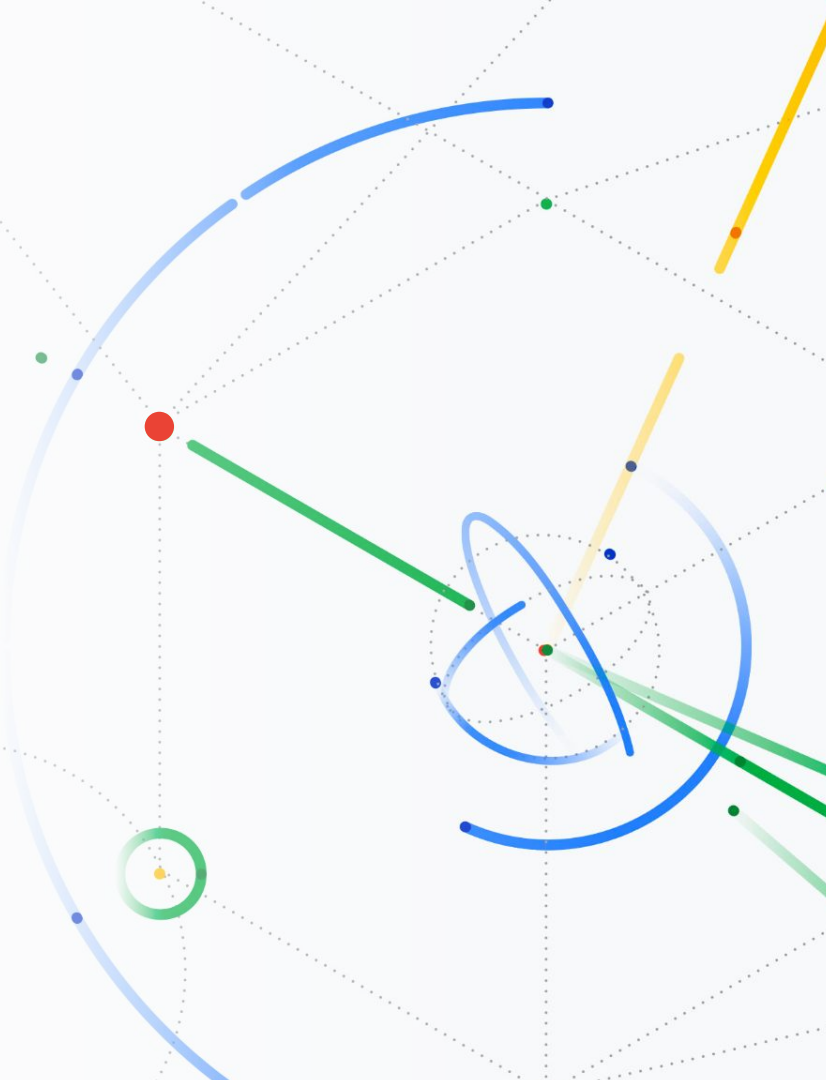
AI and Science at Google

Jeff Dean
Chief Scientist
Google Research and Google DeepMind



Advance progress on Scientific Grand Challenges

NAE's Grand Engineering Challenges for 21st Century

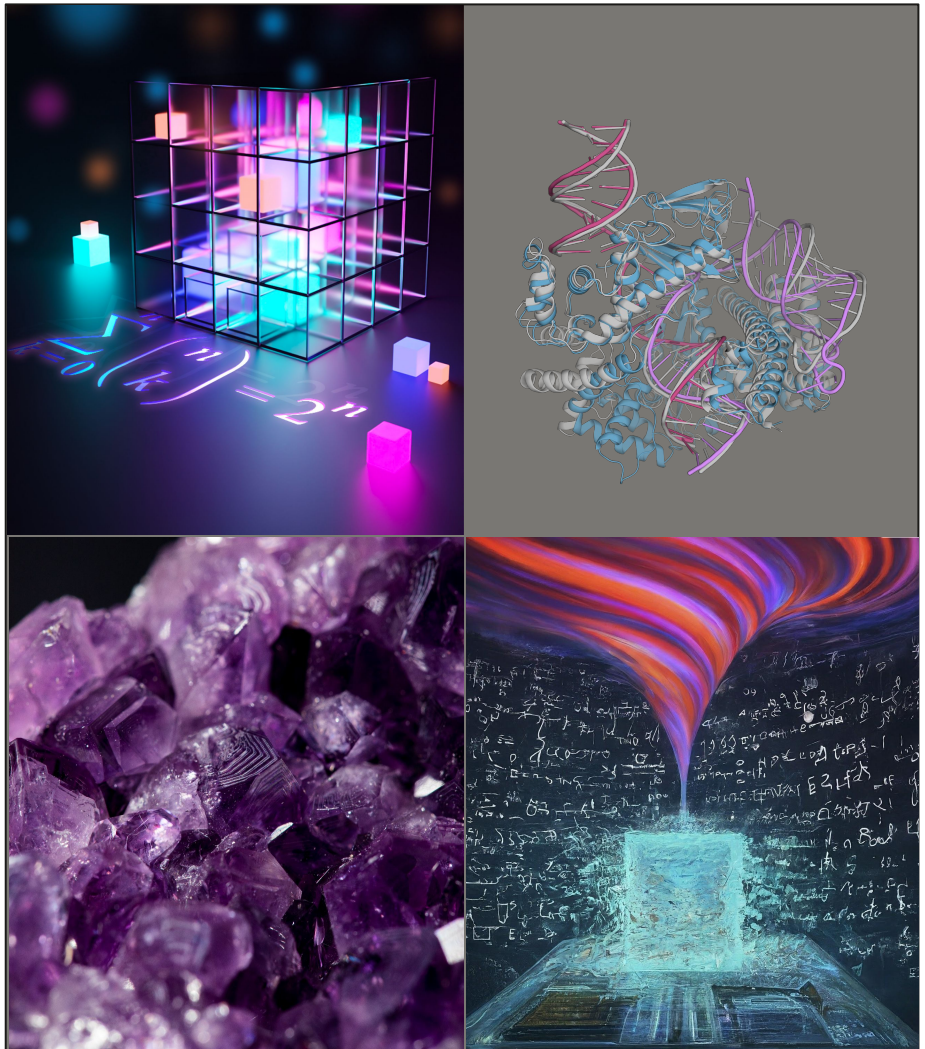
- Make solar energy affordable
- Provide energy from fusion
- Develop carbon sequestration methods
- Manage the nitrogen cycle
- Provide access to clean water
- Restore & improve urban infrastructure
- Advance health informatics
- Engineer better medicines
- Reverse-engineer the brain
- Prevent nuclear terror
- Secure cyberspace
- Enhance virtual reality
