Los Alamos NATIONAL LABORATORY

Non-Technical Introduction to Artificial Intelligence

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Outline

- What is AI?
- AI Breakthroughs
  - Chess (1997)
  - Image classification (2012)
  - AlphaGo (2016)
  - Transformers->ChatGPT (2017)
  - AlphaFold Protein Folding (2022)
  - ChatGPT and Generative AI (2023)
  - AI-enabled Nobel Prizes in Physics and Chemistry (2024)
- History of Data Driven and Physics-Informed Approaches
- AI as a new Information Network
- Risks with AI
- What is LANL doing with AI

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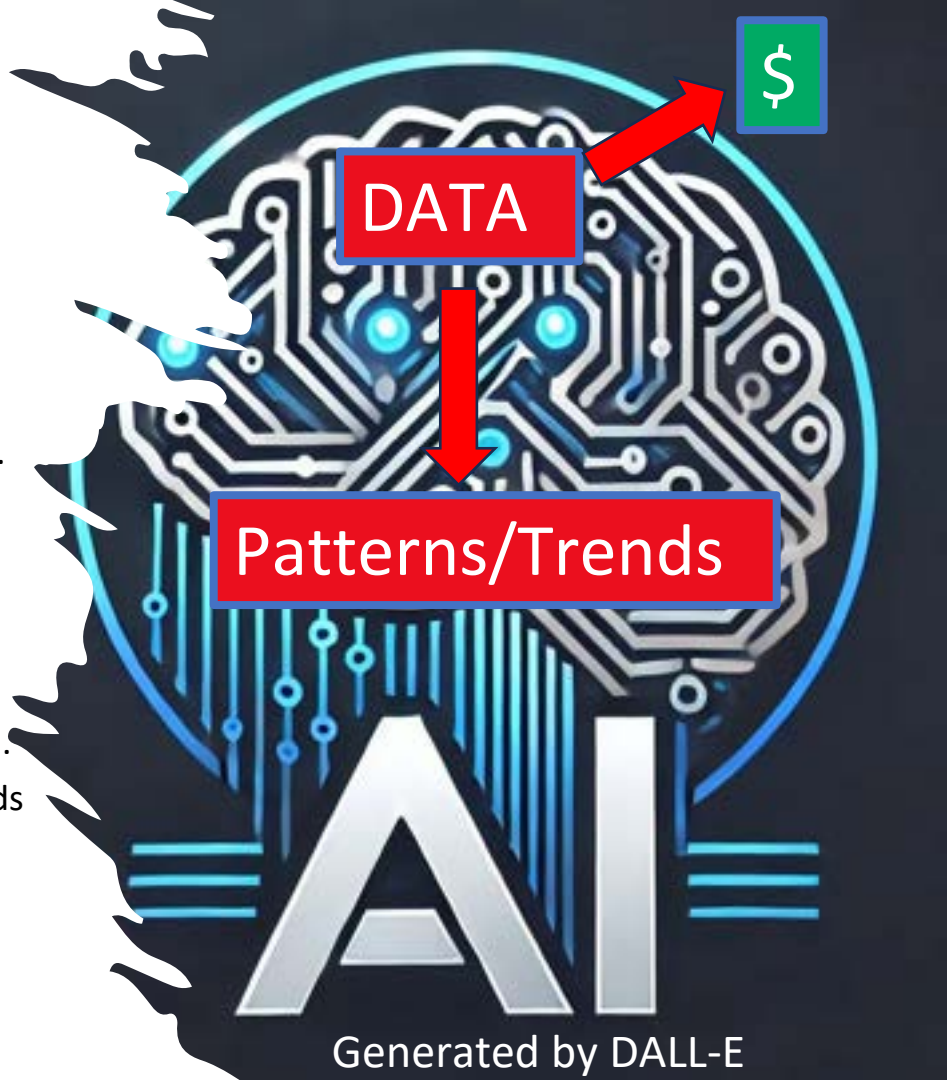
What is Artificial Intelligence?

