

Success Stories of Machine Learning

Melih Kandemir

Story 1: Computer Vision



Model	Top-1	Top-5
<i>Sparse coding [2]</i>	47.1%	28.2%
<i>SIFT + FVs [24]</i>	45.7%	25.7%
CNN	37.5%	17.0%

ImageNet Classification with Deep Convolutional Neural Networks

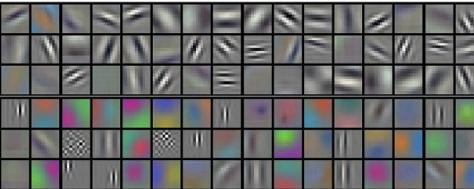
Alex Krizhevsky
University of Toronto
kriz@cs.toronto.ca

Ilya Sutskever
University of Toronto
ilya@cs.toronto.ca

Geoffrey E. Hinton
University of Toronto
hinton@cs.toronto.ca

Abstract

We trained a large, deep convolutional neural network to classify the 1.2 million high-resolution images in the ImageNet LSVRC-2010 contest into the 1000 different classes. On the test data, we achieved top-1 and top-5 error rates of 37.5% and 17.0%, which is considerably better than the previous state-of-the-art. The neural network, which has 6 layers, takes 256,000 input channels and consists of five convolutional layers, some of which are followed by max-pooling layers, and three fully-connected layers with a final 1000-way softmax. To make training faster, we used non-saturating neurons and a very efficient GPU implementation of the convolution operation. To reduce overfitting in the fully-connected layers we employed a recently-developed regularization method called “dropout” that proved to be very effective. We also entered a variant of this model in the ILSVRC-2012 competition and achieved a winning top-5 test error rate of 15.3%, compared to 26.2% achieved by the second-best entry.

