Introduzione all'Intelligenza Artificiale

Riccardo Bellazzi

Dipartimento di Ingegneria Industriale e dell'Informazione, Università di Pavia

IRCCS ICS Maugeri, Pavia

Università di Pavia

Bologna, 3 Ottobre 2023

XLVIII
CONGRESSO NAZIONALE
AIEOP

Bologna
2-4 Ottobre 2023

Il sottoscritto Riccardo Bellazzi

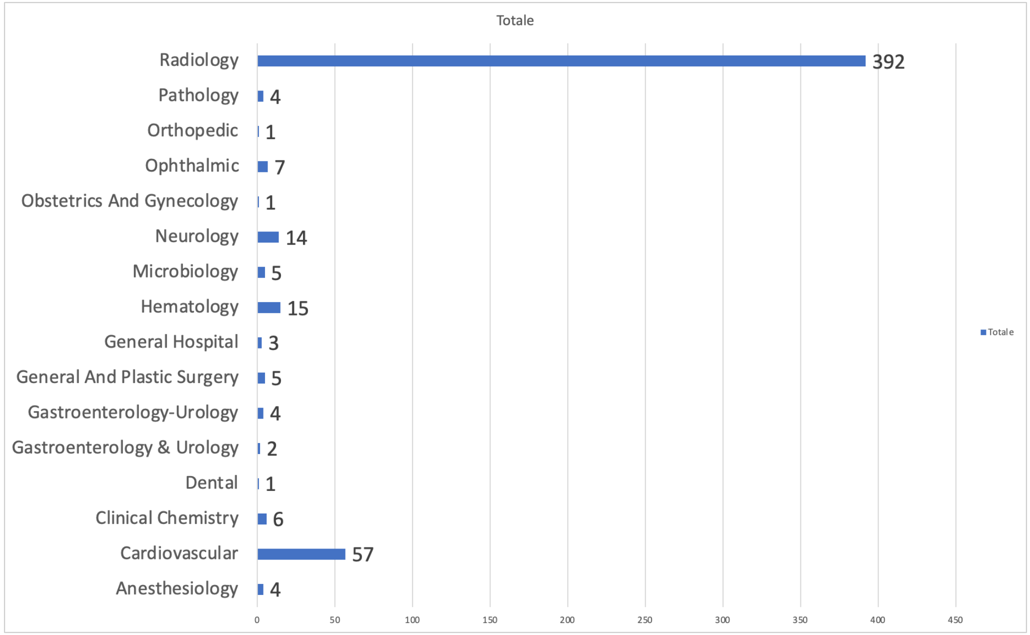
ai sensi dell'art. 3.3 sul Conflitto di Interessi, pag. 17 del Reg. Applicativo dell'Accordo Stato-Regione del 5 novembre 2009,

dichiara

- *che negli ultimi due anni ha avuto rapporti diretti di finanziamento con i seguenti soggetti portatori di interessi commerciali in campo sanitario:*
  - *Biomeris s.r.l.*
  - *Engenome s.r.l.*

Artificial Intelligence and Machine Learning (AI/ML)-Enabled Medical Devices

October 5, 2022 update: 178 Artificial Intelligence and Machine Learning (AI/ML)-Enabled Medical Devices were added to the list below. With this update, the FDA has also added the ability to download the list as an Excel file.