Artificial Intelligence (AI) is the field of computer science that focuses on simulating human intelligence.

Key Aspects of AI:

- **Machine Learning (ML)** – AI systems learn from data and improve performance without being explicitly programmed.
- **Natural Language Processing (NLP)** – AI understands, processes, and generates human language (e.g., chatbots)
- **Computer Vision** – AI can analyze and interpret images and videos (e.g., facial recognition, medical imaging).
- **Robotics** – AI-powered robots can perform tasks autonomously (e.g., self-driving cars, industrial automation).
- **Expert Systems** – AI mimics human expertise in specific fields (e.g., medical diagnosis, fraud detection).

You Use it Everyday: Facial ID on your phone, Google Search (with Gemini), GPS Directions in your car, ads you are shown in social media



Why is AI having so much impact now?

1958

Perceptron (Frank Rosenblatt): First trainable neural network, capable of learning simple patterns. Field did not take off for decades.

Today: Neural Network Power Unleashed

- **Computing Power** – Faster GPUs & cloud AI enable large-scale processing
- **Big Data** – AI thrives on massive data from IoT, social media, and sensors
- **Advanced Models** – Deep learning & multimodal AI Neural Networks (text, images, speech)

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Chess (1997)

- **Event:** IBM’s Deep Blue vs. Garry Kasparov
- **Outcome:** Deep Blue defeats Kasparov in a six-game match
- **Significance:** First time an AI defeated a reigning world chess champion in a match
- **Why Was This Victory Important?**
- ✅ Proved that AI could outperform human intelligence in structured tasks
  ✅ Showcased the power of machine learning and computational analysis
  ✅ Inspired advancements in AI, leading to modern supercomputers and AlphaZero

Beyond Deep Blue

- **Stockfish & AlphaZero** – AI engines that dominate chess today
- **AI's Learning Evolution** – From brute-force calculations to neural networks (self play)
- **Impact on Strategy** – AI-generated insights help human players improve

Image Classification Breakthrough (2012)

- **Revolution in Computer Vision**
- **Key Moment:** AlexNet winning ImageNet Challenge (14 M images in 1000 different categories)
- **Breakthrough:** Deep learning surpassed traditional methods
- **Significance:** Enabled AI to classify images with human-like accuracy
- **Why Was This Breakthrough Important?**
- ✅ Proved deep neural networks outperform classical algorithms
  ✅ Led to advancements in medical imaging, self-driving cars, and more
  ✅ Marked the rise of deep learning in AI research
- **Applications Today:** Facial recognition, medical diagnostics, security

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AlphaGo (2016)

- **Key Event:** AlphaGo defeated Go world champion Lee Sedol (2016)
- **Significance:** First AI to defeat a top human player in the complex game of Go
- **Game Complexity:** More possible board states than atoms in the universe (believed intuition needed to win)
- **How Did AlphaGo Achieve This?**
- ✅ Deep reinforcement learning and neural networks
  ✅ Self-learning through millions of simulated games
  ✅ AI developed innovative, unpredictable strategies
- **Impact of AlphaGo's Success**
- Asia has entire schools to learn Go and AI came up with a bizarre solution, laughed at by experts, to be the champ
- Led to AlphaZero (2017), which mastered multiple games without human data

