

Introduction to Deep Learning

By

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Artificial Intelligence (AI)

- AI was born in the 1950s.
- “artificial intelligence” crystallized as a field of research in 1956, when John McCarthy, then a young Assistant Professor of Mathematics at Dartmouth College, organized a summer workshop under the following proposal:
 - The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it. An attempt will be made to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves...

AI

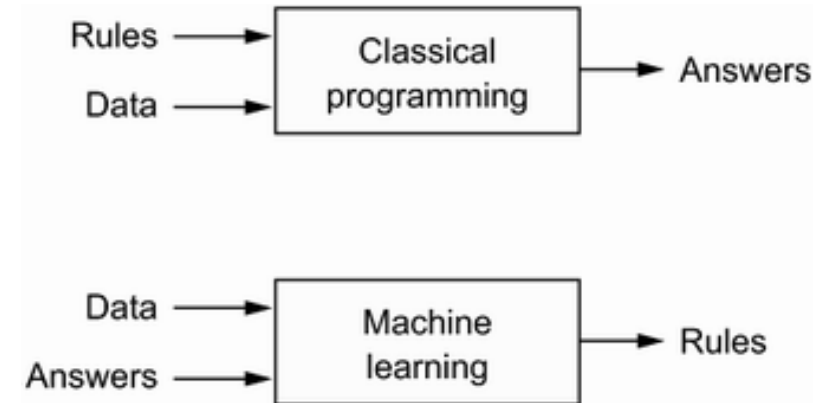
- AI: the effort to automate intellectual tasks normally performed by humans.
- Not necessarily related to learning
- Used mostly hardcoded rules crafted by programmers (referred to as Symbolic AI) – Chess game
- It reached its peak popularity during the expert systems boom of the 1980s.

AI to ML

- Symbolic AI proved suitable to solve well-defined, logical problems (e.g. chess).
- It turned out to be intractable to figure out explicit rules for solving more complex problems (e.g. image classification, speech recognition, or natural language translation)
- A new approach arose to take symbolic AI's place: machine learning (ML).

ML

- The machine looks at the **input data** and the corresponding **answers**, and figures out what the **rules** should be.
- A machine learning system is *trained* rather than **explicitly programmed**.
- It's presented with many **examples** relevant to a task, and it finds **statistical structure** in these examples that eventually allows the system to come up with **rules** for automating the task.



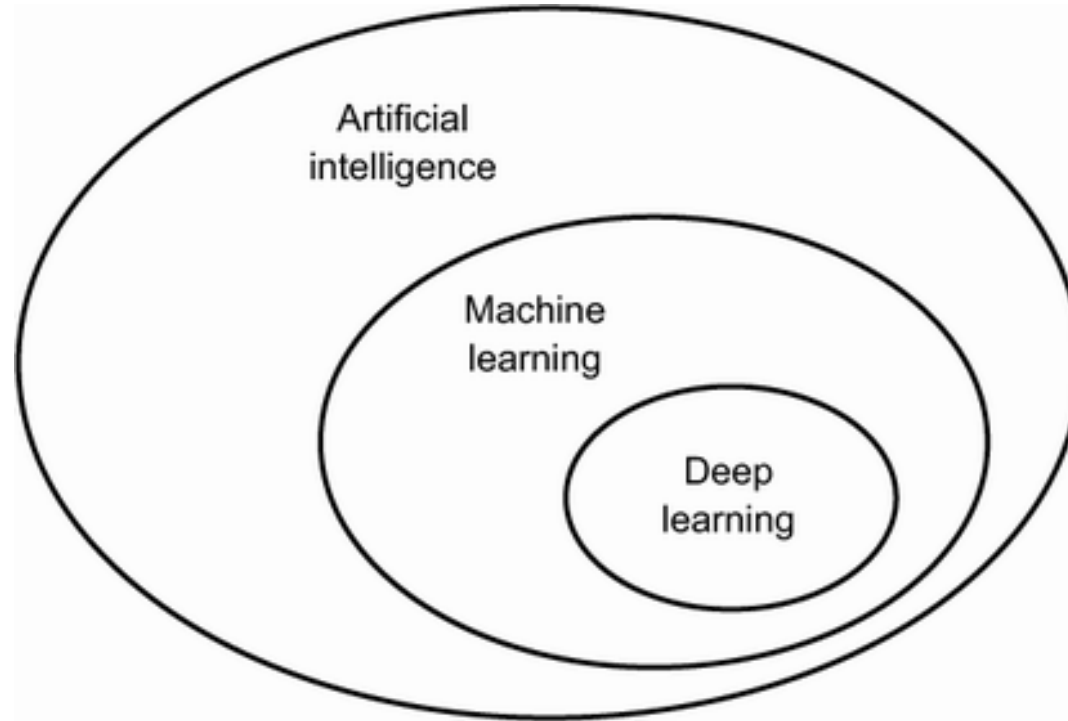
ML...

- Machine learning only started to flourish in the 1990s.
- Machine learning is a very hands-on field **driven by empirical findings** and deeply reliant on advances in software and hardware.

