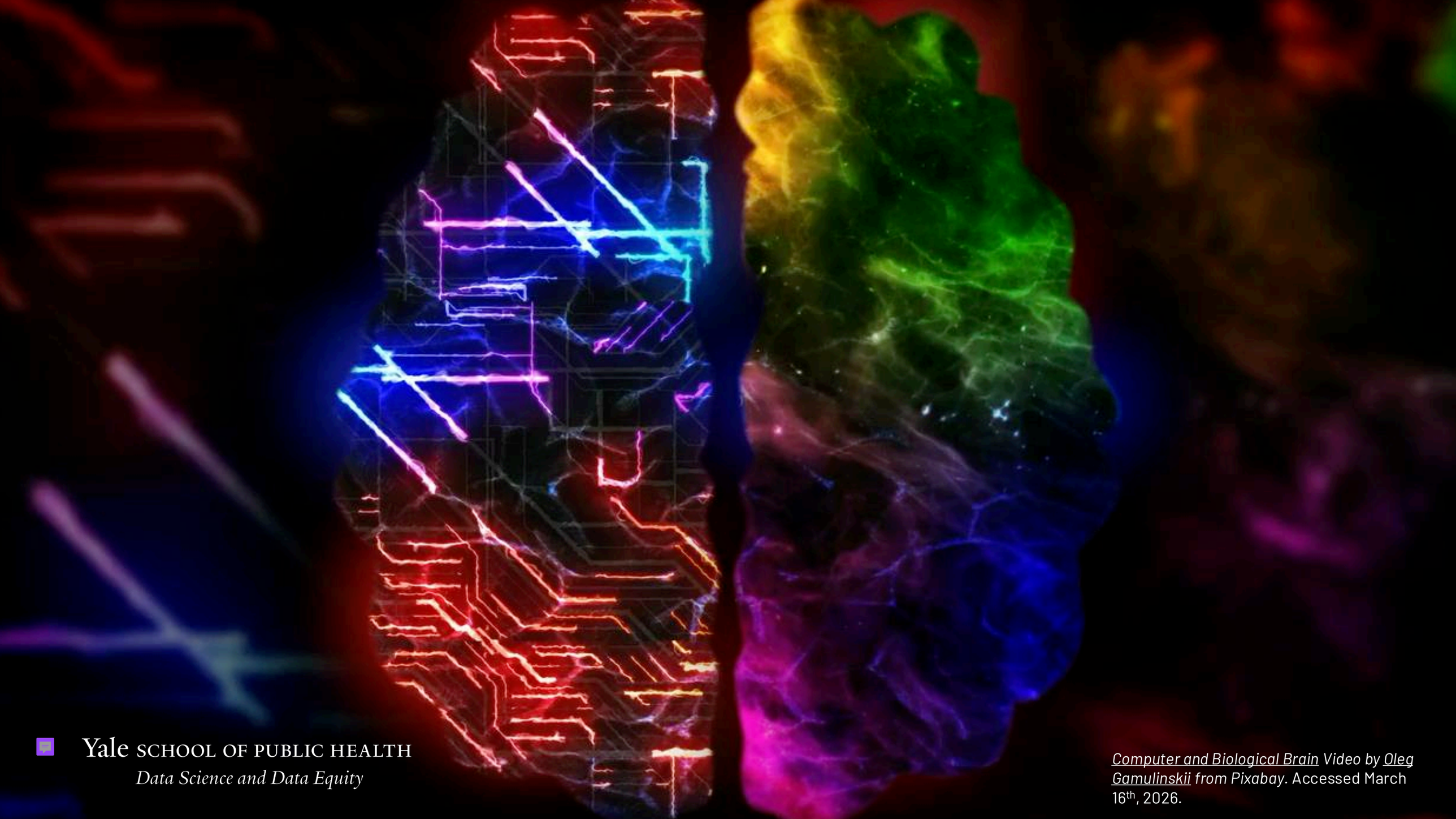


Vaucanson's three automata from Kat Eschner of the Smithsonian Magazine. Accessed March 16th, 2026.

Vaucanson 1737 Life-Sized Mechanical Flutist from Yulia Berry, DMA in the Flute Almanac. Accessed March 16th, 2026.



Maillardet's 19th Century Writing Automata by Matthew Teevan. Accessed March 15th, 2026.



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Computer and Biological Brain Video by Oleg Gamulinskii from Pixabay. Accessed March 16th, 2026.

“I sometimes wonder whether robots were invented to answer philosophers’ questions” – TIK-TOK

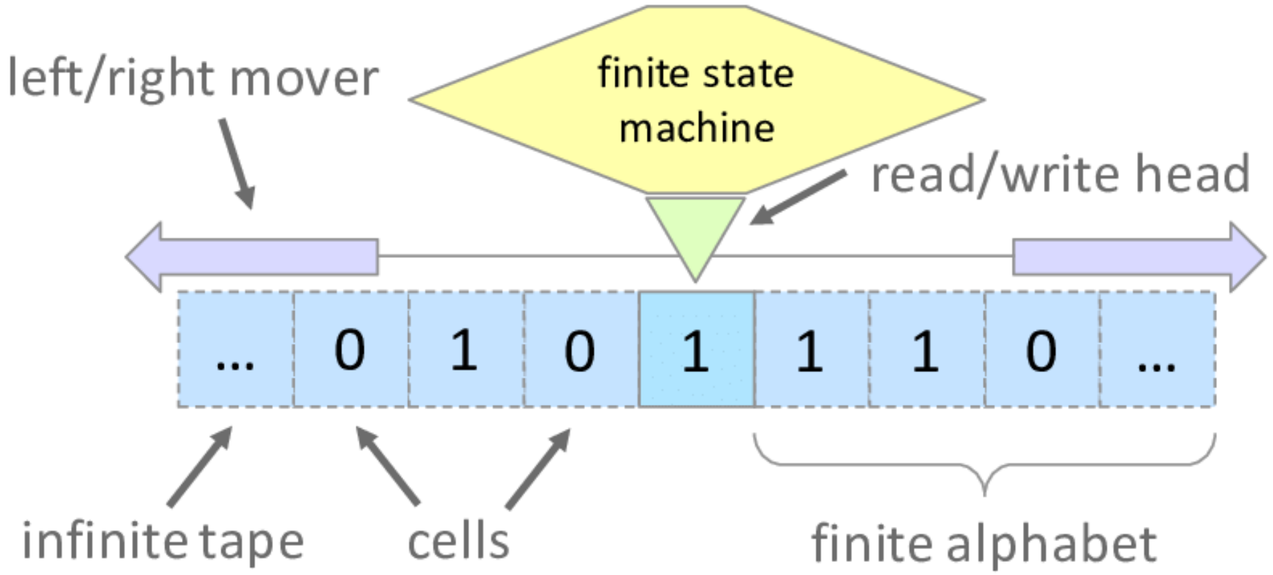
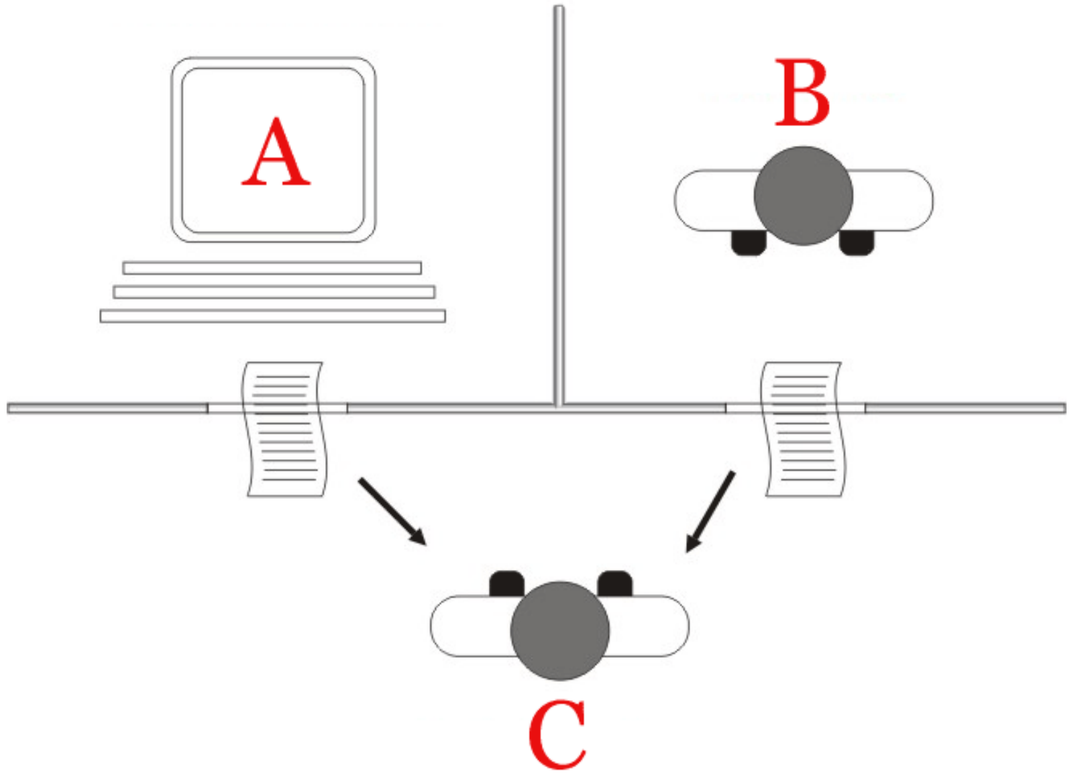


Figure 1: Computational model of a Turing Machine
Sarkar et al. 2020. Accessed March 15th, 2026.