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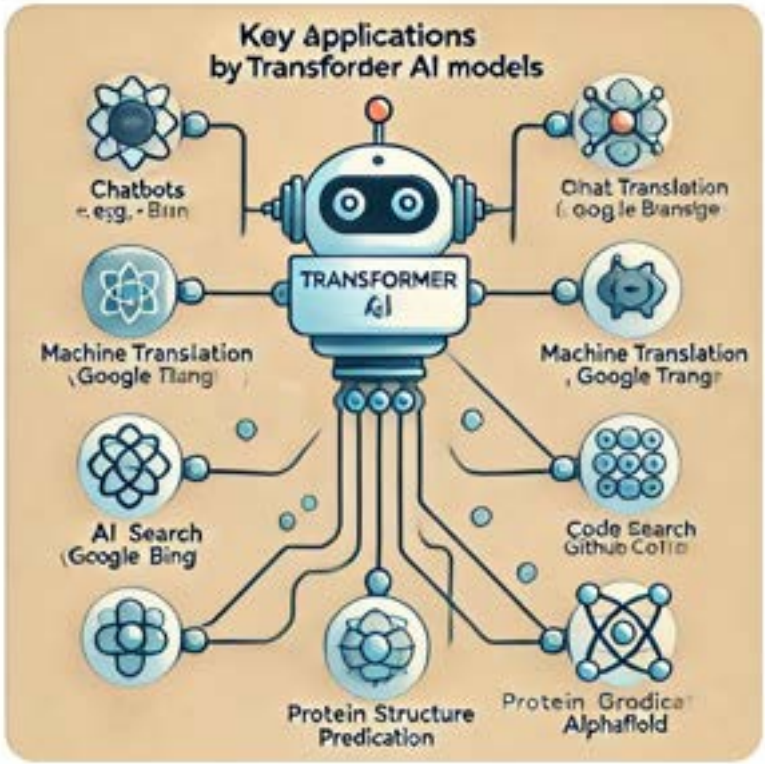
Transformers (2017)

AI models using **self-attention**, introduced by **Google (2017)**

- Foundation of **ChatGPT, BERT, and AI-powered search**.
- **Key Impacts:**
  ✅ **NLP Breakthroughs** – Chatbots, translation, search
  ✅ **AI Creativity** – Image (DALL·E), video, music generation
  ✅ **Scientific Innovation** – Protein folding (AlphaFold), drug discovery
  ✅ **Future Potential** – Smarter, efficient AI i daily life



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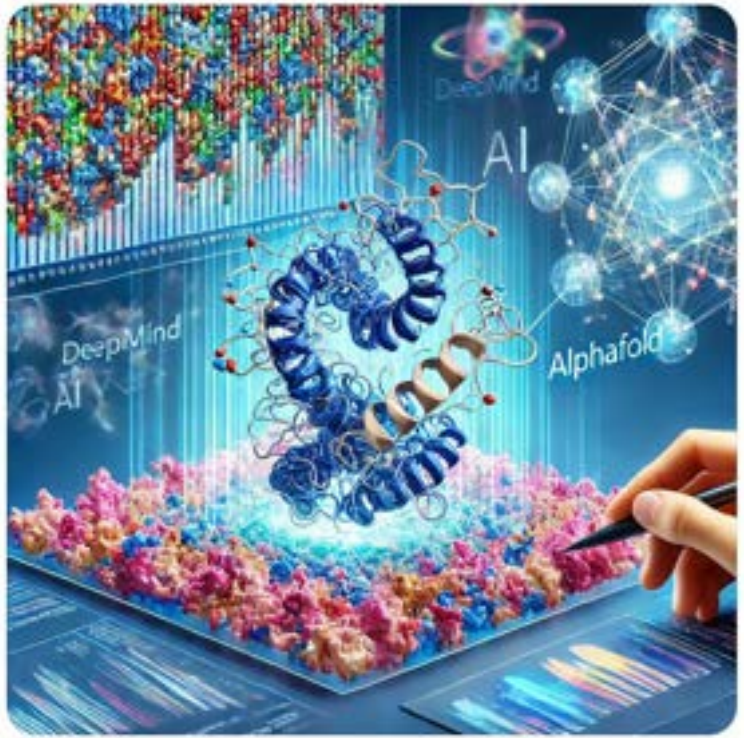
Protein Folding (2022)

Protein Structure determines their function

Key Milestones:

- **2018**: AlphaFold win a global protein-folding competition
- **2020**: AlphaFold 2 achieves breakthrough accuracy in protein structure prediction, winning CASP14
- **2021**: DeepMind publishes AlphaFold's results and open-sources its predictions
- **2022**: AlphaFold predicts structures for nearly all known proteins, revolutionizing biomedicine & drug discovery
- **Impact:** Transformed biology, medicine, and drug discovery by solving the 50-year-old protein-folding problem



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Generative AI (2023)

AI that **generates new content** (text, images, music, code) by learning patterns from data.