Deep Learning (DL)

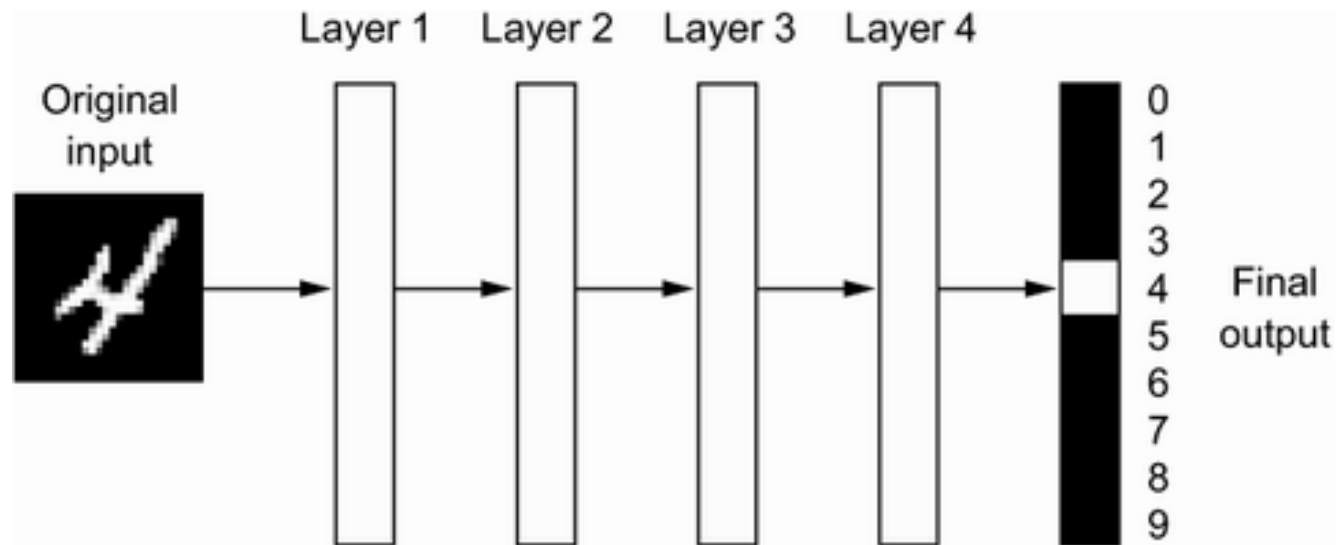
- A subfield of ML, a new take on learning representations from data that puts an emphasis on learning successive layers of increasingly meaningful representations
- Machine learning tends to focus on learning only one or two layers of representations of the data called shallow learning.
- Modern deep learning often involves tens or even hundreds of successive layers of representations, and they're all learned automatically from exposure to training data.

Relating AI, ML, and DL

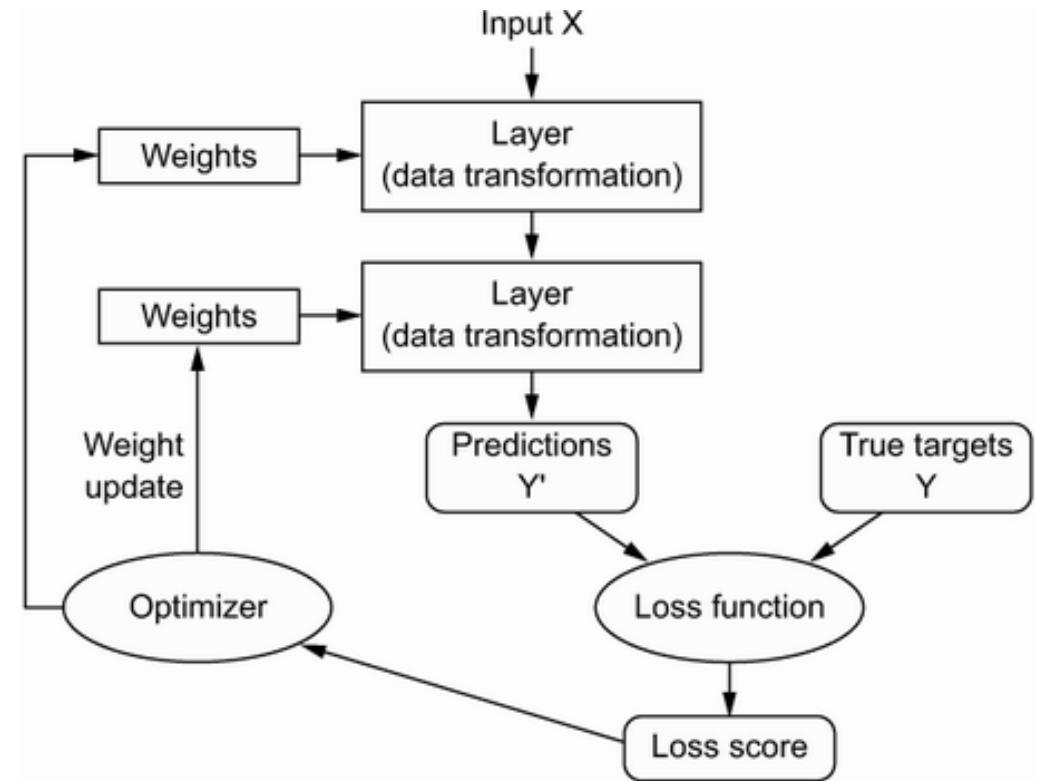
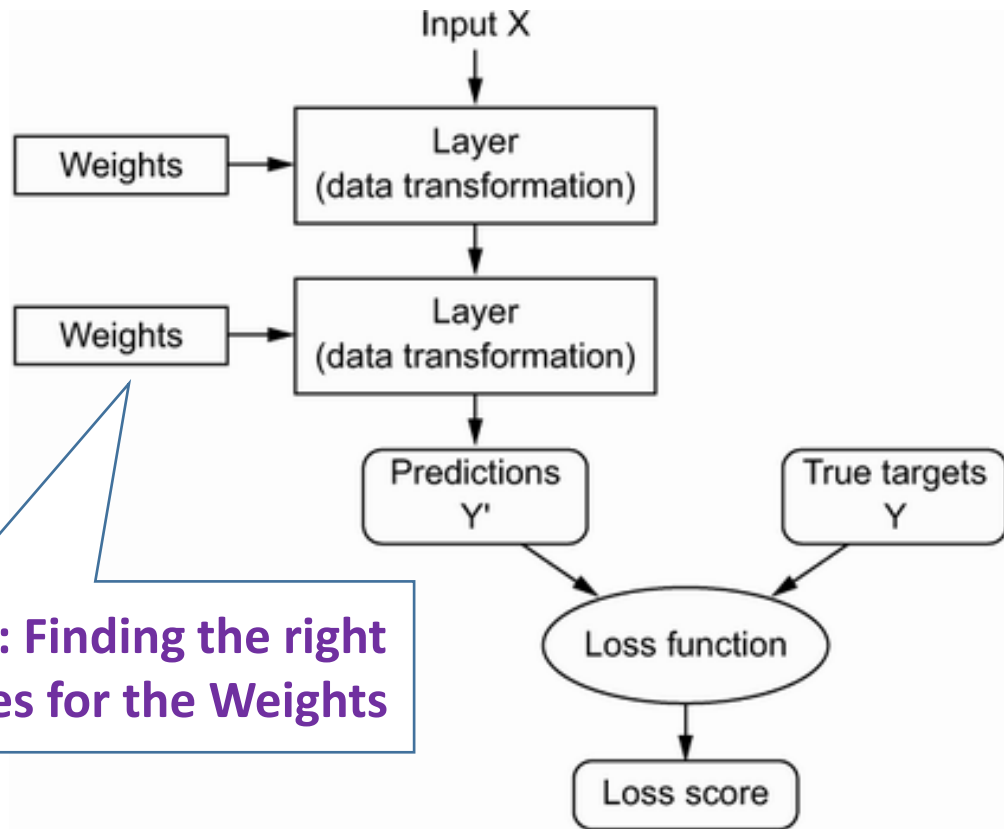