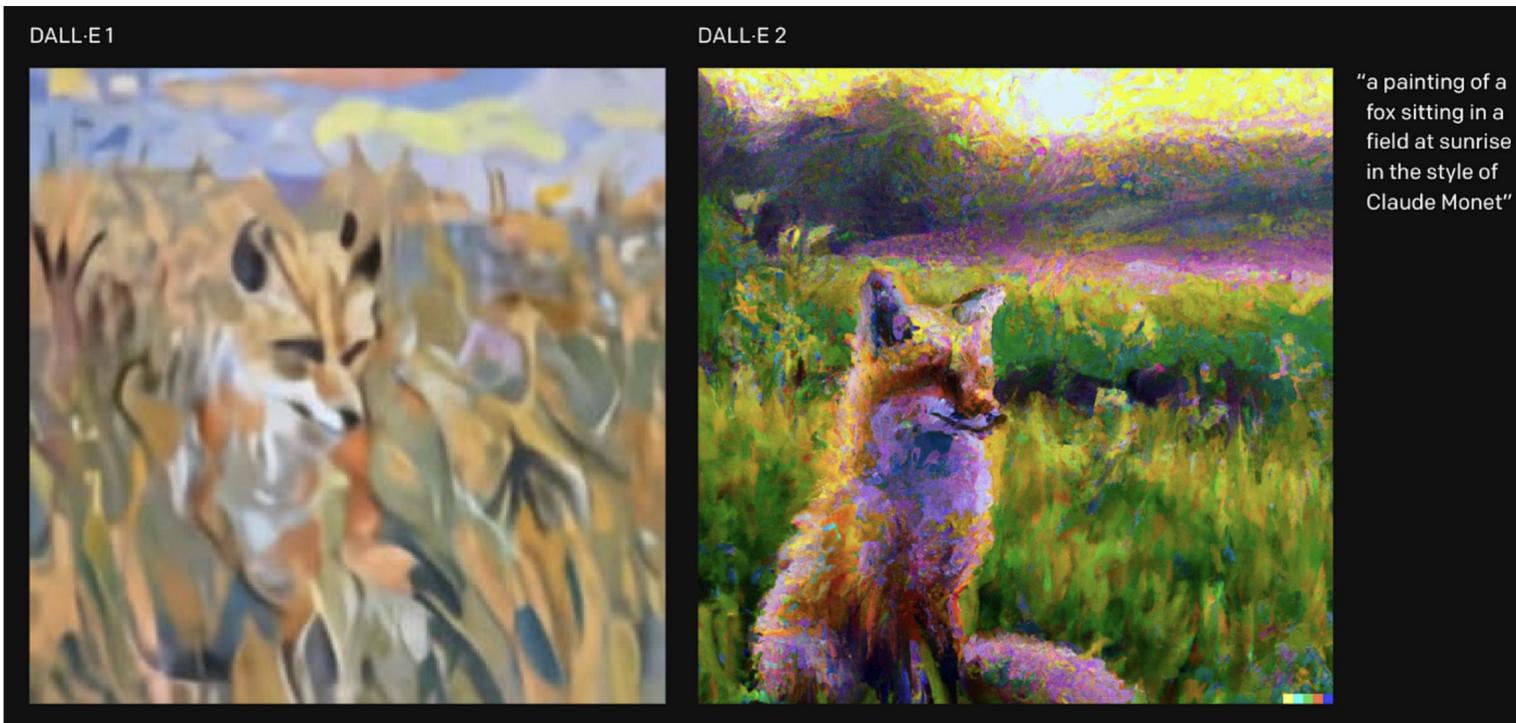


mite	container ship	motor scooter	leopard
black widow	lifeboat	go-kart	jaguar
cockroach	amphibian	moped	cheetah
tick	fireboat	bumper car	snow leopard
starfish	drilling platform	golfcart	Egyptian cat

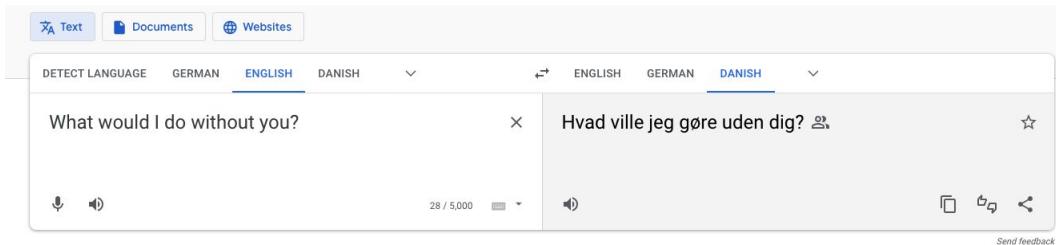
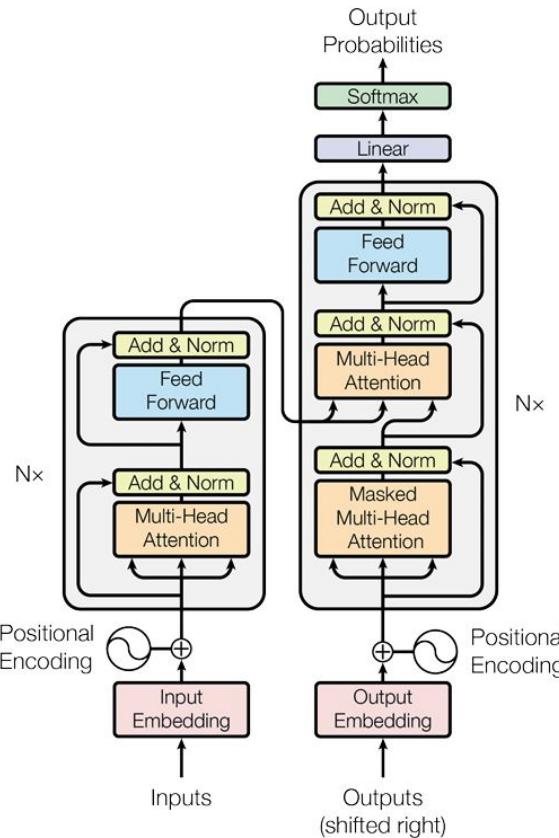


grille	mushroom	cherry	Madagascar cat
convertible	agaric	dalmatian	squirrel monkey
grille	mushroom	grape	spider monkey
pickup	jelly fungus	elderberry	titi
beach wagon	gill fungus	fordshire bullterrier	Indri
fire engine	dead-man's-fingers	currant	howler monkey