⚙️ **How it works?**

•Uses **deep learning** & neural networks.

•Trained on **large datasets** to produce:

✅ Text (chatbots, content)

✅ Images & Video (AI art, deepfakes)

✅ Music & Code (composition, automation)

Impact:

🔹 **Pros:** Boosts creativity & efficiency.

🔸 **Cons:** Raises ethical concerns (bias, misinformation)

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Deep Learning Nobel Prize Physics
Hinton, LeCun, Bengio (2024)

“Godfather of Deep Learning”
Breakthrough: Revolutionized AI with deep learning & neural networks

Key Innovation: Developed **backpropagation** for training neural networks

Impact: Enabled modern AI applications like ChatGPT, self-driving cars, and medical AI

Legacy: AI shaping the future of technology, automation, and intelligence

Drug and Materials Discovery Nobel Prize Chemistry
Baker, Hassibis, and Jumper (2024)

- Faster, cost-effective **drug discovery**.
- AI-powered **green chemistry** solutions.
- New frontiers in **materials design** and **synthetic biology**.

Data-Driven Approach vs Physics-Informed Approach

- A **data-driven approach** is a **decision-making method** that relies on **collecting, analyzing, and interpreting data** to identify patterns, make predictions, and optimize outcomes, rather than relying on intuition or assumptions -> AI is a data-driven approach
- A **physics-informed approach** integrates **physical laws, mathematical models (e.g. equations), and empirical data** to improve predictions, optimize solutions, and enhance understanding, ensuring consistency with real-world principles.
- Both have advantages and limitations so throughout history these methods combine and separate

Generative AI misspells a lot

History of Data-Driven Approaches

- **Babylonians: Early Data-Driven Thinkers**
- **Using Data for Astronomy & Prediction**
- **Systematic Data Collection**
  - Recorded celestial events on clay tablets (e.g., *Astronomical Diaries*).
  - Tracked planetary movements, eclipses, and lunar cycles.
- **Pattern Recognition**
  - Identified recurring cycles, like the Saros cycle for eclipses.
  - Analyzed historical data to find trends in celestial movements
- **Predictive Modeling**
  - Developed **arithmetical algorithms** for forecasting planetary positions.
  - Used past data to predict future eclipses with high accuracy.
- **Limitations:** Many processes cannot be predicted without knowing the underlying physics

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History of Physics-Informed Approaches

- **Greeks & the Physics-Informed Approach** ⚖️🔬
- **Aristotle** – Linked logic & observation to physical laws.
- **Archimedes** – Applied math to mechanics, pioneering hydrostatics.
- **Ptolemy** – Created astronomical models based on data.

Method:

- Combined empirical data with theory.
- Used mathematics to refine physics laws.
- Developed engineering solutions (levers, pulleys).

Legacy:

- Foundations for modern physics modeling & AI algorithms.

Limitations: Equations have many assumptions and simplifications that may not work for overly complex problems

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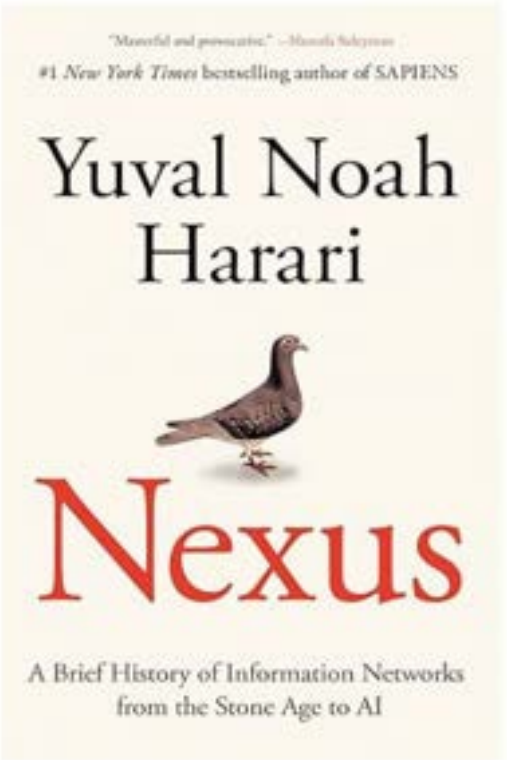
Impact: AI the Latest Information Network