Deep Learning Network

- A Deep Learning Network for digit recognition



How Deep Learning works



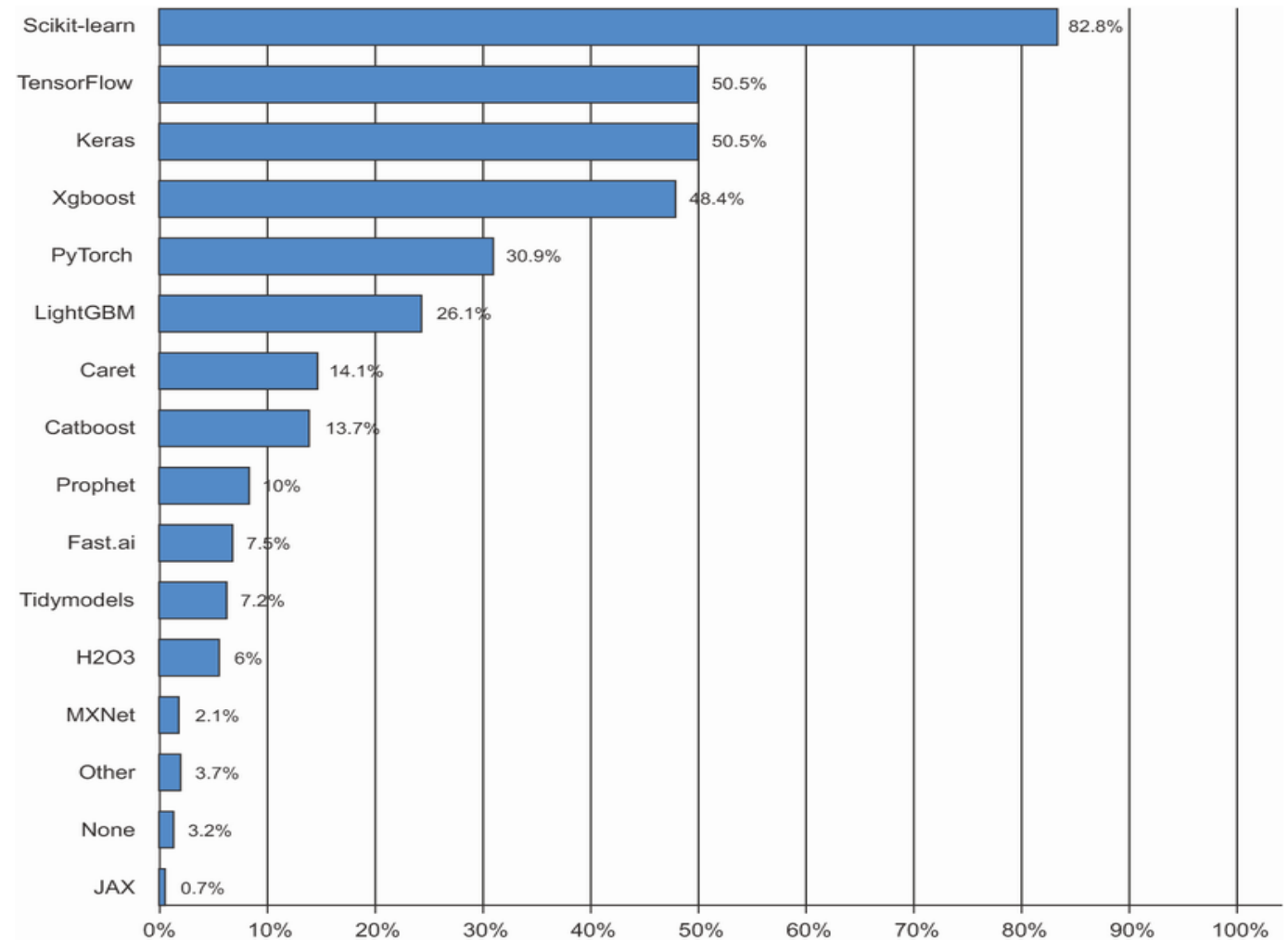
A neural network is parameterized by its weights.