- Advance personalized learning
- Engineer the tools for scientific discovery

www.engineeringchallenges.org/challenges.aspx

Close collaboration is key

We collaborate with:

external scientific communities, publish our research in peer-reviewed journals, and publicly release approaches and data for use by the scientific community.



Protein structure prediction

Google contribution

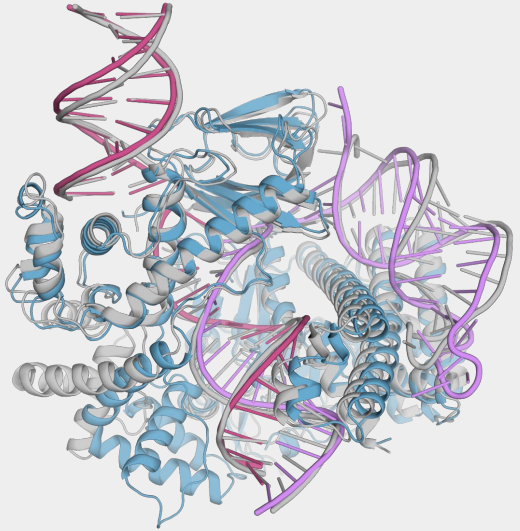
- AlphaFold

AI technologies

- Deep neural networks, Transformers, attention mechanisms
- Evolutionary information, multiple sequence alignments (MSAs)
- Gradient Descent algorithm
- Representation of 3D structures

