

How can AI accelerate climate-positive action?

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 Research

[Project Contrails](#)



The Anatomy of a Large-Scale Hypertextual Web Search Engine

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Abstract

In this paper, we present Google, a prototype of a large-scale search engine which makes heavy use of the structure present in hypertext. Google is designed to crawl and index the Web efficiently and produce much more satisfying search results than existing systems. The prototype with a full text and hyperlink database of at least 24 million pages is available at <http://google.stanford.edu/>. To engineer a search engine is a challenging task. Search engines index tens to hundreds of millions of web pages involving a comparable number of distinct terms. They answer tens of millions of queries every day. Despite the importance of large-scale search engines on the web, very little academic research has been done on them. Furthermore, due to rapid advance in technology and web proliferation, creating a web search engine today is very different from three years ago. This paper provides an in-depth description of our large-scale web search engine -- the first such detailed public description we know of to date. Apart from the problems of scaling traditional search techniques to data of this magnitude, there are new technical challenges involved with using the additional information present in hypertext to produce better search results. This paper addresses this question of how to build a practical large-scale system which can exploit the additional information present in hypertext. Also we look at the problem of how to effectively deal with uncontrolled hypertext collections where anyone can publish anything they want.

Keywords

World Wide Web, Search Engines, Information Retrieval, PageRank, Google

Ambition to reduce 1 GT of CO₂eq emissions annually by 2030



Empowering individuals to take action

We're empowering people with information to make more sustainable choices



Working together with our partners and customers

We're working together with our partners and customers to advance technology for sustainability