What deep learning has achieved so far

- Near-human-level **image classification**
- Near-human-level speech transcription
- Near-human-level handwriting transcription
- Dramatically improved **text-to-speech conversion**
- Digital assistants such as Google Assistant and Amazon Alexa
- Near-human-level **autonomous driving**
- Improved ad targeting, as used by Google, Baidu, or Bing
- Improved **search results** on the web
- Ability to answer natural language questions
- **Superhuman** Go playing

The modern ML landscape: Tool usage

- Tool usage across the machine learning and data science industry (Source: www.kaggle.com/kaggle-survey-2020)



Why deep learning? Why now?

Three technical forces are driving advances in machine learning:

- Hardware
- Datasets and benchmarks
- Algorithmic advances

Hardware

- The NVIDIA Titan RTX, a GPU that cost \$2,500 at the end of 2019, can deliver a peak of 16 teraFLOPS in single precision (16 trillion float32 operations per second).
 - That's about 500 times more computing power than the world's fastest supercomputer from 1990, the Intel Touchstone Delta.
- Google revealed its Tensor Processing Unit (TPU) project
- In 2020, the third iteration of the TPU card represents 420 teraFLOPS of computing power.
 - That's 10,000 times more than the Intel Touchstone Delta from 1990.

Data

If deep learning is the **steam engine** of this revolution, then data is its **coal**:

- User-generated image tags on Flickr, for instance, have been a treasure trove of data for **computer vision**.
- YouTube videos,
- Wikipedia
- **ImageNet** dataset, consisting of 1.4 million images that have been hand annotated with 1,000 image categories is a key dataset for natural language processing.
- **EkushNet** (Bangla OCR)
- Bengali to English Translation Dataset (**2.75 million sentence pairs**)

Algorithms

- Better *activation functions* for neural layers
- Better *weight-initialization schemes*, starting with layer-wise pretraining, which was then quickly abandoned
- Better *optimization schemes*, such as RMSProp and Adam

Only when these improvements began to allow for training models with 10 or more layers did deep learning start to shine.

AI Revolution

Deep learning has several properties that justify its status as an AI revolution

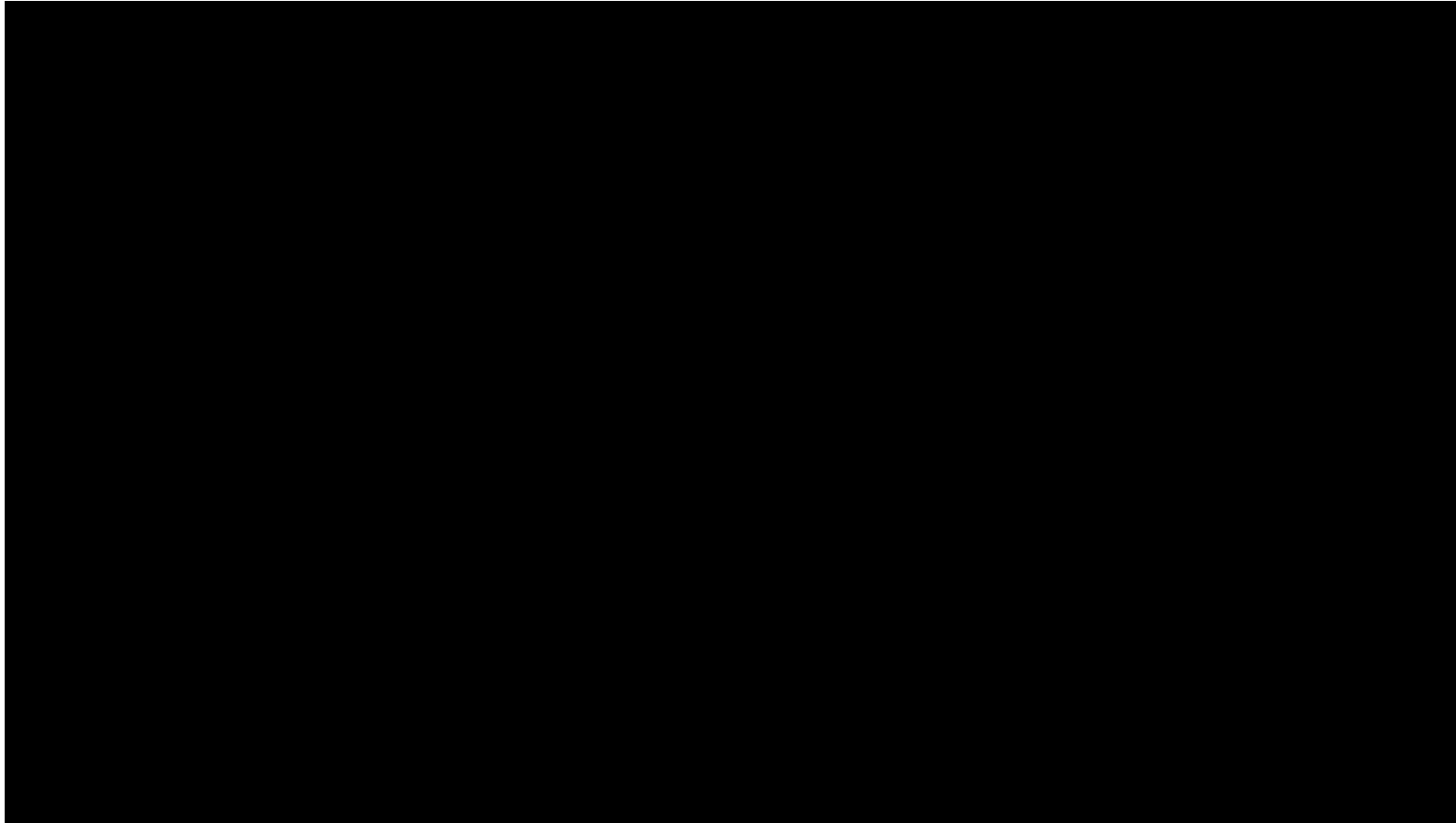
- *Simplicity*: end-to-end trainable models
- *Scalability*: highly amenable to parallelization on GPUs or TPUs
- *Versatility and reusability*: can be trained on additional data without restarting from scratch