DALL-E 2: The SotA of the Deep Fake Technology



Story 2: Natural Language Understanding



Ashish Vaswani*
Google Brain
avaswani@google.com

Noam Shazeer*
Google Brain
noam@google.com

Niki Parmar*
Google Research
nikip@google.com

Jakob Uszkoreit*
Google Research
usz@google.com

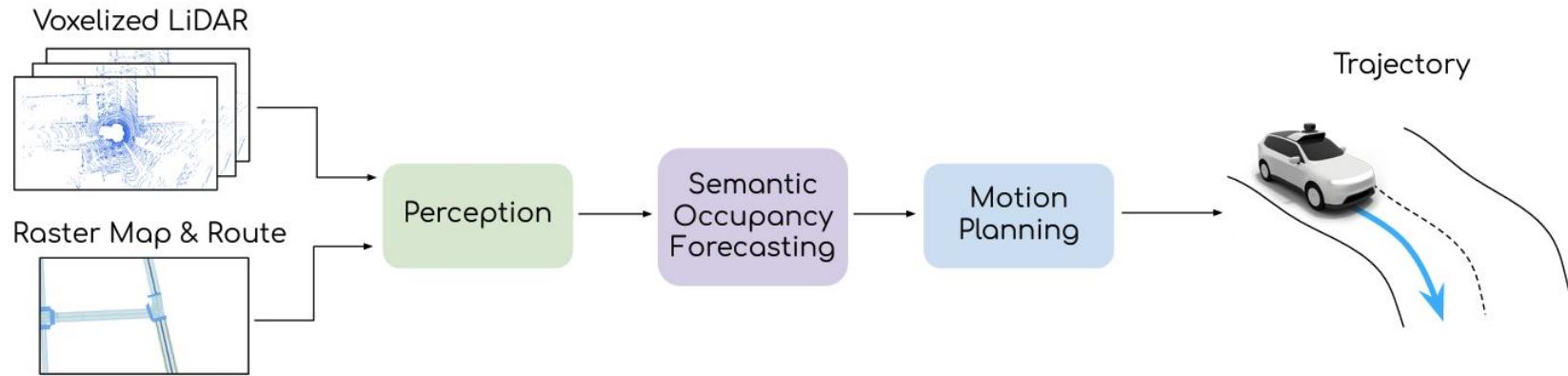
Llion Jones*
Google Research
llion@google.com

Aidan N. Gomez* †
University of Toronto
aidan@cs.toronto.edu

Lukasz Kaiser*
Google Brain
lukaszkaiser@google.com

Illia Polosukhin* ‡
illia.polosukhin@gmail.com

Story 3: Autonomous Driving

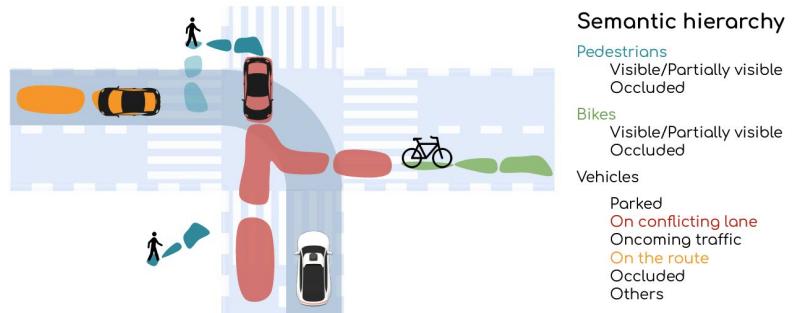


Perceive, Predict, and Plan: Safe Motion Planning Through Interpretable Semantic Representations