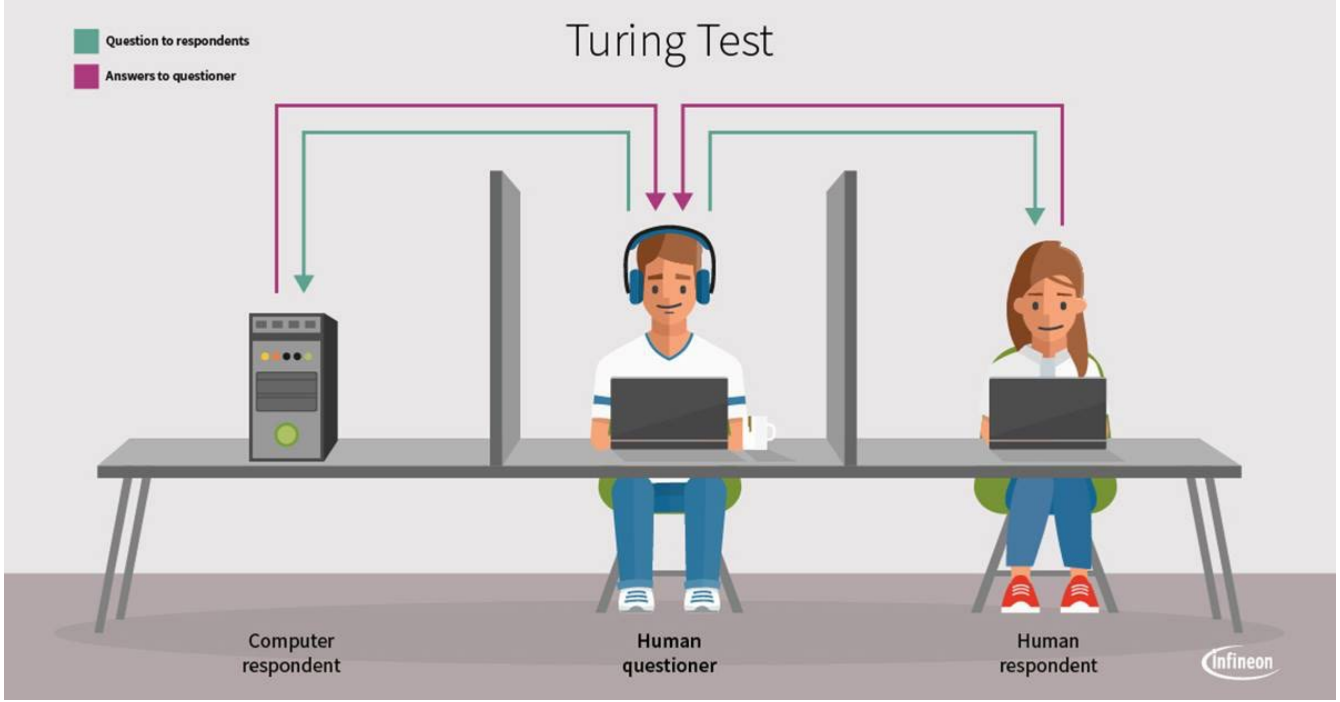
DOCTOR PENGUIN
Catch the Latest AI + Healthcare Research

Eric Topol
Professor, Molecular Medicine, Scripps Research

Andrew Ng
Professor of Computer Science, Stanford University

Tuesday, September 13, 2022

NIH launches Bridge2AI program to expand the use of artificial intelligence in biomedical and behavioral research



Nel 2022 il test di Turing è stato superato
… 2 volte (LaMDA + ChatGPT)

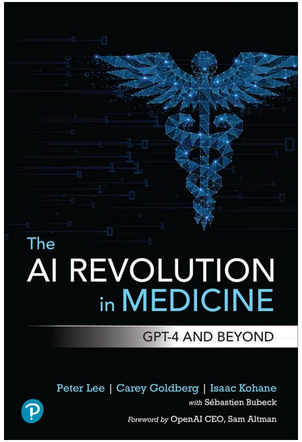
The NEW ENGLAND JOURNAL of MEDICINE

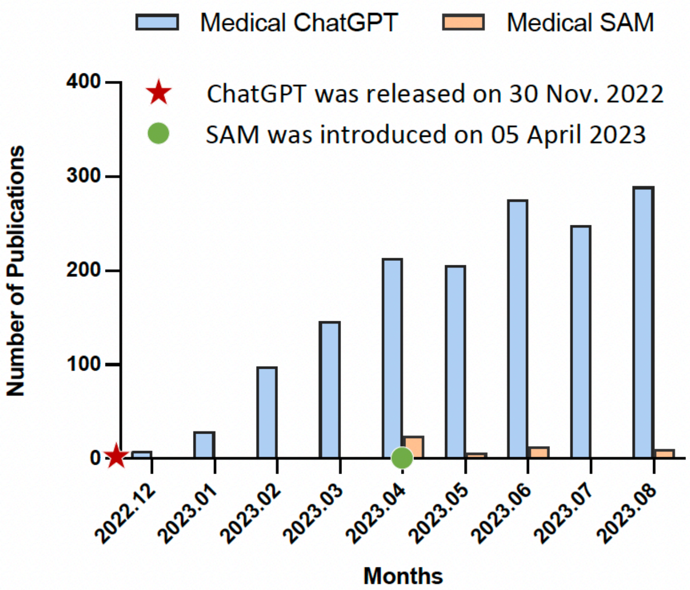
EDITORIALS

Artificial Intelligence in Medicine

Andrew L. Beam, Ph.D., Jeffrey M. Drazen, M.D., Isaac S. Kohane, M.D., Ph.D., Tze-Yun Leong, Ph.D., Arjun K. Manrai, Ph.D., and Eric J. Rubin, M.D., Ph.D.