Deep learning is still a revolution in the making, and it will take many years to realize its full potential.

AI in Actions: Google Assistant (NLP)



AI in Actions: Autonomous Vehicle (Computer Vision)



AI in Actions : ChatGPT 3.5 (Generative AI)

Me: Please prepare me a 10 min lecture on Taj mahal.

ChatGPT: Certainly! Here's a 10-minute lecture on the Taj Mahal:

Slide 1: Title Slide (1 minute)

Title: "The Taj Mahal: Symbol of Eternal Love and Architectural Marvel"

Subtitle: "A Journey Through History, Design, and Cultural Significance"

Brief introduction and your name.

Slide 2: Introduction (2 minutes)

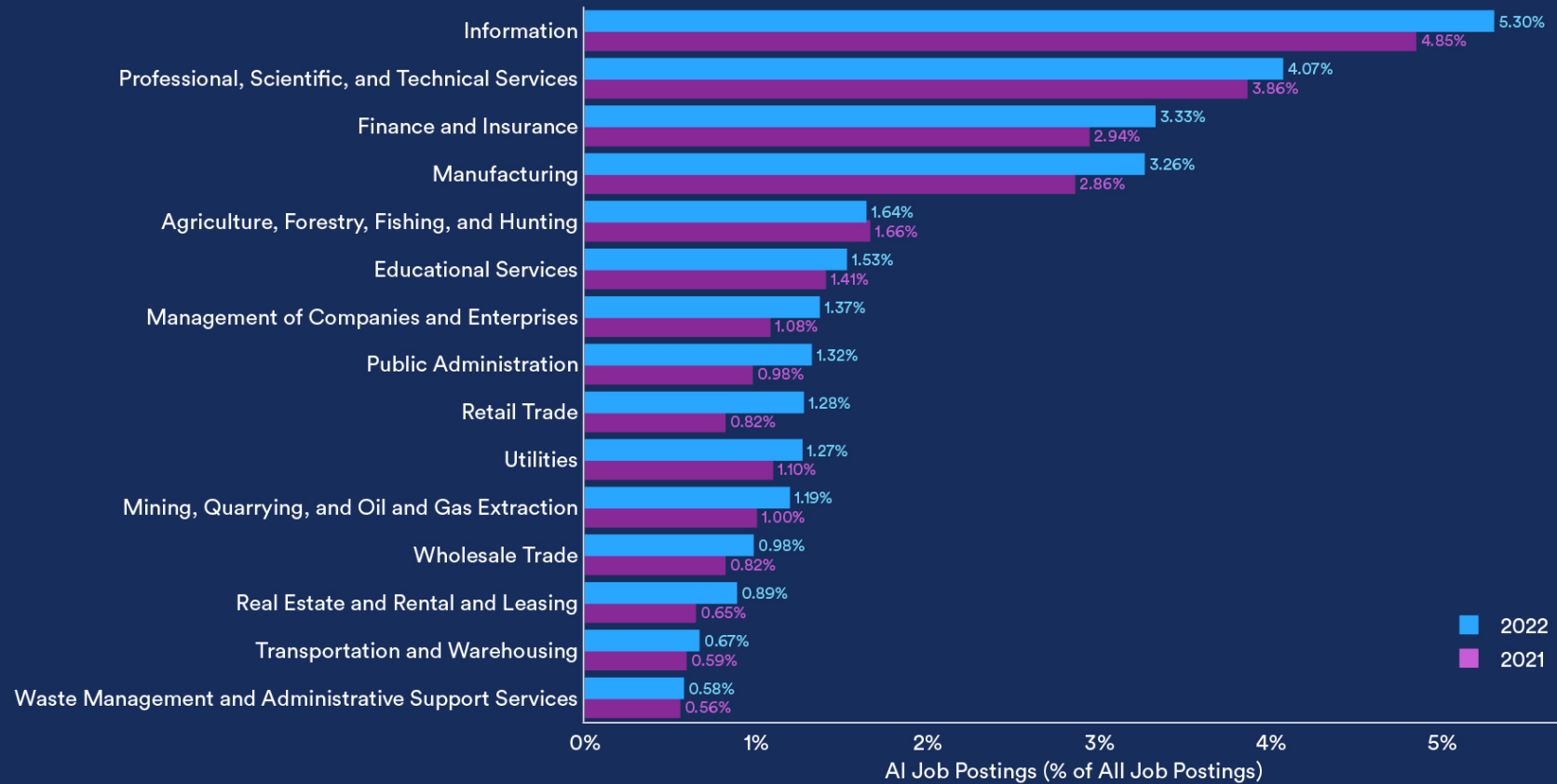
Begin with a captivating image of the Taj Mahal.