Major collaborators

- EMBL-EBI



AI applied to healthcare

Google contributions

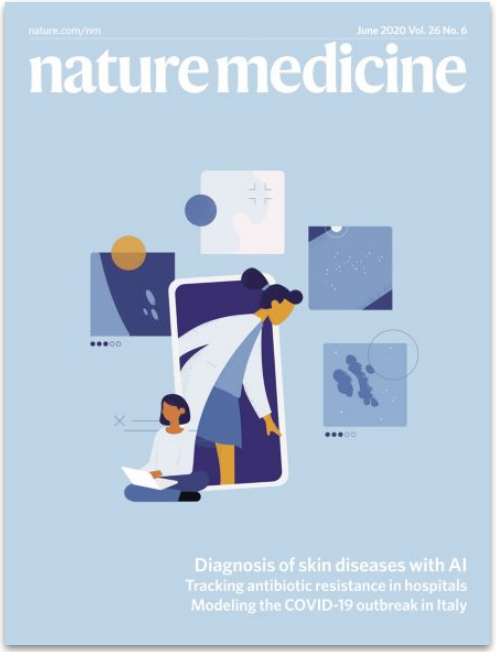
- Many pioneering advances in medical diagnostics: diabetic retinopathy detection, breast cancer screening, lung cancer screening and skin disease classification.
- Demonstrated AI-based predictive modeling with electronic health record data.
- Med-PaLM, which has demonstrated "expert level" (85%) on U.S. medical exam questions, a first step toward creating safe, helpful LLMs for clinical applications.

AI technologies

- CNN, LLM

Major collaborators

- Mayo Clinic, iCAD, Aravind and Sankara Eye Hospitals, Rajavithi Hospital, Apollo Hospital and many more!



Genomics

Google contributions

- >2M genomes processed using open source methods DeepVariant and DeepConsensus, including Telomere-to-Telomere Consortium, Human Pangenome Reference Consortium, UKBiobank, and world record for fastest genetic diagnosis
- Leveraged AlphaFold toward missense variant pathogenicity prediction with AlphaMissense

AI technologies

- CNN, gap-aware sequence transformer

Major collaborators

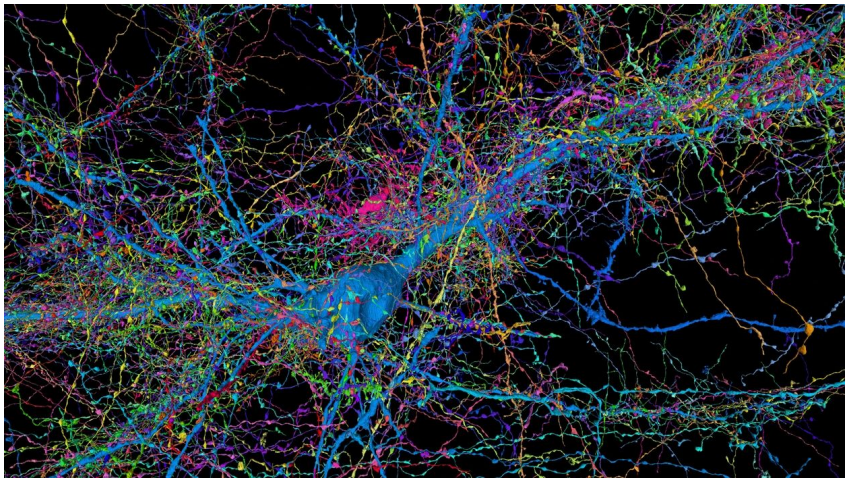
- Pacific Biosciences, UC Santa Cruz, Regeneron Genomics Center, Stanford University