COMING SOON
NEJM AI – A NEW JOURNAL



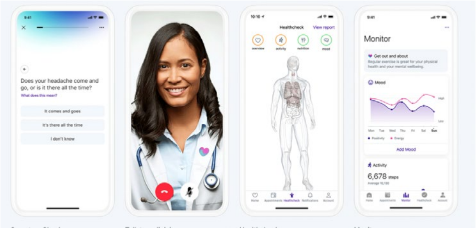


Intelligenza Artificiale - una definizione

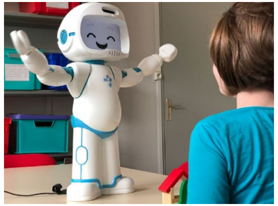
L'intelligenza artificiale (IA) è l'abilità di una macchina di mostrare capacità umane quali il ragionamento, l'apprendimento, la pianificazione e la creatività.

Parlamento europeo

Software: assistenti virtuali e sistemi di supporto alle decisioni, software di analisi di immagini, motori di ricerca, sistemi di riconoscimento facciale e vocale



Embodied intelligence: robot, veicoli autonomi, droni, l'internet delle cose



L’intelligenza artificiale (IA) è l’abilità di una macchina di mostrare capacità umane quali il ragionamento, l’apprendimento, la pianificazione e la creatività.

Pre-AI-winter

ARTIFICIAL INTELLIGENCE IN MEDICINE

Proceedings of the International Conference on Artificial Intelligence in Medicine
Pavia, Italy, 13-14 September, 1985

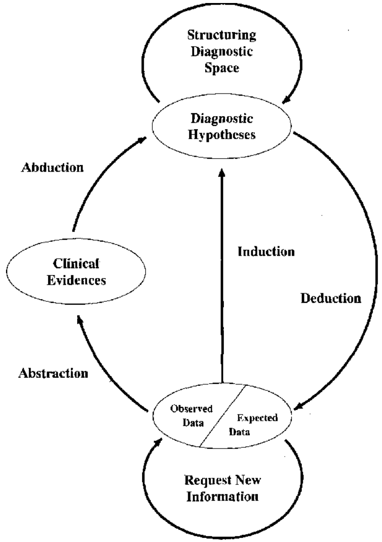
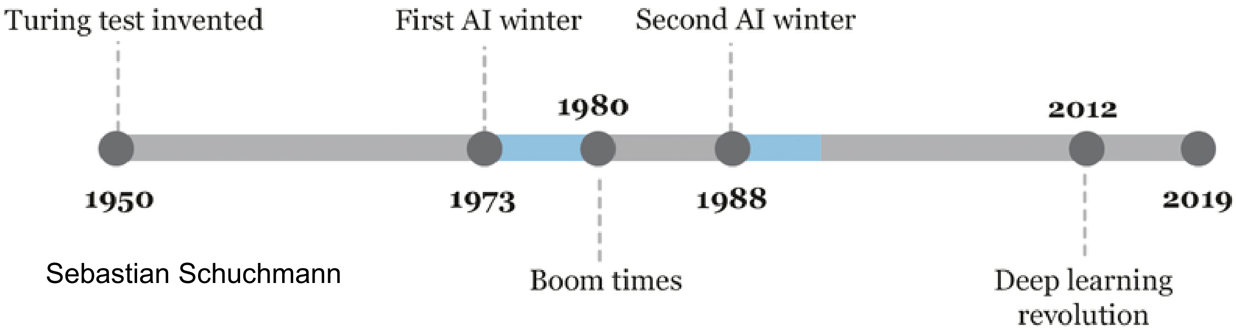


Fig. 3. Specializing the STModel in the diagnostic task.

(H. Simon, 1983):
“Forse la ragione più profonda per le ricerche nel campo dell’apprendimento automatico è che, sul lungo periodo e per grandi basi di conoscenza, **apprendere** risulterà molto **più efficiente** che **esplicitare o programmare la conoscenza stessa**, per quanto il processo di apprendimento possa essere inefficiente."