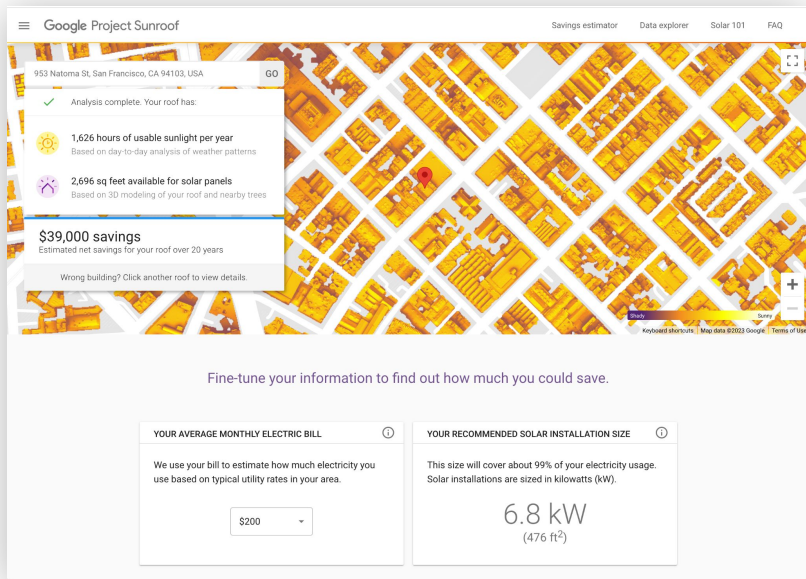


Operating our business sustainably

We're showing the way forward through our own operations

Google Climate Research: help mitigate and adapt to global warming

Project Sunroof



Wildfire Detection



Find more info at research.google/teams/climate-and-sustainability/

Aviation's climate impact

CO2 emissions
55.9%

Contrails
35.3%

NOx
8.8%

MTCO_{2e} (GWP100)
Lee et al 2021

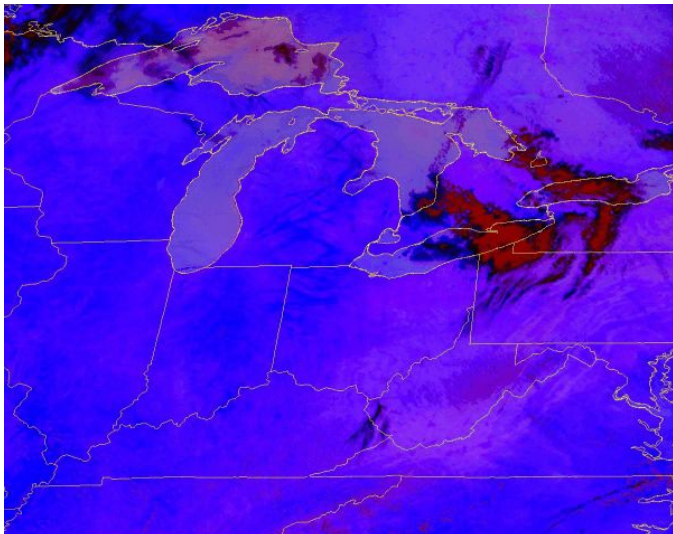


Project Contrails

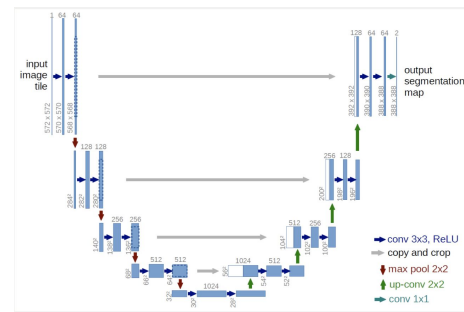


**Using
computer vision
to detect & predict
contrails**

Using sat imagery to detect contrail formation - same technical approach used in Waymo cars and Youtube videos



Infrared satellite shows contrails over North of US



Computer Vision has many AI applications:

*Chihuahua puppy
or
Blueberry muffin?*



[Source](#)

Computer Vision has many AI applications:

*Chocolate Croissant
or
Baby Sloth?*



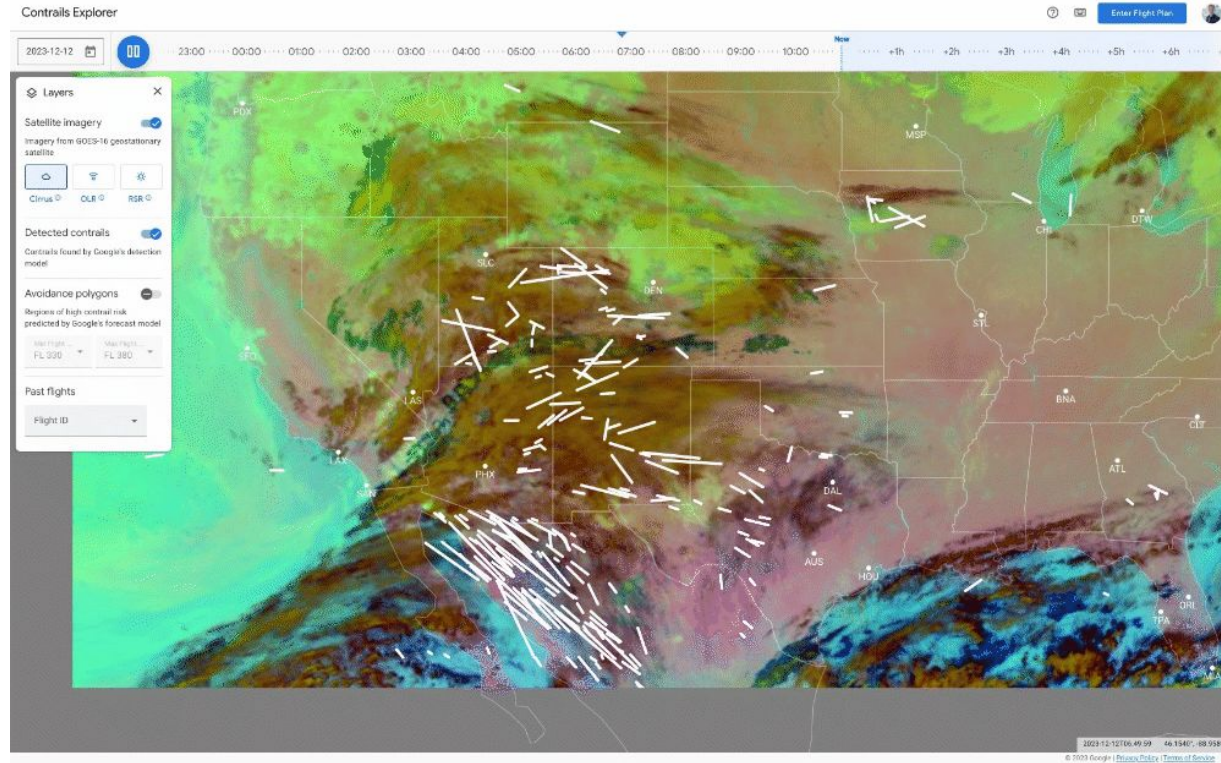
[Source](#)

Computer Vision has many AI applications:

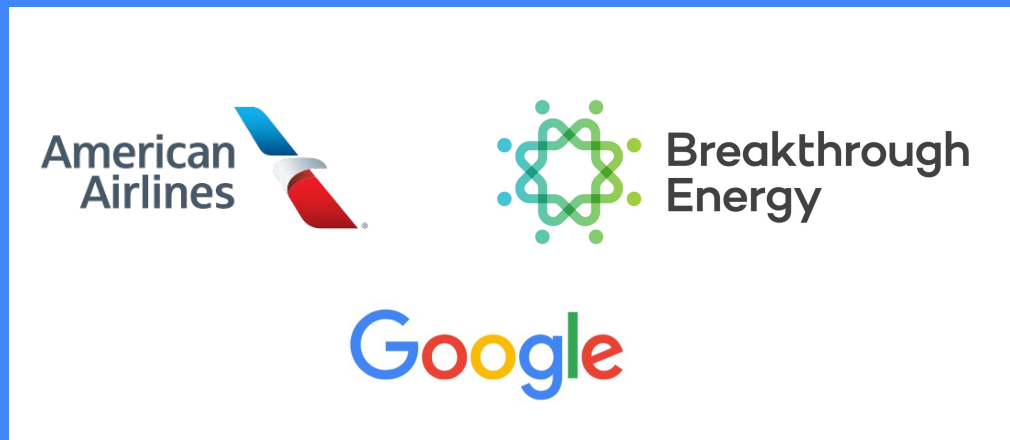
*Natural Cirrus
or
Contrail-Cirrus?*



Computer Vision can detect contrails at scale



Contraails avoidance trial



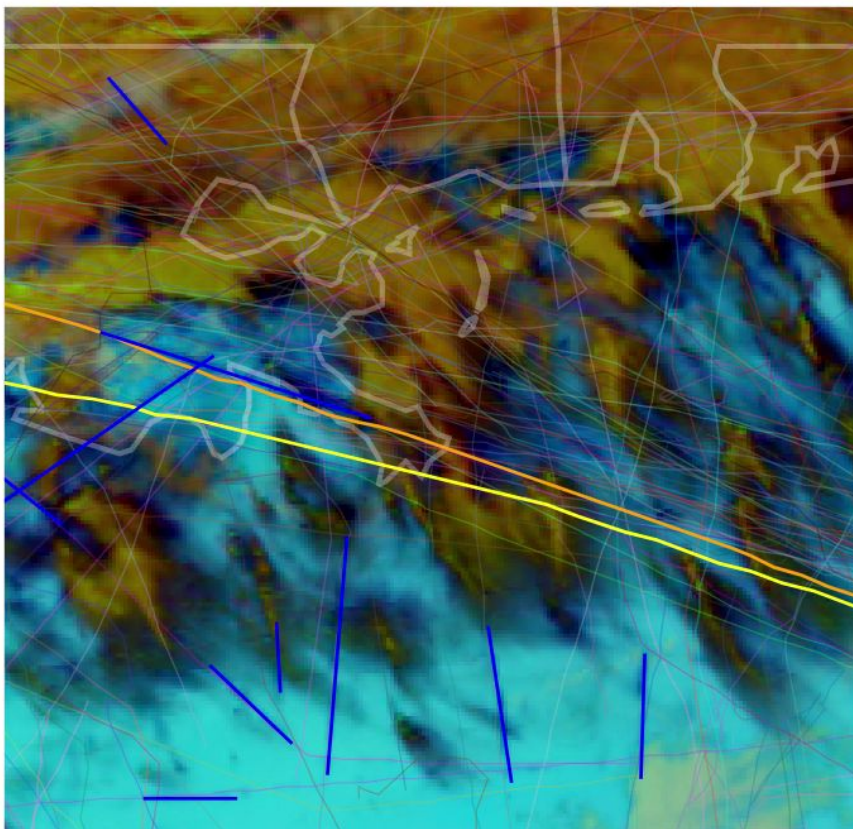
Case study of successful contrail avoidance



Source: [How AI Is Helping Mitigate the Climate Impact of Contrails](#)

Google Research

Case study of successful contrail avoidance



Geographic Features
Boundaries

Other flights
— other flights

AAL189
— advected flight path

AAL189
— original flight path

Contrails
— contrails

AA Experimental Study: Successful demonstration of Contrails Reduction

First *per-flight* real-world trial with a commercial airline demonstrates:

- Contrail formation **verified** through satellite imagery
- Statistically significant **reduction in contrails**
- Contrails avoidance could be **cost effective**

-54%

Reduction in contrails

+2%

Additional fuel costs for adjusted flights

+0.3%

Additional fuel costs across fleet





What's next:

EU Expansion

Expand contrail forecasts and detection to EU with new European satellites

Software Integration

Integrate into pilot and dispatcher software - EFB and flight planning

10x Trial

Run an automated contrail avoidance trial for 100s of flights

find more info & papers at:
g.co/research/contrails

Thank You

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