Share a brief overview of the Taj Mahal as an iconic symbol of love and a masterpiece of architecture.

Slide 3: Historical Background (2 minutes)

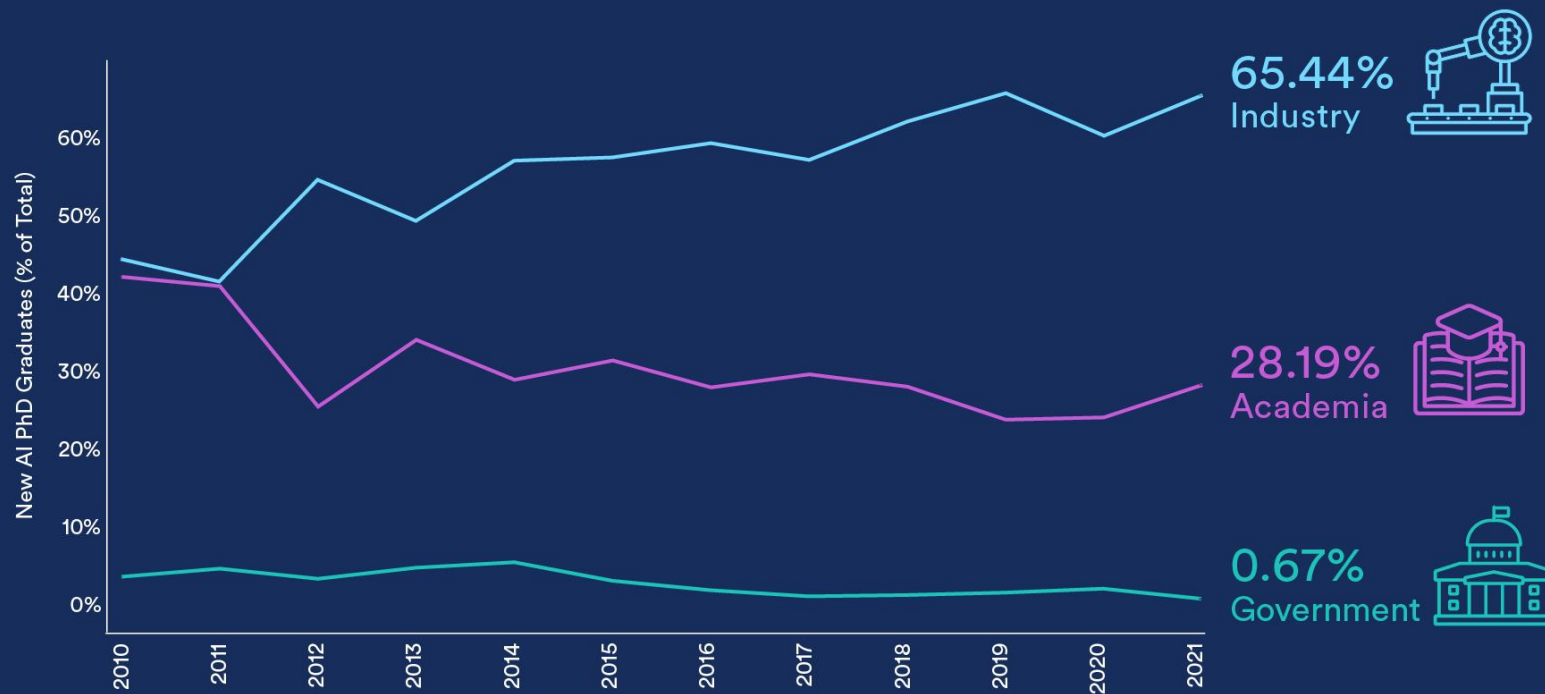
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AI Job Postings (By % of All Postings) in the U.S.