Alan Turing in 1951 from Wikipedia.
Accessed March 16th, 2026.

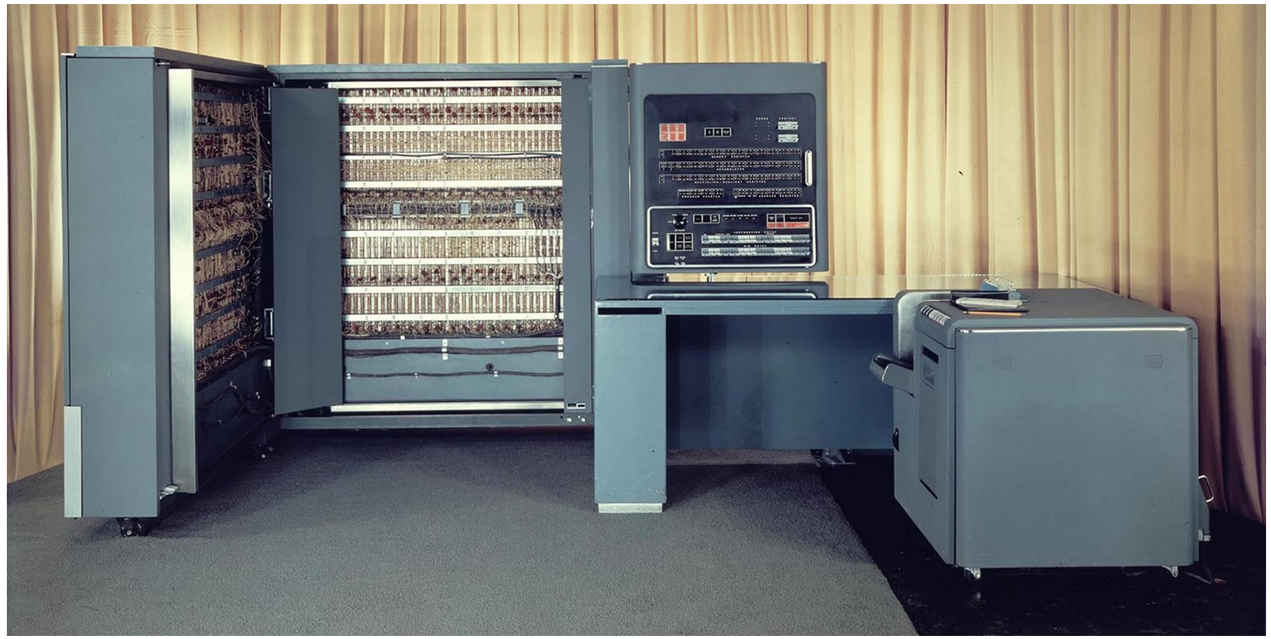
“I sometimes wonder whether robots were invented to answer philosophers’ questions” — TIK-TOK



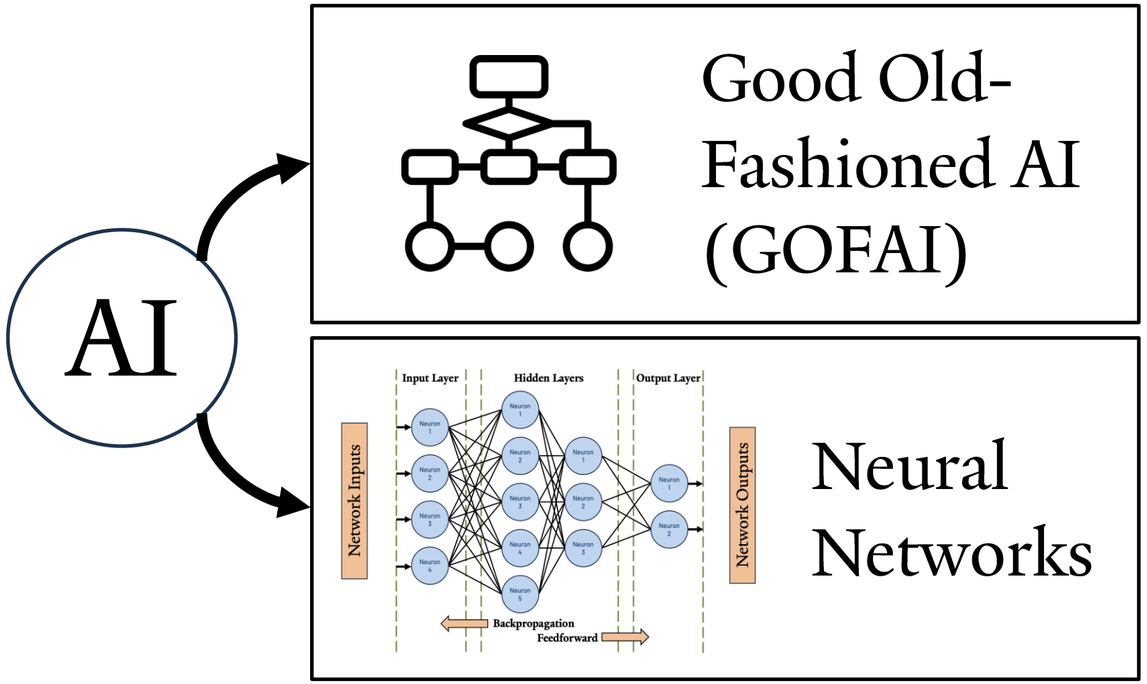
The "standard interpretation" of the Turing test from Wikipedia. Accessed March 15th, 2026.

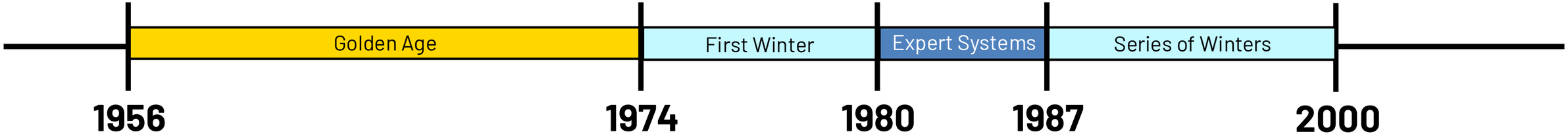
Alan Turing in 1951 from Wikipedia. Accessed March 16th, 2026.

“… we humans are not very good at identifying the heuristics we ourselves use.” — John McCarthy, 2006



The IBM 701's Electronic Analytic Control Unit from IBM. Accessed March 16th, 2026.





Feedforward vs Backpropagation Artificial Neural Network (ANN) from SaffronEdge. Accessed March 16th, 2026.

Flow Chart Icon by Pause08 on Flaticon. Accessed March 16th, 2026.

Big Data

Expansion from traditional, structured data, to other forms: images, free text, audio, spatial.

The V's: volume, velocity, variety, veracity, and value.

Scaled Infrastructure

Data processing and storage systems needed at scale to support a World Wide Web.

Transition to personalized and portable devices driven by market demand.

Graphics Processing Units (GPU)

Primarily designed for image processing.

Can perform complex mathematical calculations faster.

Hundreds or thousands of cores, enabling rapid parallel processing.

A Field Guide to AI Typologies and Systems

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"… to hear is not the same thing as to listen, to take pictures is not the same thing as to see." – Fei-Fei Li

Weak AI (Narrow AI)
Trained for specific tasks. May have limited "memory" and "learning" capacity.

Strong AI (General Intelligence AGI)
Limited human intelligence: learning, reasoning, self-aware.

Super AI
Possess human intelligence (creativity and beliefs) and new cognitive abilities.

AND

Type I
Strictly adheres to the algorithm, no "memory" or "learning" capacity, i.e. GOFAI.

Type II
Limited "memory" and "learning" capacity, i.e. Neural Networks/Deep Learning.

Type III
Limited human intelligence: anticipates others' expectations and desires.

Type IV
Possess human intelligence: self-aware.

Discussion:

What are the typologies of these AI?