- **Concept**: History, biology, technology, and information networks are deeply interconnected.
- **Key Themes**:
  - **AI & Big Data** – Reshaping society, power, and decision-making.
  - **Human Evolution** – Biology + culture + networks shaping behavior.
  - **Power & Narratives** – Myths, stories, and now digital networks drive civilizations.
- **Impact**:
  - Information networks amplify influence and control.
  - Raises ethical concerns about AI, surveillance & misinformation.
  - Highlights technology's role in shaping the future.
- **Takeaway**: The **nexus of data, power, and networks** shapes humanity's path.

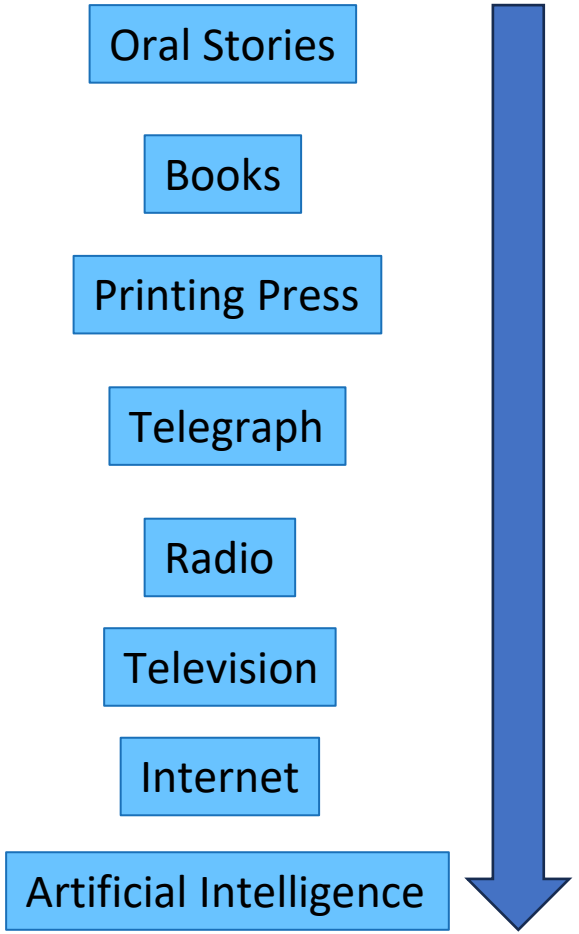


Information Networks

1. **Religious Texts & Myths** 📜 – Ancient oral traditions and scriptures acted as early information networks, shaping societies through shared beliefs and collective narratives.
2. **Trade & Knowledge Exchange** 🌍 – The Silk Road and other historical trade routes functioned as networks spreading ideas, technologies, and culture.
3. **Printing Press & Mass Media** 📰 – The invention of the printing press revolutionized information flow, enabling mass literacy and political shifts (e.g., the Reformation, Enlightenment).
4. **Digital & AI Networks** 🤖 – Today's AI-driven systems (Google, social media, blockchain) create **real-time global information ecosystems**, influencing politics, economics, and individual behavior.

Newspaper editors often became leaders (e.g. Ben Franklin, Stalin), Now AI decides which stories to amplify

Disinformation often spikes when a new network arrives



Information Networks: Balance of Order and Truth

- Hitler and Stalin maximized order and sacrificed truth
- Science prioritizes truth sacrificing order (e.g. Einstein overturning Newton celebrated)
- Strong democracies prioritize truth and can struggle with order
- Totalitarian and Authoritarian regimes prioritize order
- What does AI favor?