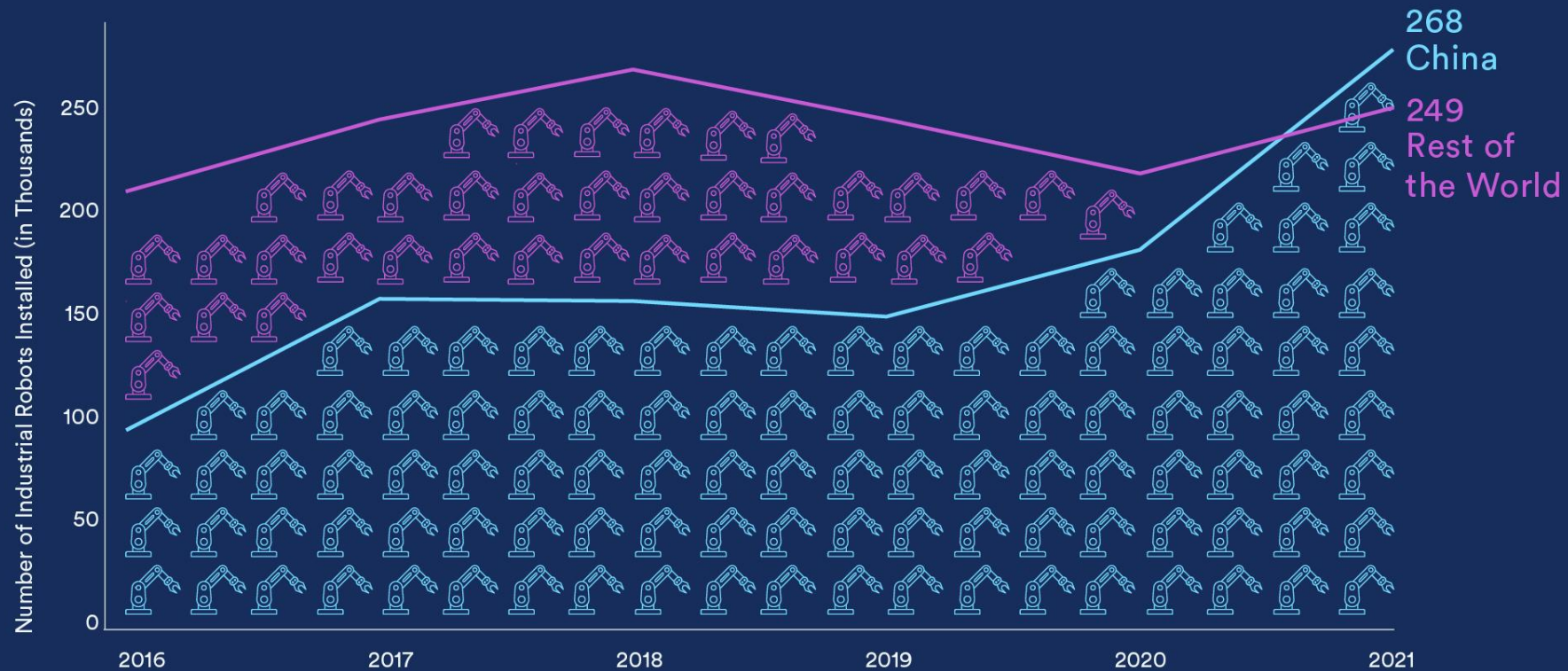
Source: Lightcast, 2022 | Chart: 2023 AI Index Report

Employment of New AI PhDs (% of Total) in North America by Sector, 2010–21



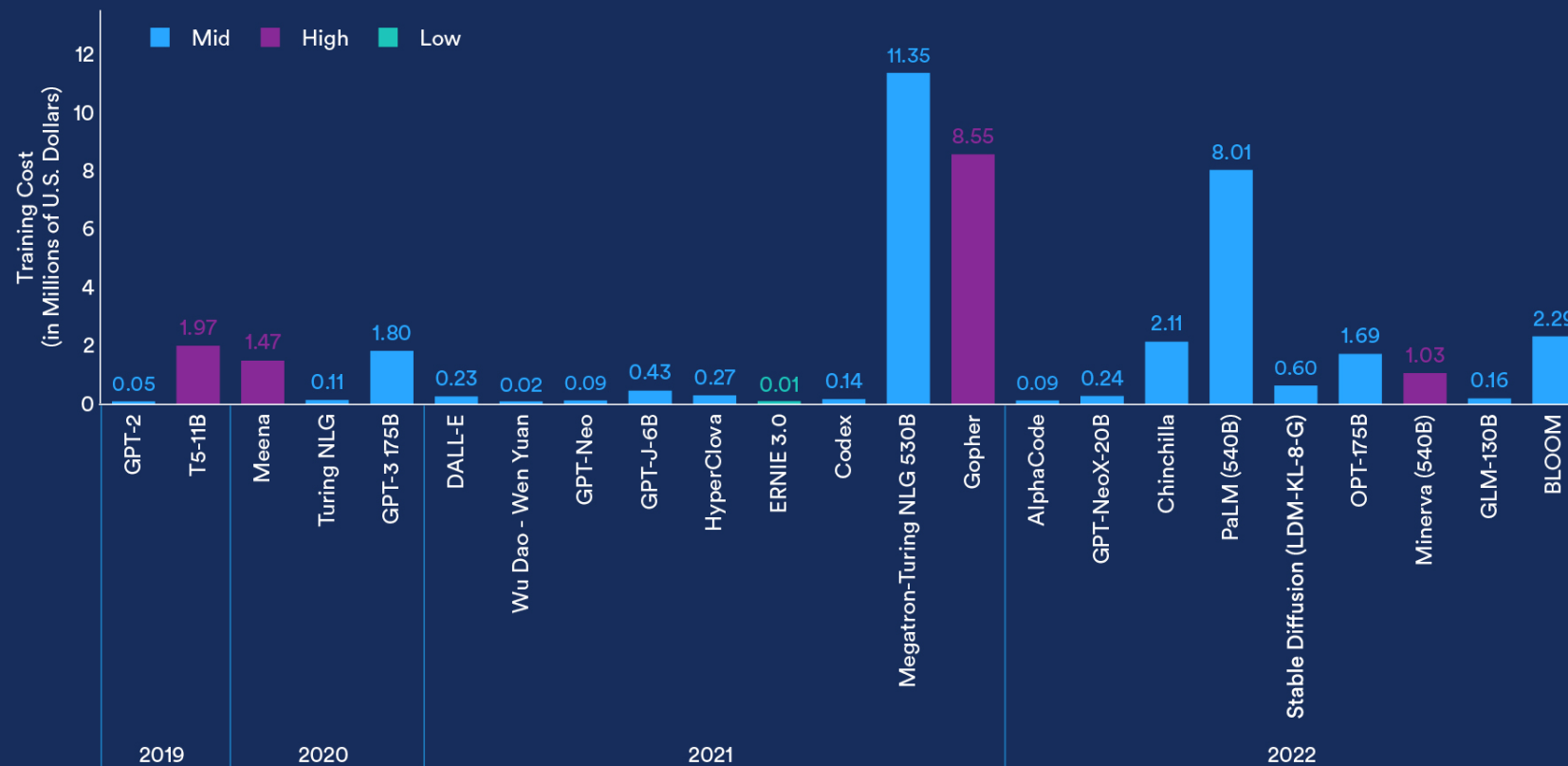
Source: CRA Taulbee Survey, 2022 | Chart: 2023 AI Index Report