Expert Systems	*Star Wars*' C- 3PO	ChatGPT/Claude/etc.
Weak AI	Strong AI	Weak AI
Type I	Type III	Type II

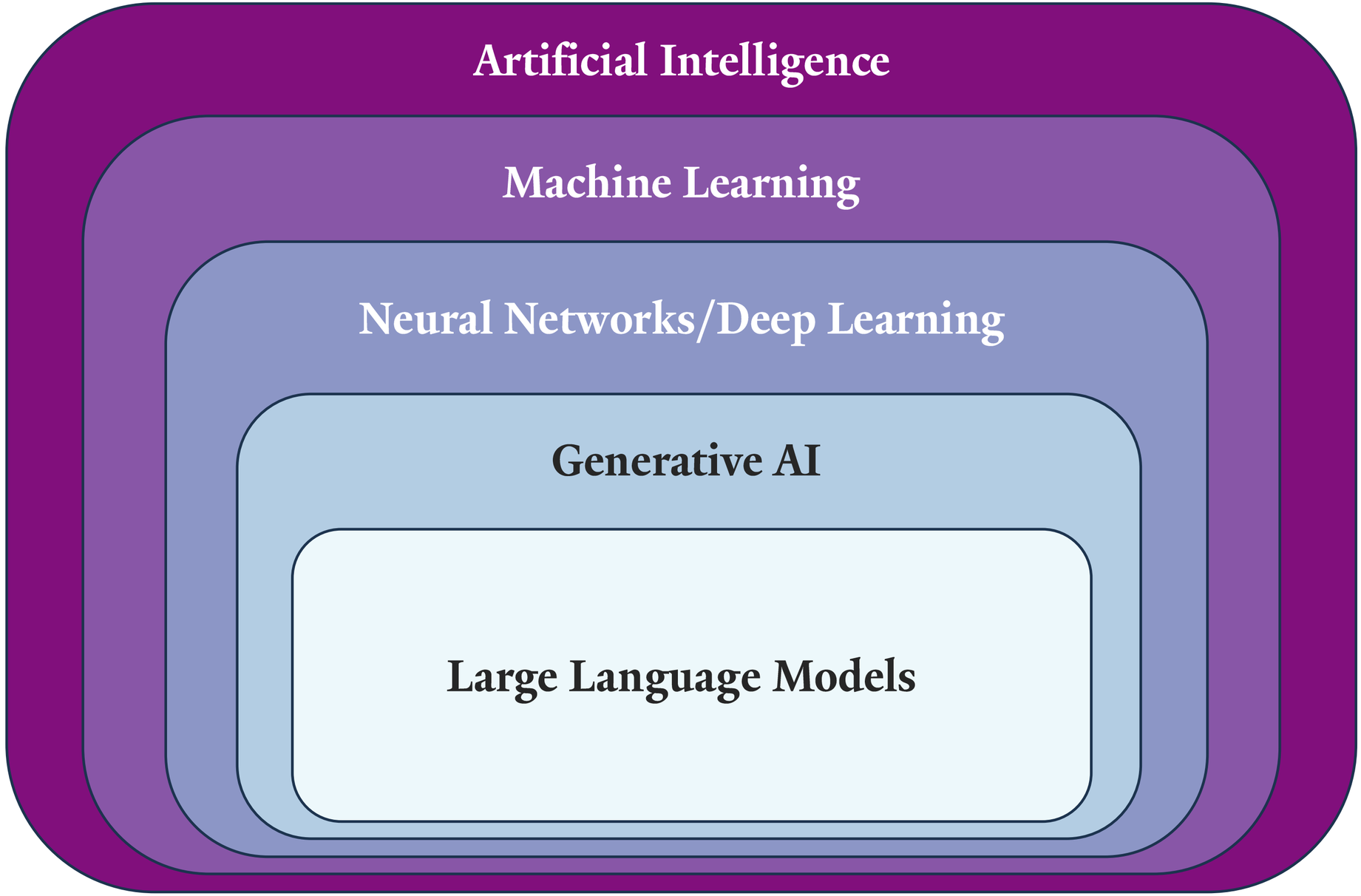
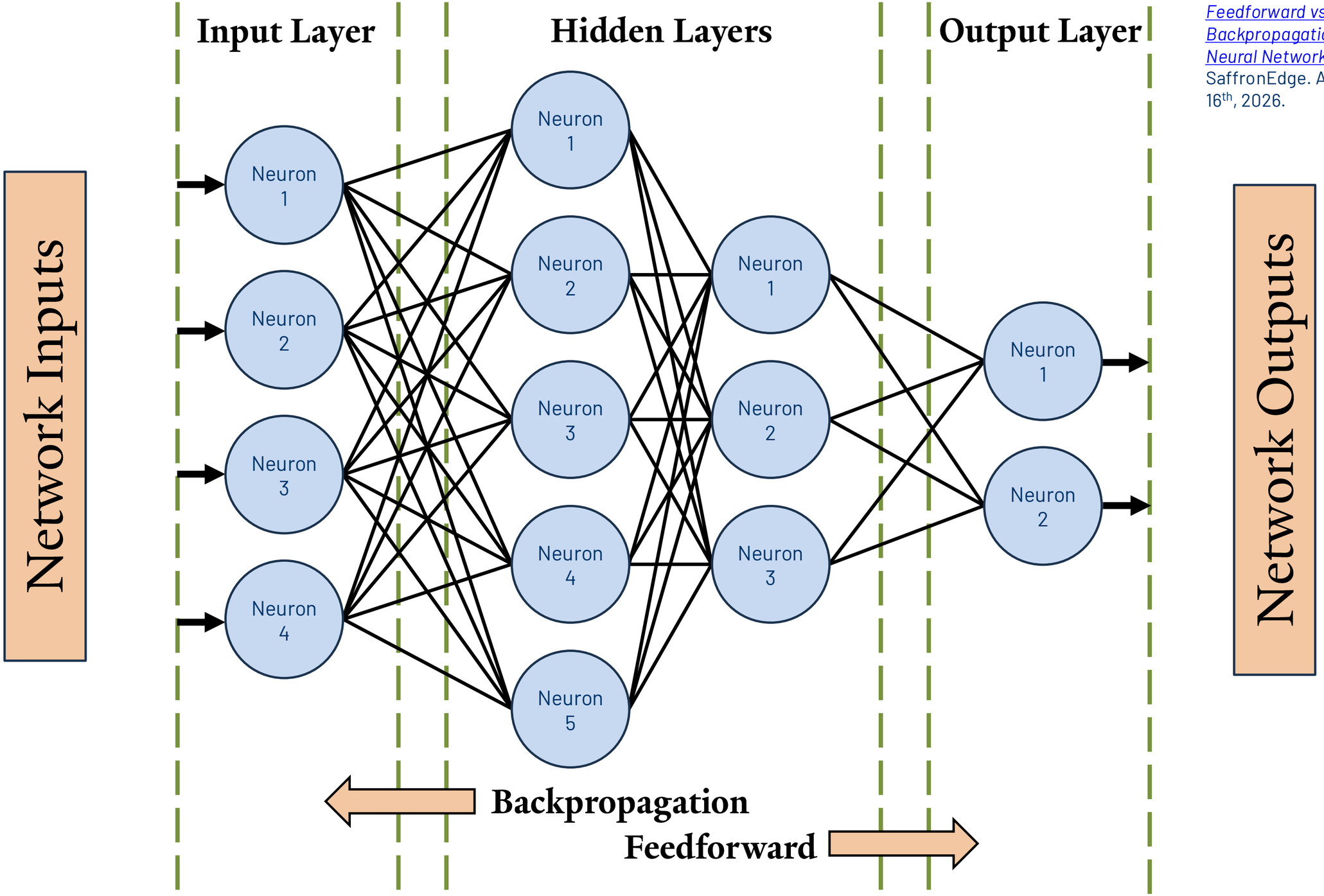


Figure 1-3 from AI-Assisted Programming by Tom Taulli. Accessed March 16th, 2026.

Briefly: Deep Learning



Feedforward vs Backpropagation Artificial Neural Network (ANN) from SaffronEdge. Accessed March 16th, 2026.

Discussion:

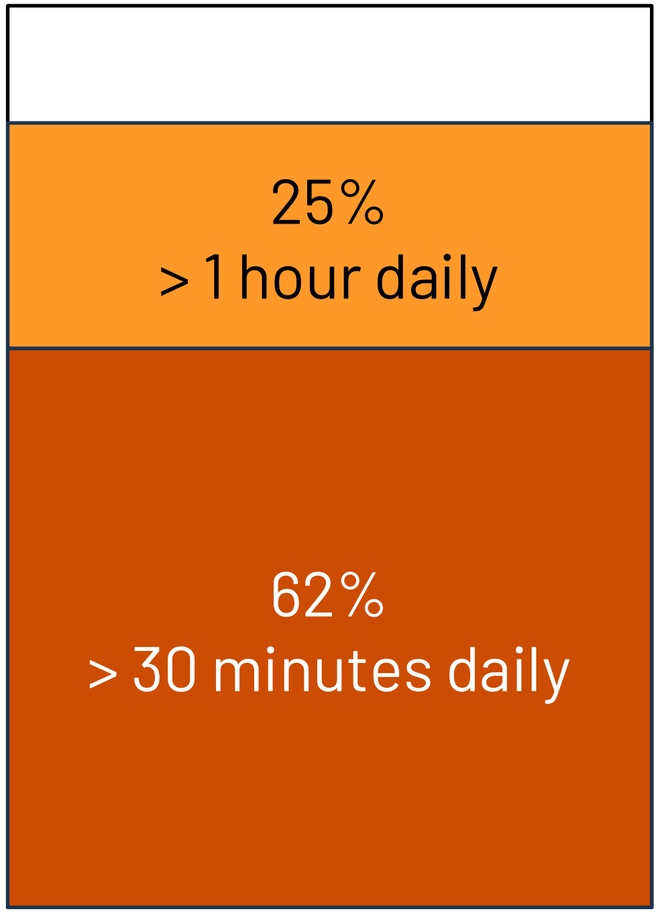
Do we agree with the definitions for AI and Machine Learning recorded in The Code of Laws of the United States of America?