Computational neuroscience

Revolutionize our understanding of the brain

Google contributions

- Collaborator on connectomes of fruit fly, human brain fragment, and NIH BRAIN Initiative toward a mouse connectome
- Orders of magnitude reductions in manual effort required to proofread and analyze connectomes
- Open source tools TensorStore and Neuroglancer for storage and visualization of connectomics data



AI technologies

- RNNs, self-supervised contrastive learning

Major collaborators

- HHMI Janelia, Harvard, Max Planck Institute, Princeton, the Allen Institute for Brain Science

Weather and climate science

Google contributions

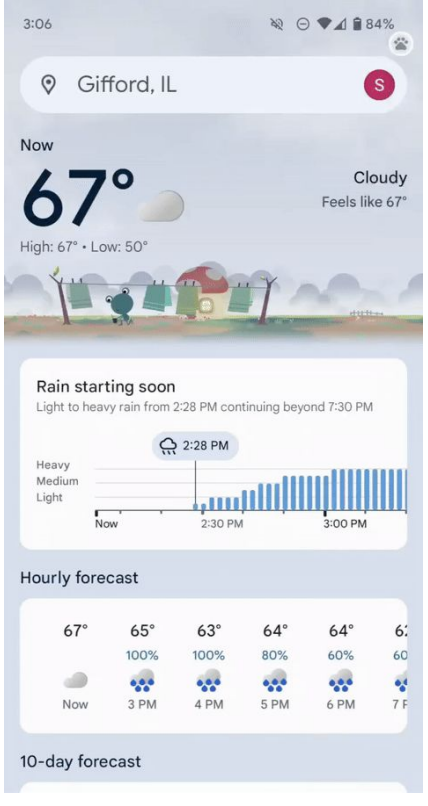
- Catalyzed the use of AI methods for weather and climate forecasting through SoTA performance in:
  - Weather nowcasting (MetNet)
  - Medium-range weather forecasting (GraphCast)
  - Climate forecasting (NeuralGCM)
- Developed and maintain WeatherBench, a benchmark for global weather models

AI technologies

- DNN, GNN, convolutional LSTM

Major collaborators

- ECMWF



Weather and climate science

Google contributions

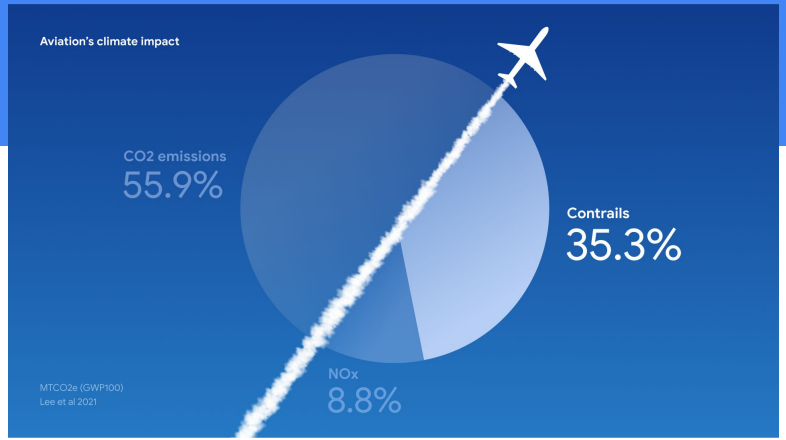
- **Project Contrails:** After test flights, we found that the predictions **reduced contrails by 54%** compared to flights that didn't use predictions.
- **Project Greenlight:** Early numbers indicate a potential for up to **30% reduction in stops** and **10% reduction in emissions** at intersections.