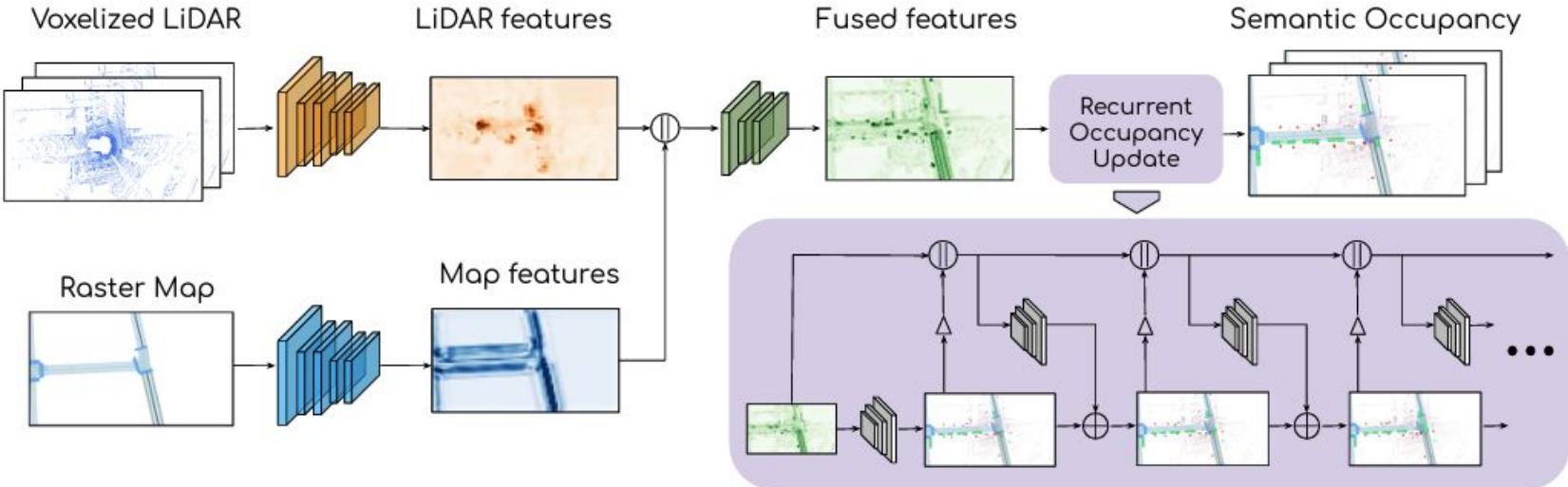
Abbas Sadat^{*1}, Sergio Casas^{*1,2},
Mengye Ren^{1,2}, Xinyu Wu¹, Pranaab Dhawan¹, Raquel Urtasun^{1,2}

Uber ATG¹, University of Toronto²

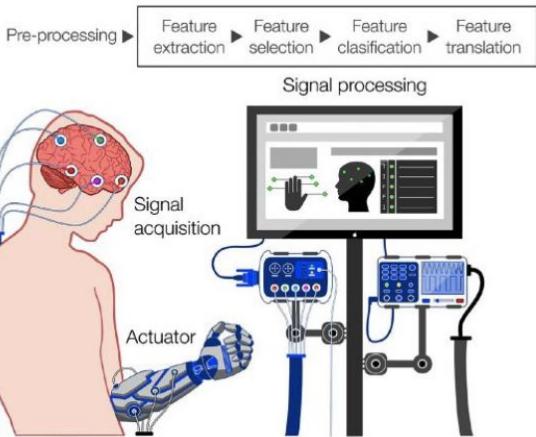
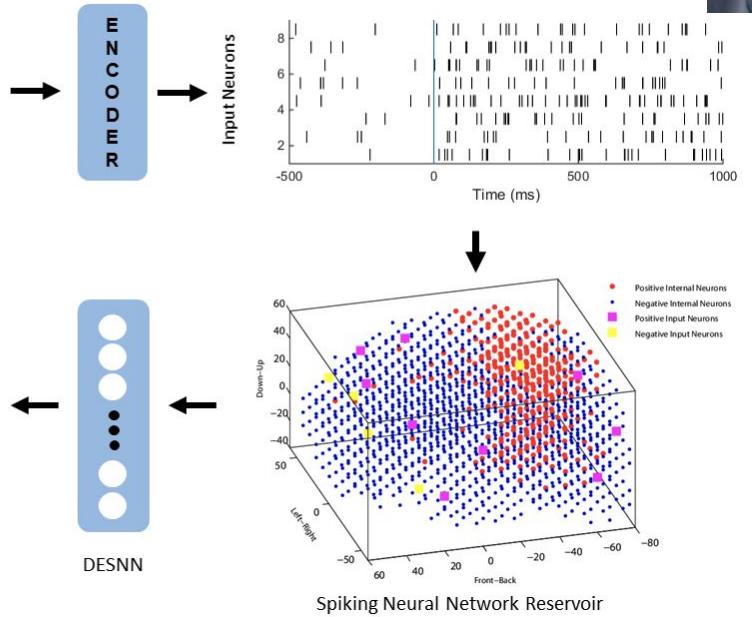
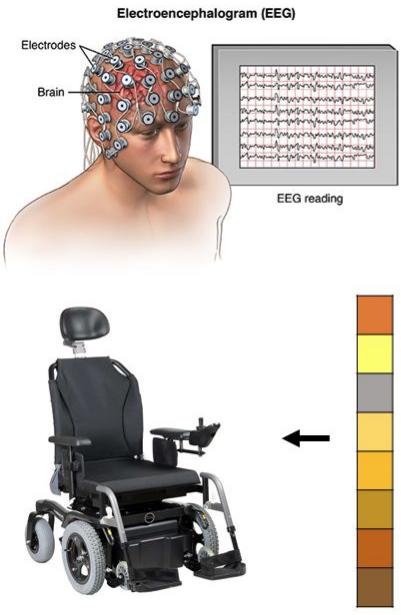
{asadat, sergio.casas, mren3, xinyuw, pdhawan, urtasun}@uber.com