You steer; AI gears

Our Choice Resources

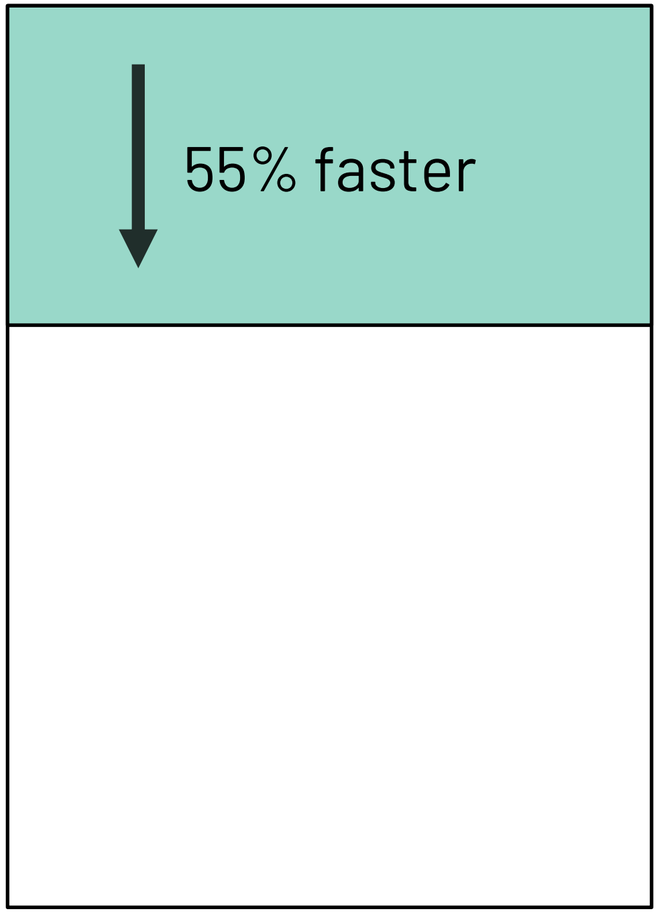
- Yale's Harvey Cushing/John Hay Whitney Medical Library workshop "Code with Clarity: AI-Powered Programming for Researchers" by Justin DeMayo and Max Wegener
- Yale's Library "Using AI in Research" webpage
- Yale's Data-Intensive Social Science Center (DISSC) "Artificial Intelligence and Machine Learning for Social Science Research" page for events and content lead by Nick Warren
- *AI-Assisted Programming - Better Planning, Coding, Testing, And Deployment* by Tom Taulli
- "What is a recurrent neural network (RNN)?" and "... a transformer model?"

Time spent searching for answers



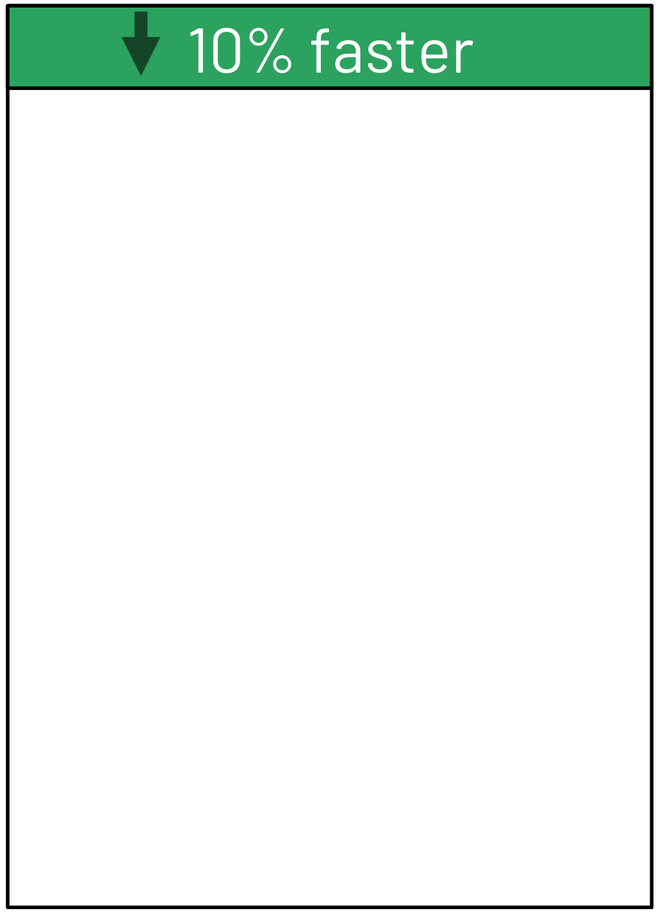
StackOverflow, n = 70,000

Time spent coding the same problem



Microsoft Study, n = 95

Time spent coding a complex problem



McKinsey & Company, n = 40

Pro's

Reduction of Routine Tasks

Do less drafting of function details and code documentation.

Accelerate Tweaking and Troubleshooting

Adapt and improve code faster with directed answers.

Get Started Faster with New Projects

TL;DR summaries of codebases and point out imported parts.

Suggest Best Practices for Code Integrity

Recommendations with code implementing them

Modernization

Quickly convert legacy languages to modern ones.

IDE Integration

Get relevant AI answers in the same coding environment.

Con's and "Gotcha's"

Hallucinations

Answers that appear correct but are in fact not.

Intellectual Property

Suggestions are trained off existing code: who owns it?

Privacy

Is my data housed securely and how is it shared?

Weaken Security

Suggestions might introduce security risks.

Quality Concerns with Training Data

i.e. representation of knowledge is limited, uneven data quality.

Bias

i.e. English-centric training data give English answers.

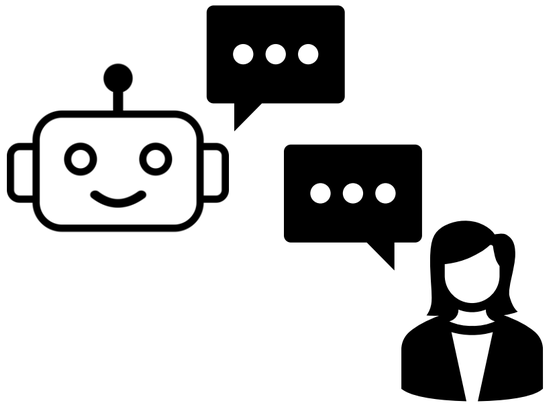
Foundational Models

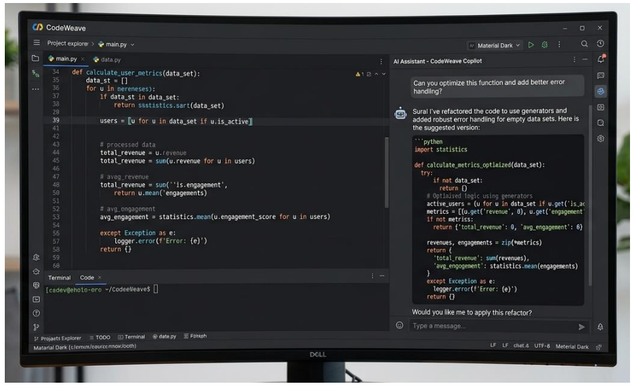
OpenAI

Gemini

Claude

Modes of Access





IDE integrated AI assistant and Agentic AI images were generated using Gemini.

OpenAI, Gemini, and Claude logos were downloaded from brandlogos.net. Accessed March 23rd, 2026.

Washington, D.C. Miss Genie Lee Neal reading a perforated tape at the Wesetern Union telegraph office: source. Contributor Bubley, Esther, photographer. Accessed March 23rd, 2026.

"On Friday, the judge issued a sentence"

- "**the**" suggests "**judge**" is a noun.
- "**judge**" in context of "**sentence**" implies a legal penalty rather than a grammatical sentence.
- Presence of "**issued**" strengthens the interpretation about "**sentence**"
- The model should increase "attention" to "**judge**" and "**issued**" when interpreting "**sentence**" while "**the**" is less important

Example from "What is a transformer model?" by IBM. Accessed March 23rd, 2026.

Prompt Engineering

Be specific, include examples, use relevant terms.

Paired Programming/ Refactor

Improve results with back-and-forth's. Restructure when needed.

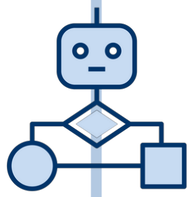
Plan the Project

Know how the analysis needs to be structured.

Build Iteratively

Start small and increment to more complex tasks.

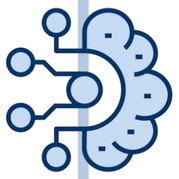
L0: Luddite
Does not believe in AI and does not use it in any capacity.