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What Type of System does AI Favor?

AI in Democratic Systems 🗳️

✅ **Boosts citizen engagement** – open data, and digital platform increase participation.

❌ **Risk of manipulation** – AI-driven misinformation (e.g., deepfakes, biased algorithms) can distort elections and reality.

❌ **Corporate AI dominance** – Tech companies influence public discourse and privacy.

AI in Autocratic Systems 🔒

✅ **Strengthens control** – AI-driven surveillance (e.g., facial recognition, predictive policing) enhances state power.

✅ **Strengthens control** – Separate media ecosystems may favor strong man leader with simple solutions

❌ **One Ruler less Robust** – Most information funnels to one leader making system vulnerable to AI

❌ **Suppresses dissent** – Censorship, propaganda, and digital monitoring restrict freedoms.

❌ **Social scoring & restrictions** – AI-based systems (e.g., China's social credit) enforce behavior control.

Problematic AI Examples

📢 **Facebook & Myanmar (2017)**

1. AI-driven **content algorithms** amplified hate speech, fueling violence against the Rohingya minority. **Created different media spheres.**
2. Facebook later admitted failing to prevent the spread of harmful content.

📰 **AI-Generated Fake News & Deepfakes**

1. AI-generated misinformation and **deepfake videos** spread **false political narratives**.
2. Example: **2020 U.S. Elections** saw AI-assisted misinformation campaigns.

🎭 **Bias in AI Facial Recognition**

1. Studies found **racial and gender biases** in AI recognition (e.g., misidentifying minorities).
2. Example: **IBM, Amazon, and Microsoft paused** facial recognition sales due to ethical concerns.

⚖️ **AI & Criminal Justice Bias**

1. Predictive policing and sentencing AI tools **disproportionately targeted minorities**.
2. Example: **COMPAS Algorithm** in the U.S. had racial bias in predicting recidivism.

Problematic AI Examples

🛑 **Tesla Autopilot Accidents**

1. AI-powered self-driving caused fatal crashes due to failures in object recognition & decision-making.
2. Example: Tesla crashes (2018, 2021) linked to AI misjudging road hazards.

🔍 **AI Hiring Discrimination**

1. AI-based recruitment tools (e.g., Amazon's hiring AI) showed gender bias, favoring male applicants.

⚡ **AI & Mass Surveillance**

Governments (e.g., China's social credit system) use AI to monitor, rank, and control citizens.

🚨 **Key Takeaway:** AI has transformative power but requires ethical oversight & regulation to prevent harm. Currently this regulation is lacking.

AI and Blue-Collar Jobs

- **Manufacturing & Warehousing** – Robotics replacing manual labor
- **Transportation** – Self-driving trucks & delivery drones
- **Construction & Agriculture** – AI-powered machinery improving efficiency
- **Retail & Fast Food** – Self-checkouts & robotic kitchens
- **Security & Cleaning** – AI-driven surveillance & autonomous cleaners

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AI and White-Collar Jobs

- **Customer Service** – AI chatbots handling queries & support
- **Finance & Accounting** – AI automating bookkeeping & fraud detection
- **Legal Work** – AI-powered contract analysis & document review
- **Healthcare** – AI diagnosing medical images & assisting doctors
- **Marketing & Content** – AI-generated ads, blogs, and media
- **Software Development** – AI-assisted coding & debugging
- **Education** – AI-driven personalized learning & tutoring

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PEEC Nature Youth Group AI Example

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- High school kids developed an AI-enabled method to detect mountain lions for non-lethal mitigation
- Won international award at the NeurIPS conference in Vancouver (4/330 winning projects world wide)
- There effort is one of the first attempts at using AI for wildlife conservation
- AI models amazing at analyzing photos
- Future workforce will need to be familiar with what AI can do to stay ahead of it while using it effectively and responsibly