Story 3: Autonomous Driving



Story 4: Brain-Computer Interfaces



Is imitation learning the route to humanoid robots?

Stefan Schaal

This review investigates two recent developments in artificial intelligence and neural computation: learning from imitation and the development of humanoid robots. It is postulated that the study of imitation learning offers a promising route to gain new insights into mechanisms of perceptual motor control that could ultimately lead to the creation of autonomous humanoid robots. Imitation learning focuses on three important issues: efficient motor learning, the connection between action and perception, and modular motor control in the form of movement primitives. It is reviewed here how research on representations of, and functional connections between, action and perception have contributed to our understanding of motor acts of other beings. The recent discovery that some areas in the primate brain are active during both movement perception and execution has provided a hypothetical neural basis of imitation. Computational approaches to imitation learning are also described, initially from the perspective of traditional AI and robotics, but also from the perspective of neural network models and statistical-learning research. Parallels and differences between biological and computational approaches to imitation are highlighted and an overview of current projects that actually employ imitation learning for humanoid robots is given.

Story 5: Human-Robot Interaction

- a) Skill transfer
- b) Cobots



Story 6: Ad Placement

How do search engines make money?

The screenshot shows a Bing search results page for the query "organic apples". The top navigation bar includes links for WEB, IMAGES, VIDEOS, MAPS, and MORE. The search bar contains "organic apples". Below the bar, it says "100,000,000 RESULTS". The results are displayed in two columns: "Mainline" and "Sidebar".

- Mainline:**
 - Organic Just Apples** (iHerb.com): Consumer Rated #1 Online Retailer - Great Value and Fast Shipping. iherb.com is rated on PriceGrabber (43 reviews).
 - Comparing apples to organic apples - Boston.com**: articles.boston.com/2008-11-10/news/29271514_1_organic-food... Nov 10, 2008 · With the recession breathing down our necks, you may be looking for ways to cut the household budget without seriously compromising family well-being. ...
 - Five Reasons to Eat Organic Apples: Pesticides, Healthy ...**: www.forbes.com/.../23/five-reasons-to-eat-organic-apples-pe... Apr 23, 2012 · There are good reasons to eat **organic** and locally raised fruits and vegetables. For one, they usually taste better and are a whole lot fresher. Yet ...
- Sidebar:**
 - Organic Fruit Deal \$29.99** (www.CherryMoonFarms.com/Fruit): Use PromoCode GET10 for Discount on All Fresh **Organic** Fruit Baskets. cherrymoonfarms.com is rated on Bizrate (106 reviews).
 - Organic Fruit Delivery** (TheFruitCompany.com/Organic): Find Great Fresh **Organic** Gifts From The Fruit Company®. Ship Today.
 - Organic Apples at Amazon** (www.Amazon.com): Low prices on **Organic Apples**. Qualified orders over \$25 ship free.

Léon Bottou

LEON@BOTTOU.ORG

Microsoft Research, Redmond, WA.