L1: Chat-Overflow
Uses ChatGPT instead of Google but uses very little AI coding.

L2: Copy and Complete
Uses code-completion and chats to generate snippets, <20%.

L3: Feature Editor
Prompt for full features across multiple files, >50%.



L4: Full Agentic ("Vibe Coder")
All coding is done by the AI. The user provides only prompts.

Levels of Code Autonomy by Max Struever, Matthew Kropp, and Julie Bedard. Accessed March 21st, 2026.

Worked-Through Example

THE GERONTOLOGICAL SOCIETY OF AMERICA®

Journals of Gerontology: Biological Sciences
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https://doi.org/10.1093/gerona/glad082
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OXFORD

Editor's choice

Original Article

Healthy Lifestyle Behaviors and Biological Aging in the U.S. National Health and Nutrition Examination Surveys 1999–2018

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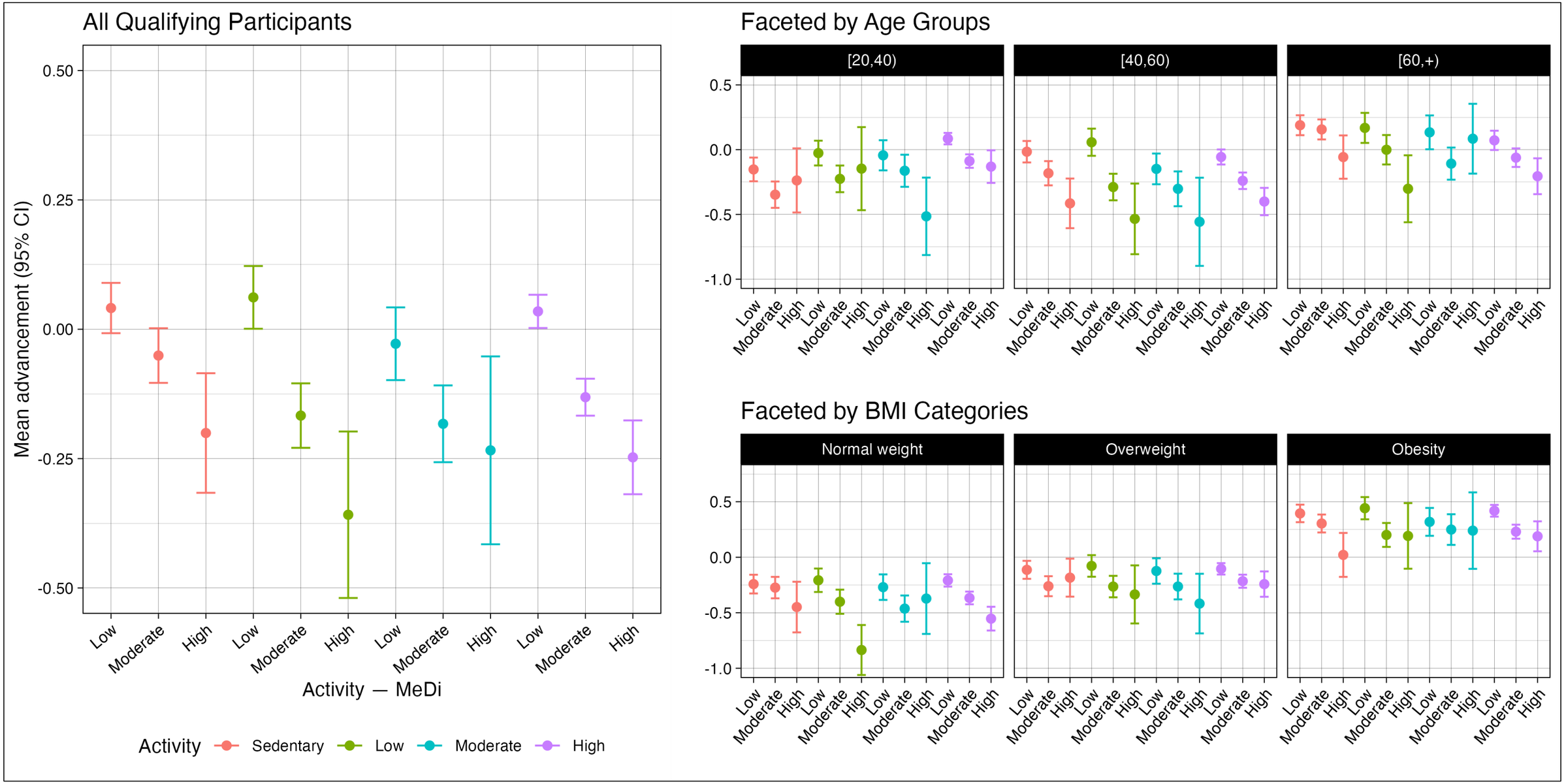
Decision Editor: Gustavo Duque, MD, PhD

Thomas et al. 2023


All Qualifying Participants
Mean advancement (95% CI)
0.50
0.25
0.00
-0.25
-0.50
Low
Moderate
High
Activity — MeDi
Activity
Sedentary
Low
Moderate
High
Faceted by Age Groups
[20,40)
[40,60)
[60,+)
0.5
0.0
-0.5
-1.0
Faceted by BMI Categories
Normal weight
Overweight
Obesity

Appendix

Glossary

AI Literacy

Artificial Intelligence (AI) Intelligence or mind displayed by artificial life or machines, analogous to the natural intelligence of animals and humans, capable of perceiving its environment and taking action. AI can be classified by category ("weak," "strong," or "super") and by type (Types I–IV), representing varying degrees to which the technology has achieved true artificial intelligence.

Glossary

AI Literacy

Automaton, Automata A self-moving mechanical device, typically resembling an animal or human, that operates without direct human control. Some automata follow predetermined instructions, while others can produce a range of responses to varying circumstances. Might be considered an early Type I "weak" AI.

Black Box Complex entity, machine, or system whose outputs are known or observable but whose inner contents and internal workings are hidden, unknown, opaque, and mysterious to the user.

Glossary

AI Literacy

Big Data A shift in data collection marked by increased volume and velocity (speed of collection), where data expanded beyond traditional tabular formats to include greater variety: images, free text, audio, and spatial data. Maintaining data veracity became more challenging, increasing the need for valuable (i.e. reliable) data. Big Data also exacerbates the "curse of dimensionality," where the number of variables (columns) outpaces the number of observations (rows).

Glossary

AI Literacy

Central Processing Unit (CPU)	Electronic circuitry that run a computer's operating system and apps and manage a variety of other computer operations. Thought of as the "brain" of the computer.
Connectionism	A movement in cognitive science that hopes to explain intellectual abilities using artificial neural networks (also known as "neural networks" or "neural nets").
Computer Vision	A field of AI that enables machines to interpret and understand visual information from the world, such as images and video.

Glossary

AI Literacy

Deep Networks A type of neural network characterized by many hidden layers. Made computationally feasible through theoretical advances such as backpropagation, deep networks support deep learning-based machine learning — a core technique underlying generative AI.

Disambiguate To resolve ambiguity by clarifying or distinguishing the intended meaning of a word, phrase, or concept. "Weak" AI algorithms lack the ability to understand context beyond modeled patterns and typically underperform in this regard.

Glossary

AI Literacy

Generative AI	A type of AI based on neural network/deep learning machine learning that generates new content, such as text, images, audio, or video, by learning patterns from existing data.
Good Old-Fashioned AI (GOFAI)	An early approach to AI based on explicit, hand-coded rules and logical reasoning. All Type I “weak” AI are GOFAI.
Graphics Processing Units (GPU)	A computer circuit designed for fast graphic and image processing. Its greater number of processing cores and memory also make it ideal for complex mathematical calculations and were necessary in the advancement of AI development.

Glossary

AI Literacy

Large Language Models (LLMs) Generative AI models designed specifically for text generation, i.e. chat bots. Popular foundation models behind these tools include ChatGPT, Gemini, Claude, and LLaMA.

Machine A mechanical structure or device based on one or more components (such as lever, pulley, wheel and axle, inclined plane, screw, wedge) that changes the direction or magnitude of a force.

Glossary

AI Literacy

Machine Learning "Weak" AI with Type II capabilities; limited memory and the ability to optimize based on new input. Canonically refers to mathematical techniques where an algorithm optimizes criteria to minimize prediction errors based on answers it generates from training data.

Mechanism, Mechanical Something made of parts that move or work together to perform an action; a machine or something resembling a machine.

Glossary

AI Literacy

Natural Language Processing (NLPs) A technology that uses machine learning-based modeling to train computers to generate responses relevant to a given prompt in a human-esque manner, effectively emulating human communication. This advancement served as a foundational development that enabled the field of generative AI.

Glossary

AI Literacy

Neural Networks A subset of machine learning that use pattern recognition techniques loosely inspired by biological neuron propagation. Contemporary networks typically leverage many layers — giving rise to the term **deep learning**. Due to their abstract mathematics and probabilistic nature, their decision-making process is difficult to interpret or explain in real-world terms, which is why AI is often referred to as a "black box."