Recent Rapid Progression of AI

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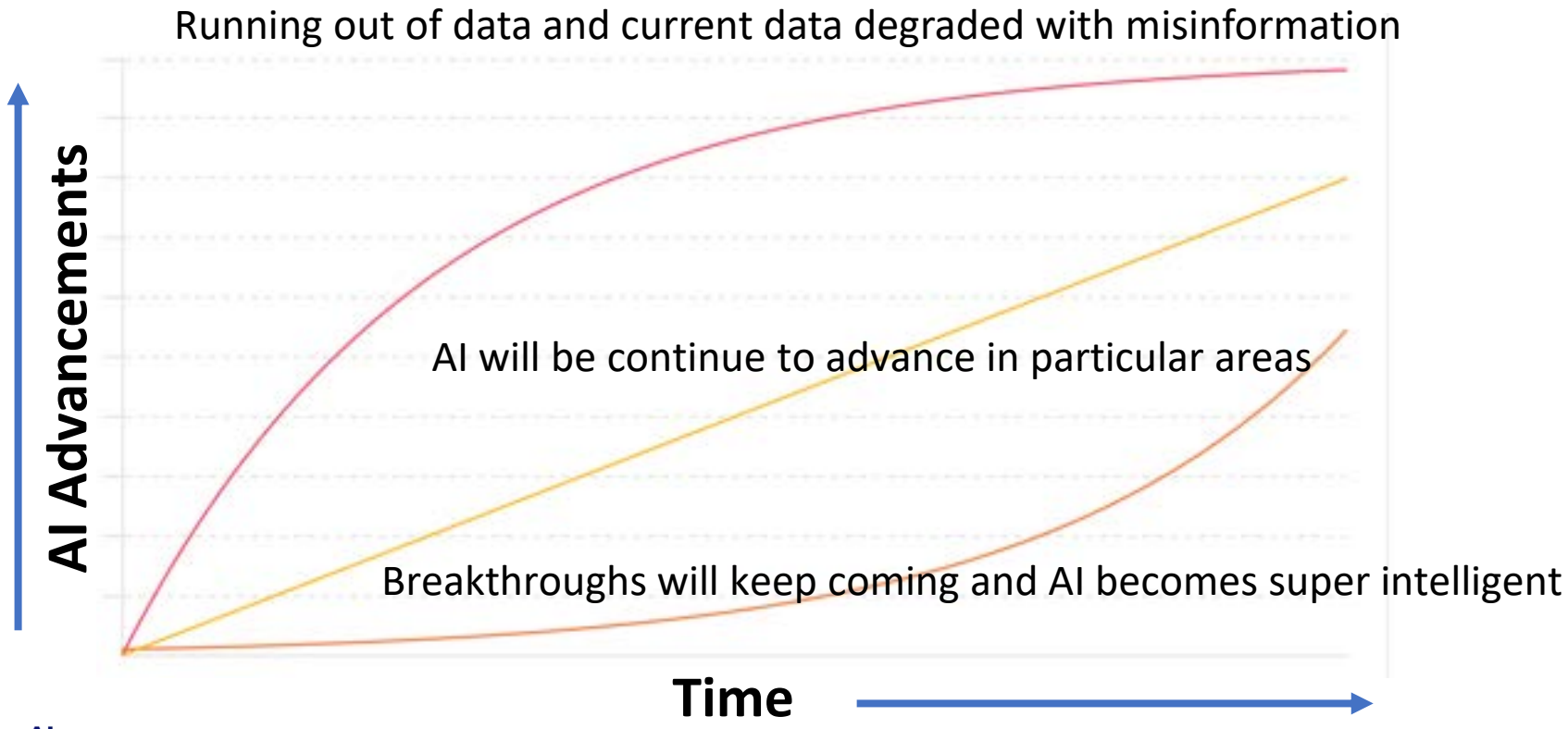
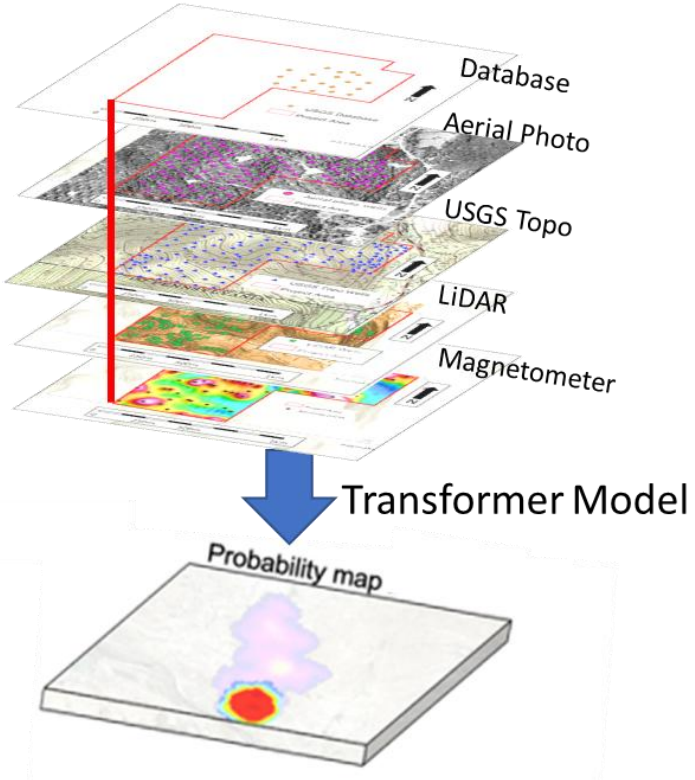
- I've been shocked at how quickly these models are improving
- They write very well so it is difficult to tell if they are incorrect
- They are mostly correct
- Image generation is not as far along requiring much more trial and error
- Video generation is in its infancy
- Evens the playing field when writing papers, proposals, etc.