Jonas Peters[†]

JONAS.PETERS@TUEBINGEN.MPG.DE

Max Planck Institute, Tübingen.

Joaquin Quiñonero-Candela,^{a†} Denis X. Charles,^b D. Max Chickering,^b Elon Portugaly,^a Dipankar Ray,^c Patrice Simard,^b Ed Snelson^a

^a Microsoft Cambridge, UK.

^b Microsoft Research, Redmond, WA.

^c Microsoft Online Services Division, Bellevue, WA.

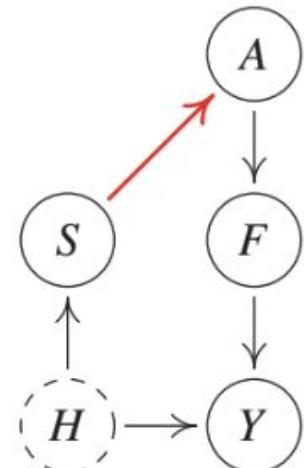
Y: Whether user clicked

A: mainline reserve

F: number of ads in the mainline

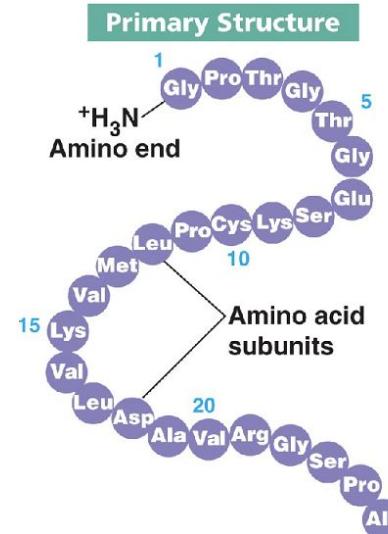
S: User status and statistics

H: Hidden user state



Story 7: Protein Folding

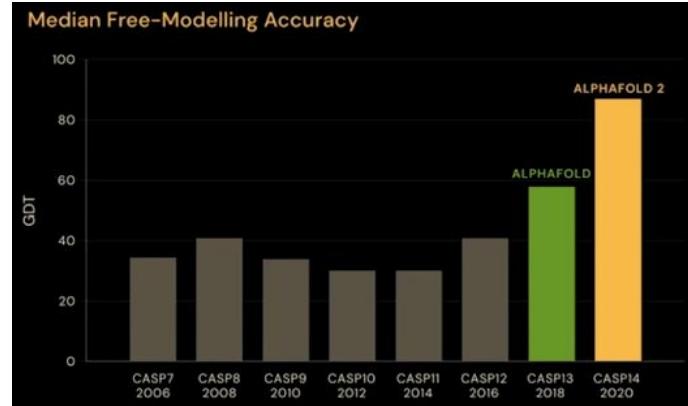
- Biggest advancement in structural biology since 20+ years
- Proteins are structure providers, mover, reaction catalyst, etc. of living things
- Proteins are chains of 21 elementary molecules called “amino acids”
- The problem:
 - Given the 1D chain, predict the 3D structure
- Why care?
 - 3D structure determines its function