Glossary

AI Literacy

Perceptron An alternative term used to describe individual "neurons," the most basic unit of a neural network, modeled loosely after a biological neuron in the human brain. It is used to distinguish the differences between machine learning-based neural networks and biological neural connections.

Programmed Supplied with a predetermined set of (coded) instructions for automatic performance.

Reinforcement Learning with Human Feedback (RLHF) Human users respond to generated content with evaluations and scores the model can use to update the model for greater accuracy or relevance.

Glossary

AI Literacy

Robot, Bot Complex and ambiguous to define, but a robot usually is a machine or self- moving object with a power source that provides energy. It can be "programmed" to "sense" its surroundings, and has a kind of "intelligence" or way of processing data to "decide" to interact with the environment to perform actions or tasks. Talos, the bronze animated statue powered by ichor, fits this definition.

Strong AI A theoretical AI capable of learning, understanding, and reasoning at a human level.

Glossary

AI Literacy

Super AI A theoretical AI capable of creativity and holding belief systems at a human level. Also, might possess additional cognitive abilities that surpass human capacity.

Weak AI Also referred to as "narrow AI," a system designed to perform specific tasks, either explicitly defined or determined by probabilistic models from detected patterns in a training dataset. Though some systems can mimic human-esque responses, they lack genuine understanding or reasoning capacities. Type II "weak" AI has limited “memory” and “learning” capacity —that is, the ability to tune model parameters based on recent input.

Glossary

AI Coding

AI-Assisted Coding The use of AI tools to support software development tasks, such as generating, completing, explaining, or debugging code based on natural language prompts or existing code context. Reliance on AI for coding support exists on a spectrum, ranging from no use to full, unsupervised dependence.

Autocompletion A code editor feature that predicts and suggests code as you type, based on context and syntax. AI-powered versions can suggest entire functions or logic blocks.

Glossary

AI Coding

Foundational Model Large, pre-built deep learning models trained on vast, generalized datasets, capable of processing text, images, and more. They serve as a base that developers can adapt for their own AI projects. Common examples include GPT-4, Gemini, and Claude.

Glossary

AI Coding

Tokens, Tokenization Tokens are the basic text units — whole words, word parts, or punctuation — that an AI language model uses to process and generate language. In English, one token averages roughly 3–4 characters. Tokenization is simply the process of breaking input text into these units before the model processes it. Token counts matter because they determine a model's context-length limit, drive API billing costs, and affect processing and generation speed.

Glossary

AI Coding

Recurrent Neural Network (RNN) A type of neural network designed to process sequential data by retaining memory of previous inputs and updating predictions based on recent data. RNNs were widely used in early NLP and code-related AI tasks, though Transformer models have since proven more capable.

Refactor The process of restructuring existing code to improve its readability, efficiency, or maintainability without changing its functionality. AI tools can now suggest or automate refactoring, making it faster to clean up messy or outdated code.

Glossary

AI Coding

Transformer Model A deep learning architecture that, unlike RNNs, processes entire inputs at once rather than sequentially, making it faster and better at capturing context. It powers most modern foundational models.

Vibe Coding An approach to software development where developers use natural language to describe what they want, and AI handles the technical implementation — requiring little to no coding knowledge. While fast, it risks errors, security issues, and unreliable software, and is not recommended when the goal is a working, production-ready product.

References

Slide 4

1. "AI at Yale." Accessed: Mar. 19, 2026. [Online]. Available: https://ai.yale.edu/
2. Data-Intensive Social Science Center, "Artificial Intelligence and Machine Learning," Programs. Accessed: Mar. 17, 2026. [Online]. Available: https://dissc.yale.edu/dissc-programs/artificial-intelligence-and-machine-learning
3. Cole Stryker, "What Are Large Language Models (LLMs)?," IBM Think Topics. Accessed: Mar. 18, 2026. [Online]. Available: https://www.ibm.com/think/topics/large-language-models
4. Cole Stryker and Mark Scapicchio, "What is Generative AI?," IBM Think Topics. Accessed: Mar. 18, 2026. [Online]. Available: https://www.ibm.com/think/topics/generative-ai
5. Dave Bergmann, "What is Machine Learning?," IBM Think Topics. Accessed: Mar. 18, 2026. [Online]. Available: https://www.ibm.com/think/topics/machine-learning
6. Fangfang Lee, "What Is a Neural Network?," IBM Think Topics. Accessed: Mar. 18, 2026. [Online]. Available: https://www.ibm.com/think/topics/neural-networks

References

Slide 4 continued

7. H. S. Kalsi, “What is Good Old-Fashioned AI?,” Medium. Accessed: Mar. 18, 2026. [Online]. Available: https://medium.com/@harrpreet/what-is-good-old-fashioned-ai-59ff4a4719ce

8. Keith Frankish and William M. Ramsey, Eds., *The Cambridge Handbook of Artificial Intelligence*. Cambridge: Cambridge University Press, 2014. doi: 10.1017/CBO9781139046855.

9. T. Taulli, Artificial Intelligence Basics: A Non-Technical Introduction, First Edition. Berkeley, CA: Apress, 2019. doi: 10.1007/978-1-4842-5028-0.

Slide 6

1. M. Černý, “University Students’ Conceptualisation of AI Literacy: Theory and Empirical Evidence,” Social Sciences, vol. 13, no. 3, p. 129, Mar. 2024, doi: 10.3390/socsci13030129.

2. M. Hornberger, A. Bewersdorff, D. S. Schiff, and C. Nerdel, “A multinational assessment of AI literacy among university students in Germany, the UK, and the US,” Computers in Human Behavior: Artificial Humans, vol. 4, p. 100132, May 2025, doi: 10.1016/j.chbah.2025.100132.

References

Slide 7

1. Alex Shashkevich, “Stanford researcher examines earliest concepts of artificial intelligence, robots in ancient myths,” Stanford Report - Arts & Humanities. Accessed: Mar. 15, 2026. [Online]. Available: https://news.stanford.edu/stories/2019/02/ancient-myths-reveal-early-fantasies-artificial-life

2. E.R. Truitt, “Surveillance, Companionship, and Entertainment: The Ancient History of Intelligent Machines,” The MIT Press Reader. Accessed: Mar. 15, 2026. [Online]. Available: https://thereader.mitpress.mit.edu/the-ancient-history-of-intelligent-machines/

3. A. Mayor, Gods and Robots: Myths, Machines, and Ancient Dreams of Technology. Princeton: Princeton University Press, 2018. Accessed: Mar. 15, 2026. [E-book]. Available: https://muse.jhu.edu/pub/267/monograph/book/77367

4. M. Teevan, “TALOS - Ray Harryhausen and the Argonauts,” matteline. Accessed: Mar. 15, 2026. [Online]. Available: https://www.matteline.com/blog-talos-ray-harryhausen-and-the-argonauts

References

Slide 8

1. Y. Berry, DMA, “The Evolution of Mechanical Flutists: A Detailed Historical Review of Automaton Musicians,” Flute Almanac. Accessed: Mar. 15, 2026. [Online]. Available: https://flutealmanac.com/mechanical-flutists-history-automaton-musicians/

2. P. J. Bowler, “H. G. Wells and the Uncertainties of Progress,” The Public Domain Review. Accessed: Mar. 15, 2026. [Online]. Available: https://publicdomainreview.org/essay/h-g-wells-and-the-uncertainties-of-progress/

3. D. Crevier, AI: The Tumultuous History Of The Search For Artificial Intelligence, First Edition. New York, NY: Basic Books, 1993. Accessed: Mar. 14, 2026. [Online]. Available: https://caldwelluniversity.on.worldcat.org/oclc/26858345

4. K. Eschner, “This Eighteenth-Century Robot Actually Used Breathing to Play the Flute,” Smithsonian Magazine. Accessed: Mar. 15, 2026. [Online]. Available: https://www.smithsonianmag.com/smart-news/eighteenth-century-robot-actually-used-breathing-play-flute-180962214/

References

Slide 8 continued

5. G. Hatfield, “René Descartes,” in Stanford Encyclopedia of Philosophy Archive, in Fall 2018 Edition. , Stanford, 2014. Accessed: Mar. 15, 2026. [Online]. Available: https://plato.stanford.edu/archives/fall2018/entries/descartes/

6. A. Kantosalo, M. Falk, and A. Jordanous, “Embodiment in 18th Century Depictions of Human-Machine Co-Creativity,” Front Robot AI, vol. 8, p. 662036, Jun. 2021, doi: 10.3389/frobt.2021.662036.