AI technologies

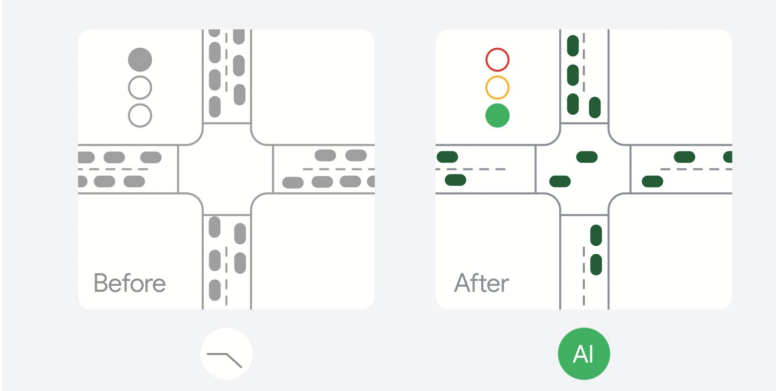
- Deep Neural Networks

Major collaborators

- **Contrails**: American Airlines, Breakthrough Energy
- **GreenLight**: 13 cities in 4 continents, including Rio de Janeiro, Brazil; Hamburg, Germany; Bangalore, India and Seattle, Washington, United States



Project Contrails



Project Greenlight

Materials science

Advance new materials

Google contributions

- **GNoME** (Graph Networks for Materials Exploration): computational tool leading to the discovery of 2.2 million new materials.
- **421,000 stable crystal structures** to the community (380k of which were generated by GNoME) via our paper, in partnership with the Materials Project via an API, and publishing the code for the GNN models to build GNoME on GitHub.

AI technologies

- GNN
- Active learning techniques

Major collaborators

- The Materials Project, Berkeley

AI for chip design

Google contributions

- Google's AI algorithms can design AI chips efficiently -- and generate better layouts than human experts.
- This lowers the fixed engineering costs of chips and enables quick creation of specialized hardware.
- **Goal:** enabling the development of custom hardware with 1/10 or 1/100 the effort will have broad application for AI for Science and many other areas!

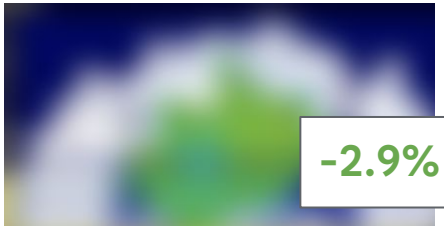
AI technologies

- Novel deep and reinforcement learning (RL) algorithms

Human Expert

Time taken: **~6-8 person weeks**
Total wirelength: 57.07m

ML Placer



-2.9% shorter

Time taken: **24 hours**
Total wirelength: 55.42m

AI at Google: our principles

Sundar Pichai
CEO

Published Jun 7, 2018

At its heart, AI is computer programming that learns and adapts. It can't solve every problem, but its potential to improve our lives is profound. At Google, we use AI to make products more useful—from email that's spam-free and easier to compose, to a digital assistant you can speak to naturally, to photos that pop the fun stuff out for you to enjoy.

Beyond our products, we're using AI to help people tackle urgent problems. A pair of high school students are building AI-powered sensors to predict the risk of wildfires. Farmers are using it to monitor the health of their herds. Doctors are starting to use AI to help diagnose cancer and prevent blindness. These clear benefits are why Google invests heavily in AI research and development, and makes AI technologies widely available to others via our tools and open-source code.

We recognize that such powerful technology raises equally powerful questions about its use. How AI is developed and used will have a significant impact on society for many years to come. As a leader in AI, we feel a deep responsibility to get this right. So today, we're announcing seven principles to guide our work going forward. These are not theoretical concepts; they are concrete standards that will actively govern our research and product development and will impact our business decisions.

1. Be socially beneficial.
2. Avoid creating or reinforcing unfair bias.
3. Be built and tested for safety.
4. Be accountable to people.
5. Incorporate privacy design principles.
6. Uphold high standards of scientific excellence.
7. Be made available for uses that accord with these principles.

https://ai.google/principles

Google

Thank you!

Questions?