Number of Industrial Robots Installed



Source: International Federation of Robotics (IFR), 2022 | Chart: 2023 AI Index Report

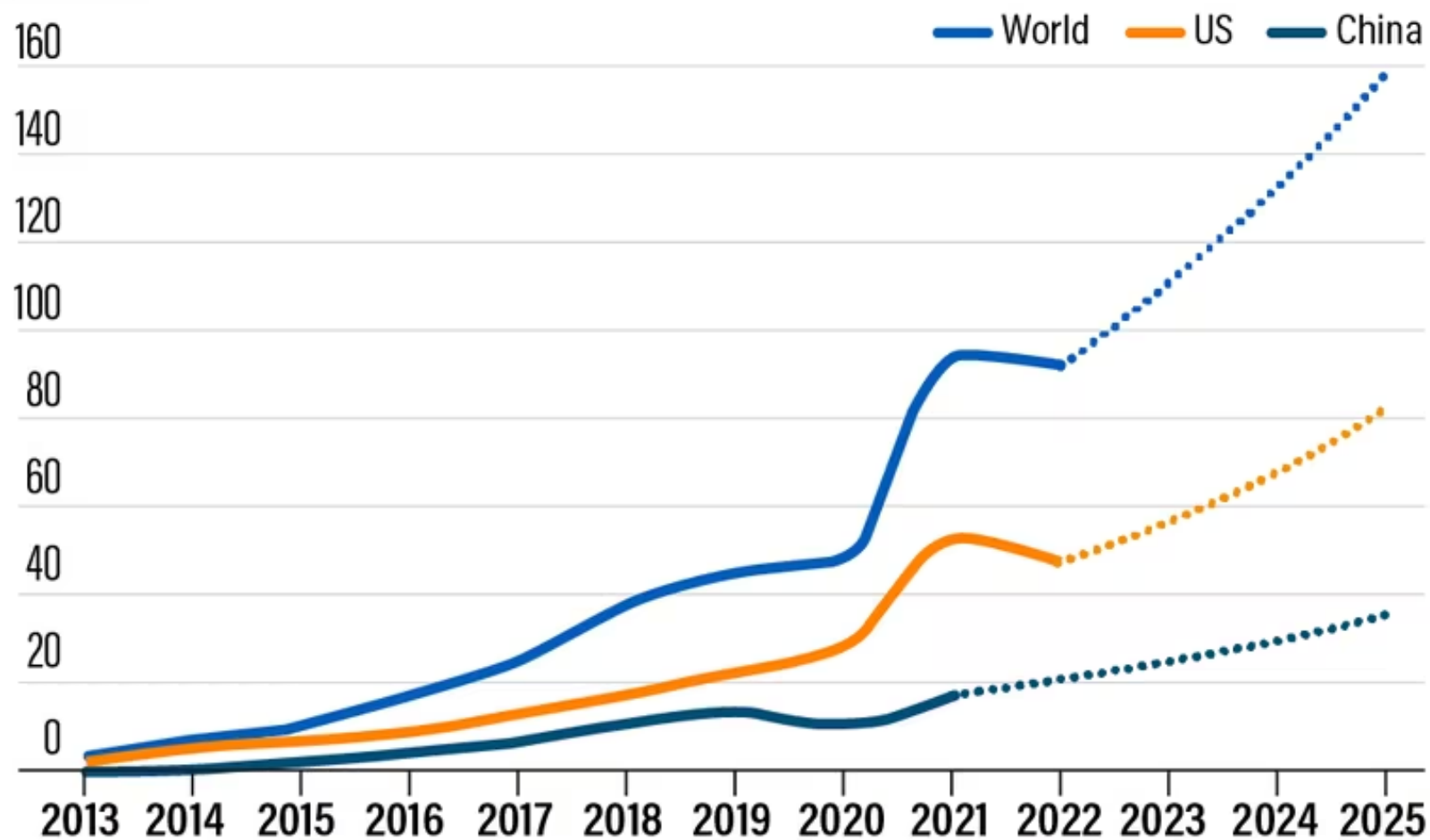
Estimated Training Costs of Large Models



Source: AI Index, 2022 | Chart: 2023 AI Index Report

AI INVESTMENT IS LIKELY TO GROW IN THE NEXT THREE YEARS

(\$billion)



Source: Stanford Institute, Goldman Sachs

References

- *Deep Learning with Python*, Second Edition by François Chollet
- <https://hai.stanford.edu/news/2023-state-ai-14-charts>
- <https://www.thenationalnews.com/business/technology/2023/08/14/global-ai-investments-could-hit-200bn-by-2025-and-have-bigger-impact-on-economy/>