7. J. Karp, “The 19th-Century Roots of Science Fiction,” Medium. Accessed: Mar. 15, 2026. [Online]. Available: https://storiusmag.com/the-19th-century-roots-of-science-fiction-d14ef75ddd61

8. Patrick J. Kiger, “Maillardet’s Automaton Is a Marvel of 19th-century Robotics,” How Stuff Works. Accessed: Mar. 15, 2026. [Online]. Available: https://science.howstuffworks.com/maillardets-automaton.htm

References

Slide 9

1. Alex Shashkevich, “Stanford researcher examines earliest concepts of artificial intelligence, robots in ancient myths,” Stanford Report - Arts & Humanities. Accessed: Mar. 15, 2026. [Online]. Available: https://news.stanford.edu/stories/2019/02/ancient-myths-reveal-early-fantasies-artificial-life

2. E.R. Truitt, “Surveillance, Companionship, and Entertainment: The Ancient History of Intelligent Machines,” The MIT Press Reader. Accessed: Mar. 15, 2026. [Online]. Available: https://thereader.mitpress.mit.edu/the-ancient-history-of-intelligent-machines/

3. Gam-OI, “Brain, The Science, Logics. Free Stock Video,” Pixabay. Accessed: Mar. 16, 2026. [Online]. Available: https://pixabay.com/videos/brain-the-science-logics-left-25196/

4. A. Kantosalo, M. Falk, and A. Jordanous, “Embodiment in 18th Century Depictions of Human-Machine Co-Creativity,” *Front Robot AI*, vol. 8, p. 662036, Jun. 2021, doi: 10.3389/frobt.2021.662036.

References

Slide 9 continued

6. A. Mayor, *Gods and Robots: Myths, Machines, and Ancient Dreams of Technology*. Princeton: Princeton University Press, 2018. Accessed: Mar. 15, 2026. [E-book]. Available: https://muse.jhu.edu/pub/267/monograph/book/77367

Slides 9-12

1. T. Taulli, Artificial Intelligence Basics: A Non-Technical Introduction, First Edition. Berkeley, CA: Apress, 2019. doi: 10.1007/978-1-4842-5028-0.

Slide 10

1. Alan M. Turing, "Computing Machinery and Intelligence," Computers in Human Behavior: Artificial Humans, vol. 49, pp. 433–460, 1950.
2. Alan M. Turing and Lorenz J. Halbeisen, "On computable numbers, with an application to the Entscheidungsproblem," vol. 42, pp. 230-265), 1937, doi: https://doi.org/10.1112/plms/s2-42.1.230.

References

Slide 10 continued

3. Aritra Sarkar, Zaid Al-Ars, and Koen Bertels, “Quantum Accelerated Estimation of Algorithmic Information,” ResearchGate. Accessed: Mar. 15, 2026. [Online]. Available: https://www.researchgate.net/figure/Computational-model-of-a-Turing-machine_fig1_341817215

4. D. Crevier, AI: The Tumultuous History Of The Search For Artificial Intelligence, First Edition. New York, NY: Basic Books, 1993. Accessed: Mar. 14, 2026. [Online]. Available: https://caldwelluniversity.on.worldcat.org/oclc/26858345

5. Jeffrey Lee, “Department of Computer Science and Technology – Raspberry Pi: Introduction: What is a Turing machine?,” Raspberry Pi Tutorials. Accessed: Mar. 15, 2026. [Online]. Available: https://www.cl.cam.ac.uk/projects/raspberrypi/tutorials/turing-machine/one.html#one-three

6. Jeremy M. Norman, “Alan Turing Publishes ‘On Computable Numbers,’ Describing What Came to be Called the ‘Turing Machine’ : History of Information,” History of Information. Accessed: Mar. 15, 2026. [Online]. Available: https://www.historyofinformation.com/detail.php?id=619

References

Slide 10 continued

7. "Alan Turing," Wikipedia. Feb. 18, 2026. Accessed: Mar. 15, 2026. [Online]. Available: https://en.wikipedia.org/w/index.php?title=Alan_Turing&oldid=1339050892

8. "Turing test," Wikipedia. Mar. 15, 2026. Accessed: Mar. 16, 2026. [Online]. Available: https://en.wikipedia.org/w/index.php?title=Turing_test&oldid=1343592804

Slide 11

1. H. S. Kalsi, "What is Good Old-Fashioned AI?," Medium. Accessed: Mar. 18, 2026. [Online]. Available: https://medium.com/@harrpreet/what-is-good-old-fashioned-ai-59ff4a4719ce

2. Pause08, "Flow Chart free icons designed," Flaticon. Accessed: Mar. 16, 2026. [Online]. Available: https://www.flaticon.com/free-icon/flow-chart_858164

3. SaffronEdge, "Feedforward vs Backpropagation ANN," LinkedIn. Accessed: Mar. 16, 2026. [Online]. Available: https://www.linkedin.com/pulse/feedforward-vs-backpropagation-ann-saffronedge1/

References

Slide 11 continued

4. "The IBM 700 Series," Advancing Humanity. Accessed: Mar. 16, 2026. [Online]. Available: https://www.ibm.com/history/700

5. "AI winter," *Wikipedia*. Feb. 12, 2026. Accessed: Mar. 16, 2026. [Online]. Available: https://en.wikipedia.org/w/index.php?title=AI_winter&oldid=1337912995

Slide 12

1. Annie Badman and Matthew Kosinski, "What is Big Data?," IBM Think Topics. Accessed: Mar. 17, 2026. [Online]. Available: https://www.ibm.com/think/topics/big-data

2. M. R. Betker, J. S. Fernando, and S. P. Whalen, "The history of the microprocessor," Bell Labs Technical Journal, vol. 2, no. 4, pp. 29–56, 1997, doi: 10.1002/bltj.2082.

3. K. Cukier and V. Mayer-Schönberger, "The Rise of Big Data: How It's Changing the Way We Think about the World," in The Best Writing on Mathematics 2014, M. Pitici, Ed., Princeton University Press, 2014, pp. 20–32. doi: 10.1515/9781400865307-003.

References

Slide 12 continued

4. Mesh Flinders, Stephanie Susnjara, and Ian Smalley, “What is a GPU?,” IBM Think Topics. Accessed: Mar. 17, 2026. [Online]. Available: https://www.ibm.com/think/topics/gpu

5. P. Williams, “Understanding the Dotcom Bubble: Causes, Impact, and Lessons,” Investopedia. Accessed: Mar. 17, 2026. [Online]. Available: https://www.investopedia.com/terms/d/dotcom-bubble.asp

Slide 14

1. J. Chess, “Generative Artificial Intelligence: Levels of Artificial Intelligence,” U.S. Military Academy Library. Accessed: Mar. 18, 2026. [Online]. Available: https://library.westpoint.edu/GenAI/capabilities

2. Fei-Fei Li, How we’re teaching computers to understand pictures, (Mar. 2015). Accessed: Mar. 17, 2026. [Video]. Available: https://www.ted.com/talks/fei_fei_li_how_we_re_teaching_computers_to_understand_pictures

References

Slide 14 continued

3. A. Mayor, Gods and Robots: Myths, Machines, and Ancient Dreams of Technology. Princeton: Princeton University Press, 2018. Accessed: Mar. 15, 2026. [E-book]. Available: https://muse.jhu.edu/pub/267/monograph/book/77367

4. Sospeter Mong'are, "Strong AI vs. Weak AI," DEV Community. Accessed: Mar. 18, 2026. [Online]. Available: https://dev.to/msnmongare/strong-ai-vs-weak-ai-1gi1

5. T. Taulli, Artificial Intelligence Basics: A Non-Technical Introduction, First Edition. Berkeley, CA: Apress, 2019. doi: 10.1007/978-1-4842-5028-0.

Slides 15-16

1. H. S. Kalsi, "What is Good Old-Fashioned AI?," Medium. Accessed: Mar. 18, 2026. [Online]. Available: https://medium.com/@harrpreet/what-is-good-old-fashioned-ai-59ff4a4719ce

References

Slide 16 continued

1. J. Chess, “Generative Artificial Intelligence: Levels of Artificial Intelligence,” U.S. Military Academy Library. Accessed: Mar. 18, 2026. [Online]. Available: https://library.westpoint.edu/GenAI/capabilities
2. Cole Stryker, “What Are Large Language Models (LLMs)?,” IBM Think Topics. Accessed: Mar. 18, 2026. [Online]. Available: https://www.ibm.com/think/topics/large-language-models
3. Cole Stryker and Jim Holdsworth, “What Is NLP (Natural Language Processing)?,” IBM Think Topics. Accessed: Mar. 20, 2026. [Online]. Available: https://www.ibm.com/think/topics/natural-language-processing
4. Cole Stryker and Mark Scapicchio, “What is Generative AI?,” IBM Think Topics. Accessed: Mar. 18, 2026. [Online]. Available: https://www.ibm.com/think/topics/generative-ai
5. Dave Bergmann, “What is Machine Learning?,” IBM Think Topics. Accessed: Mar. 18, 2026. [Online]. Available: https://www.ibm.com/think/topics/machine-learning

References

Slide 16 continued

6. M. L. in P. English, “Deep Learning Course — Lesson 5: Forward and Backward Propagation,” Medium. Accessed: Mar. 19, 2026. [Online]. Available: https://medium.com/@nerdjock/deep-learning-course-lesson-5-forward-and-backward-propagation-ec8e4e6a8b92

7. Fangfang Lee, “What Is a Neural Network?,” IBM Think Topics. Accessed: Mar. 18, 2026. [Online]. Available: https://www.ibm.com/think/topics/neural-networks