Where is this going?



How Have I used AI?

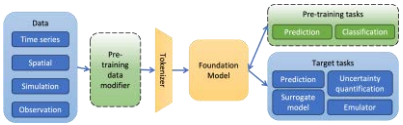


- Amazing at taking my own writing and summarizing it to whatever page limit and format required
- Very good a comprehensive literature search and synthesizing information
- Haven’t seen even the new reasoning models come up with new, innovate ideas
- It’s research approach does approach a mediocre graduate student whereas just 3 years ago it was closer to an elementary student
- Find signals from noise and to speed up simulations

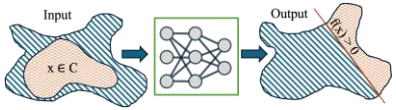
What is LANL Doing with AI

Core AI

Scientific Foundation Models

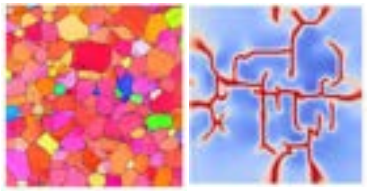


Design, Discovery & Control

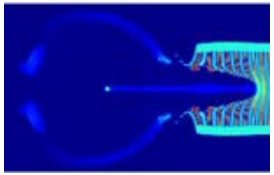


Applications

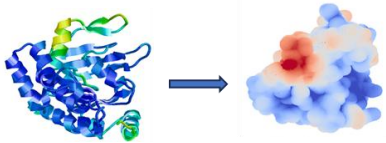
Materials Performance and Design



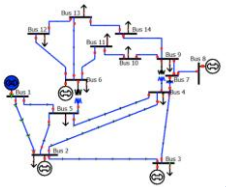
Multiphysics Systems



Biosecurity



Applied Energy



AI Support

Data

Computation

Test & Evaluation

Risk Assessment

Should AI be a Part of Your Life?

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- Highly likely AI is already used in your daily life (facial id on your phone, GPS directions, ad suggestions)
- Best to understand what it can and cannot do so you can be informed using these new tools
- As with any new technology, it can be beneficial or problematic
- For people entering the work place it will be critical to figure out how to use AI rather than having it replace a skill you have (e.g. graphic artists, writers, doctors, lawyers, scientists …)