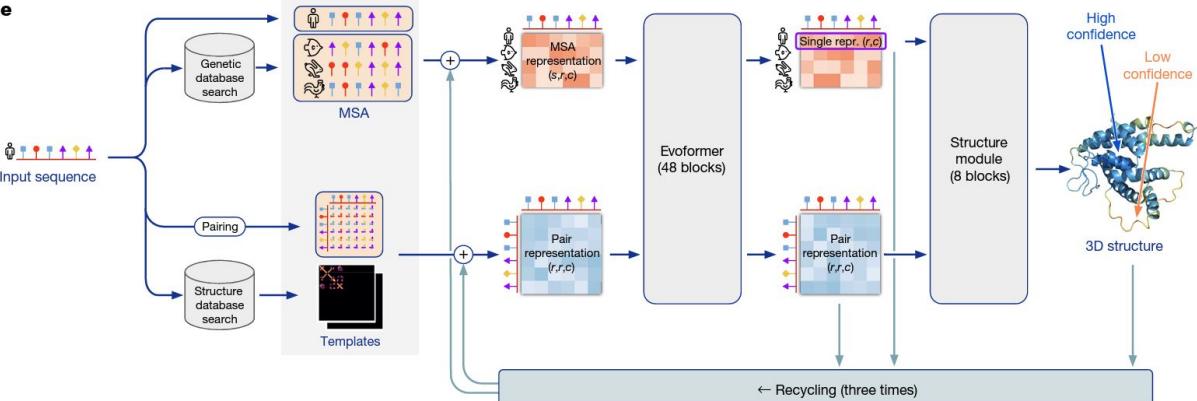
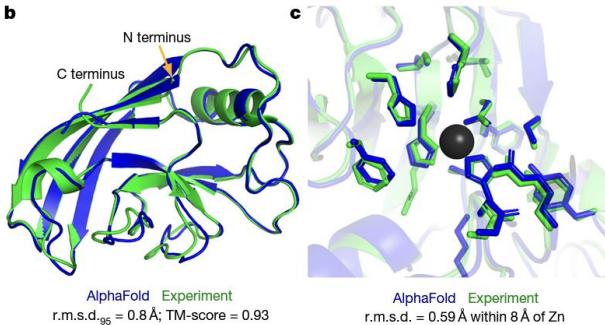
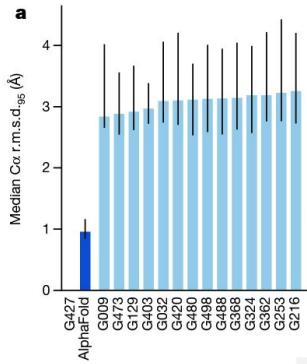
Amino Acid	Abbreviations
Alanine	Ala; A
Arginine	Arg; R
Asparagine	Asn; N
Aspartic acid	Asp; D
Cysteine	Cys; C
Glutamic acid	Glu; E
Glutamine	Gln; Q
Glycine	Gly; G
Histidine	His; H
Isoleucine	Ile; I
Leucine	Leu; L
Lysine	Lys; K
Methionine	Met; M
Phenylalanine	Phe; F
Proline	Pro; P
Serine	Ser; S
Threonine	Thr; T
Tyrosine	Tyr; Y
Tryptophan	Trp; W
Valine	Val; V

The CASP Competition

- 200 million proteins as AA sequences
- Ground-truth 3D structures for 170000 proteins
 - Super-expensive data! Requires X-ray crystallography
 - 120000\$ and take one year “per protein”
- 10^{143} possibilities (compared to 10^{80} atoms in the universe)



DeepMind's solution



Article

Highly accurate protein structure prediction with AlphaFold

<https://doi.org/10.1038/s41586-021-03819-2>

Received: 11 May 2021

Accepted: 12 July 2021

John Jumper^{1,4,5,6}, Richard Evans^{1,4}, Alexander Pritzel^{1,4}, Tim Green^{1,4}, Michael Figurnov^{1,4}, Olaf Ronneberger^{1,4}, Kathryn Tunyasuvunakool^{1,4}, Russ Bates^{1,4}, Augustin Žídek^{1,4}, Anna Potapenko^{1,4}, Alex Bridgland^{1,4}, Clemens Meyer^{1,4}, Simon A. A. Kohl^{1,4}, Andrew J. Ballard^{1,4}, Andrew Cowie^{1,4}, Bernardino Romera-Paredes^{1,4}, Stanislav Nikолов^{1,4}, Rishabh Jain^{1,4}, Jonas Adler¹, Trevor Back¹, Stig Petersen¹, David Reiman¹, Ellen Clancy¹, Michał Zieliński¹, Martin Steinegger^{2,3}, Michalina Pacholska¹, Tamas Berghammer¹, Sebastian Bodenstein¹, David Silver¹, Oriol Vinyals¹, Andrew W. Senior¹, Koray Kavukcuoglu¹, Pushmeet Kohli¹ & Demis Hassabis^{1,4,6,7}

Impact: Accurate physics-based simulation of biological systems

- Discovery of unknown functions of the human genome
- Understanding both genetic and environmental causes of many diseases
- Quick design of new proteins that alter the function of existing ones that would enable
 - New treatment methods
 - New agriculture solutions (green, more nutritious, and better protected food production)
 - New preventive health and anti-aging solutions
 - New biomaterials (e.g. textile)