8. Tom Taulli, AI-Assisted Programming - Better Planning, Coding, Testing, And Deployment, First Edition. in Programming Languages. Sebastopol, CA: O’Reilly Media, 2024. Accessed: Mar. 18, 2026. [Online]. Available: https://research.ebsco.com/c/rkfpff/ebook-viewer/pdf/afemdntevz/page/pp_18

Slide 17

1. Christopher M. Bishop, Pattern Recognition and Machine Learning (Information Science and Statistics). Springer, 2006. Accessed: Mar. 19, 2026. [Online]. Available: https://www.amazon.com/Pattern-Recognition-Learning-Information-Statistics/dp/0387310738

References

Slide 17 continued

2. Dave Bergmann and Cole Stryker, “What is Backpropagation?,” IBM Think Topics. Accessed: Mar. 19, 2026. [Online]. Available: https://www.ibm.com/think/topics/backpropagation

3. M. L. in P. English, “Deep Learning Course — Lesson 5: Forward and Backward Propagation,” Medium. Accessed: Mar. 19, 2026. [Online]. Available: https://medium.com/@nerdjock/deep-learning-course-lesson-5-forward-and-backward-propagation-ec8e4e6a8b92

4. Fangfang Lee, “What Is a Neural Network?,” IBM Think Topics. Accessed: Mar. 18, 2026. [Online]. Available: https://www.ibm.com/think/topics/neural-networks

Slide 20

1. Data-Intensive Social Science Center, “Artificial Intelligence and Machine Learning,” Programs. Accessed: Mar. 17, 2026. [Online]. Available: https://dissc.yale.edu/dissc-programs/artificial-intelligence-and-machine-learning

References

Slide 20 continued

2. Justin DeMayo and Max Wegener, “Code with Clarity: AI-Powered Programming for Researchers,” Yale Library Study Spaces Scheduling. Accessed: Mar. 18, 2026. [Online]. Available: https://schedule.yale.edu/event/16424915

3. Tom Taulli, AI-Assisted Programming - Better Planning, Coding, Testing, And Deployment, First Edition. in Programming Languages. Sebastopol, CA: O’Reilly Media, 2024. Accessed: Mar. 18, 2026. [Online]. Available: https://research.ebsco.com/c/rkfpff/ebook-viewer/pdf/afemdntevz/page/pp_18

4. Yale Library, “Using AI in Research,” Using AI in Research. Accessed: Mar. 23, 2026. [Online]. Available: https://library.yale.edu/help-and-research-support/research-support/using-ai-research

References

Slides 20-26

1. Tom Taulli, AI-Assisted Programming - Better Planning, Coding, Testing, And Deployment, First Edition. in Programming Languages. Sebastopol, CA: O'Reilly Media, 2024. Accessed: Mar. 18, 2026. [Online]. Available: https://research.ebsco.com/c/rkfpff/ebook-viewer/pdf/afemdntevz/page/pp_18

Slide 21

1. Anthropic, "How AI assistance impacts the formation of coding skills," Research. Accessed: Mar. 25, 2026. [Online]. Available: https://www.anthropic.com/research/AI-assistance-coding-skills

Slide 24

1. "What are Foundation Models? - Foundation Models in Generative AI Explained - AWS," Amazon Web Services, Inc. Accessed: Mar. 25, 2026. [Online]. Available: https://aws.amazon.com/what-is/foundation-models/

References

Slide 25

1. E. Bubley, “Washington, D.C. Miss Genie Lee Neal reading a perforated tape at the Western Union telegraph office,” Library of Congress. Accessed: Mar. 25, 2026. [Online]. Available: https://picryl.com/media/washington-dc-miss-genie-lee-neal-reading-a-perforated-tape-at-the-western
2. Cole Stryker, “What is a Recurrent Neural Network (RNN)?,” IBM Think Topics. Accessed: Mar. 25, 2026. [Online]. Available: https://www.ibm.com/think/topics/recurrent-neural-networks
3. Dave Bergmann and Cole Stryker, “What is a Transformer Model?,” IBM Think Topics. Accessed: Mar. 25, 2026. [Online]. Available: https://www.ibm.com/think/topics/transformer-model

Slide 26

1. Anthropic, “How AI assistance impacts the formation of coding skills,” Research. Accessed: Mar. 25, 2026. [Online]. Available: https://www.anthropic.com/research/AI-assistance-coding-skills

References

Slide 26 continued

2. C. Longo, “Best Practices I Learned for AI Assisted Coding,” Medium. Accessed: Mar. 25, 2026. [Online]. Available: https://statistician-in-stilettos.medium.com/best-practices-i-learned-for-ai-assisted-coding-70ff7359d403

3. Max Struever, Matthew Kropp, and Julie Bedard, “From Dev Speed to Business Impact: The Case for AI-Assisted Coding and Generative Engineering,” BCG X. Accessed: Mar. 25, 2026. [Online]. Available: https://www.bcg.com/x/the-multiplier/ai-assisted-coding-generative-engineering

Glossary

1. Annie Badman and Matthew Kosinski, “What is Big Data?,” IBM Think Topics. Accessed: Mar. 17, 2026. [Online]. Available: https://www.ibm.com/think/topics/big-data

2. C. Buckner and J. Garson, “Connectionism,” in The Stanford Encyclopedia of Philosophy, Spring 2025., E. N. Zalta and U. Nodelman, Eds., Metaphysics Research Lab, Stanford University, 2019. Accessed: Mar. 20, 2026. [Online]. Available: https://plato.stanford.edu/archives/spr2025/entries/connectionism/

References

Glossary continued

3. Cole Stryker, “What is a Recurrent Neural Network (RNN)?,” IBM Think Topics. Accessed: Mar. 25, 2026. [Online]. Available: https://www.ibm.com/think/topics/recurrent-neural-networks
4. Cole Stryker, “What Are Large Language Models (LLMs)?,” IBM Think Topics. Accessed: Mar. 18, 2026. [Online]. Available: https://www.ibm.com/think/topics/large-language-models
5. Cole Stryker and Jim Holdsworth, “What Is NLP (Natural Language Processing)?,” IBM Think Topics. Accessed: Mar. 20, 2026. [Online]. Available: https://www.ibm.com/think/topics/natural-language-processing
6. Cole Stryker and Mark Scapicchio, “What is Generative AI?,” IBM Think Topics. Accessed: Mar. 18, 2026. [Online]. Available: https://www.ibm.com/think/topics/generative-ai
7. Dave Bergmann, “What is Machine Learning?,” IBM Think Topics. Accessed: Mar. 18, 2026. [Online]. Available: https://www.ibm.com/think/topics/machine-learning

References

Glossary continued

8. Dave Bergmann and Cole Stryker, “What is Backpropagation?,” IBM Think Topics. Accessed: Mar. 19, 2026. [Online]. Available: https://www.ibm.com/think/topics/backpropagation

9. Dave Bergmann and Cole Stryker, “What is a Transformer Model?,” IBM Think Topics. Accessed: Mar. 25, 2026. [Online]. Available: https://www.ibm.com/think/topics/transformer-model

10. Fangfang Lee, “What Is a Neural Network?,” IBM Think Topics. Accessed: Mar. 18, 2026. [Online]. Available: https://www.ibm.com/think/topics/neural-networks

11. H. S. Kalsi, “What is Good Old-Fashioned AI?,” Medium. Accessed: Mar. 18, 2026. [Online]. Available: https://medium.com/@harrpreet/what-is-good-old-fashioned-ai-59ff4a4719ce

12. Max Struever, Matthew Kropp, and Julie Bedard, “From Dev Speed to Business Impact: The Case for AI-Assisted Coding and Generative Engineering,” BCG X. Accessed: Mar. 25, 2026. [Online]. Available: https://www.bcg.com/x/the-multiplier/ai-assisted-coding-generative-engineering

References

Glossary continued

13. A. Mayor, Gods and Robots: Myths, Machines, and Ancient Dreams of Technology. Princeton: Princeton University Press, 2018. Accessed: Mar. 15, 2026. [E-book]. Available: https://muse.jhu.edu/pub/267/monograph/book/77367

14. Mesh Flinders, Stephanie Susnjara, and Ian Smalley, "What is a GPU?," IBM Think Topics. Accessed: Mar. 17, 2026. [Online]. Available: https://www.ibm.com/think/topics/gpu

15. Phill Powell and Ian Smalley, "What is a Central Processing Unit (CPU)?," IBM Think Topics. Accessed: Mar. 20, 2026. [Online]. Available: https://www.ibm.com/think/topics/central-processing-unit

16. Sospeter Mong'are, "Strong AI vs. Weak AI," DEV Community. Accessed: Mar. 18, 2026. [Online]. Available: https://dev.to/msnmongare/strong-ai-vs-weak-ai-1gi1

17. T. Taulli, *Artificial Intelligence Basics: A Non-Technical Introduction*, First Edition. Berkeley, CA: Apress, 2019. doi: 10.1007/978-1-4842-5028-0.

References

Glossary continued

18. “What are Foundation Models? - Foundation Models in Generative AI Explained - AWS,” Amazon Web Services, Inc. Accessed: Mar. 25, 2026. [Online]. Available: https://aws.amazon.com/what-is/foundation-models/

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