Sebastian Schuchmann

L'intelligenza artificiale (IA) è l'abilità di una macchina di mostrare capacità umane quali il ragionamento, l'apprendimento, la pianificazione e la creatività.

Post-AI-winter

Artificial Intelligence in Medicine 65 (2015) 61–73

Contents lists available at ScienceDirect

ELSEVIER

Artificial Intelligence in Medicine

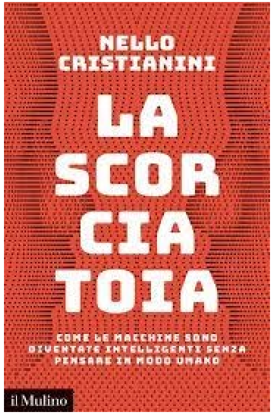
journal homepage: www.elsevier.com/locate/aiim

Thirty years of artificial intelligence in medicine (AIME) conferences: A review of research themes

CrossMark

Niels Peek[a,*], Carlo Combi[b], Roque Marin[c], Riccardo Bellazzi[d]

[a] Health e-Research Centre, Institute of Population Health, University of Manchester, Vaughan House, Portsmouth Street, Manchester M13 9GB, UK
[b] Department of Computer Science, University of Verona, Ca'Vignal 2, strada le Grazie 15, 37134 Verona, Italy
[c] Department of Information Engineering and Communications, University of Murcia, Campus de Espinardo, 30100 Espinardo (Murcia), Spain
[d] Dipartimento di Ingegneria Industriale e dell'Informazione, University of Pavia, Via Ferrata 1, 27100 Pavia, Italy

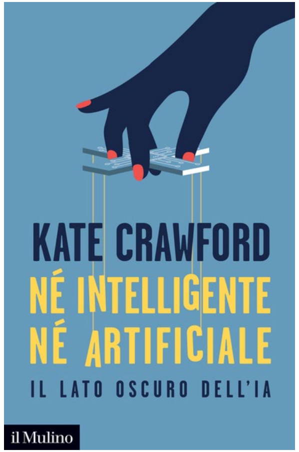


Macchine intelligenti che non ragionano

Capaci di agire autonomamente in modo appropriato (tale da aumentare la probabilità di successo nell'effettuare un compito in un ambiente incerto)

AI: Agere sine Intelligere o AI come nuova forma dell'agire

Distinzione fra AI ingegneristica e AI cognitivista

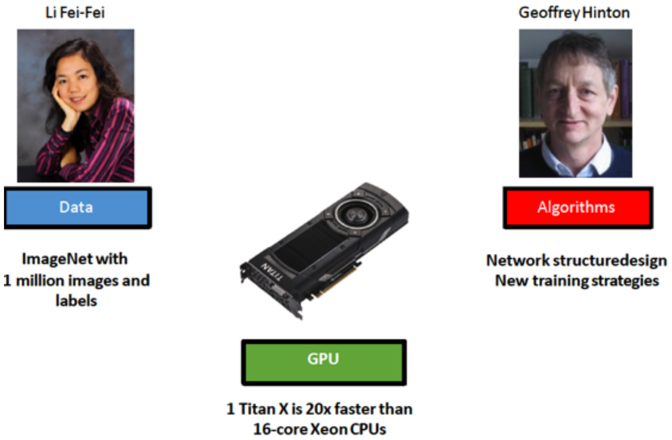


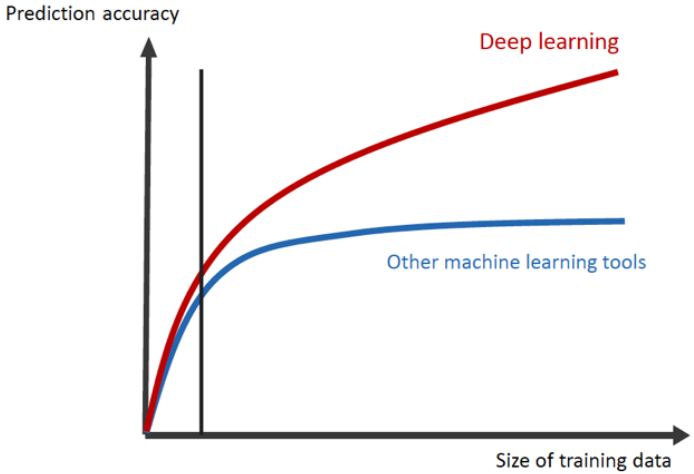
Costo ambientale e sociale dell'IA

Rischi di una IA «proprietaria»

Come ci siamo arrivati

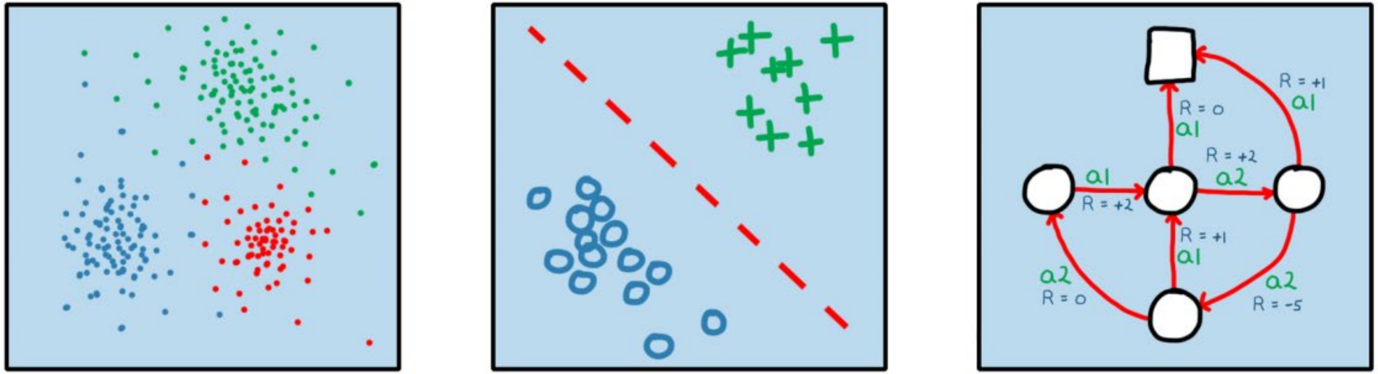
- Enorme disponibilità di dati raccolti in larga parte grazie alla rete Internet
- Algoritmi adatti
- Infrastrutture computazionali adeguate



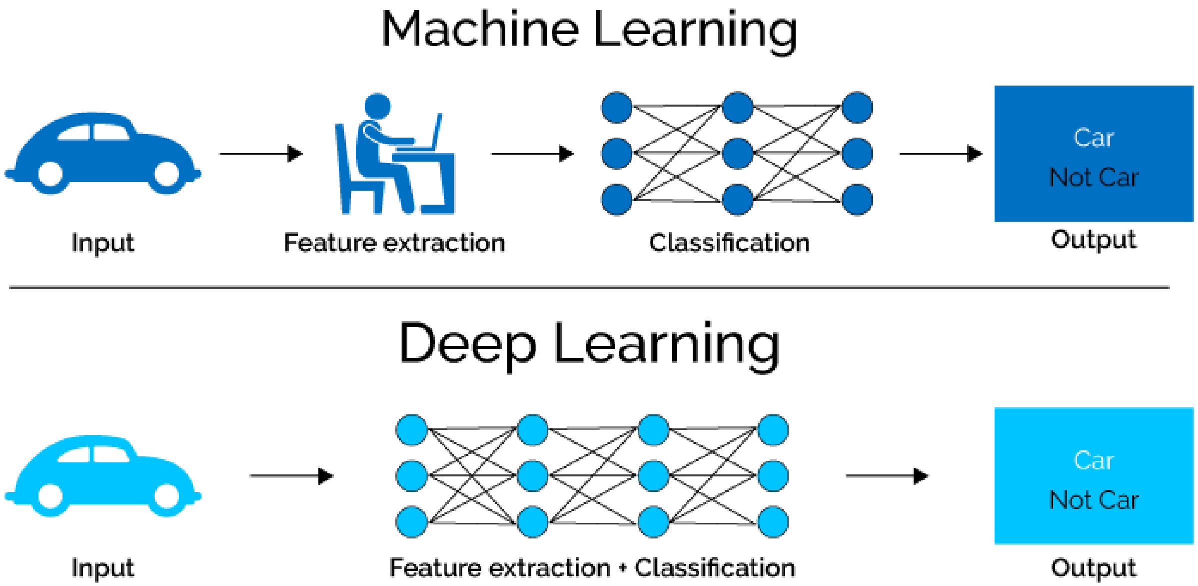


machine learning

unsupervised learning	supervised learning	reinforcement learning

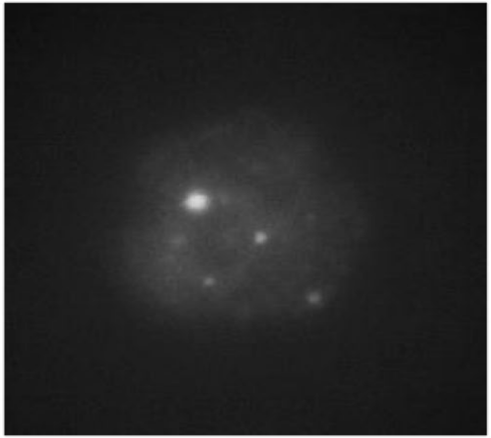


Algoritmi adatti: Machine & Deep Learning

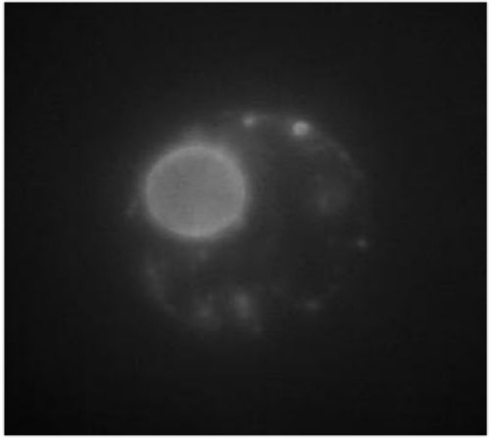


Ingredienti

Il deep learning, nelle sue varie architetture, consente di effettuare un «embedding» di oggetti digitali in una rappresentazione matematica conveniente per uno degli obiettivi del machine learning



NSN - Not Competent for development



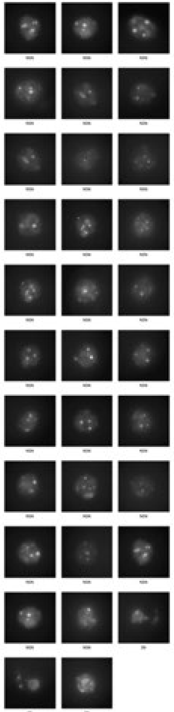
SN - Competent for development

Info

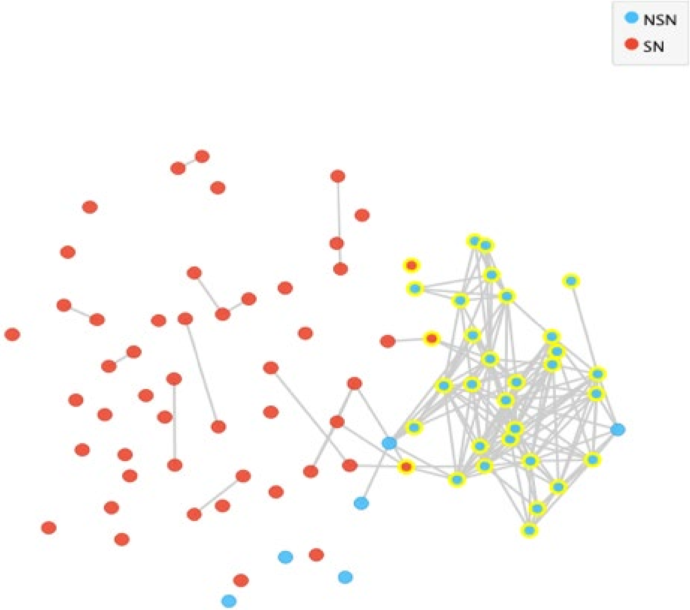
2 instances (no missing data)
2048 features
Target with 2 values
5 meta attributes

Variables

hidden origin type	category	nage nam	image :s/ricerca/bioinfor image	size	width	height	n0 True	n1 True	n2 True	n3 True	n4 True	n5 True
1	NSN	NSN...	NSN/NSN_3...	3301	265	264	1.00116	0.314914	0.037168	0.312784	0.0358623	0.257696
2	SN	SN_52	SN/SN_52.jpg	4327	265	265	0.969793	0.272101	0.252348	0.192658	0.149291	0.0803037



105 images of cell development



nature COMMUNICATIONS

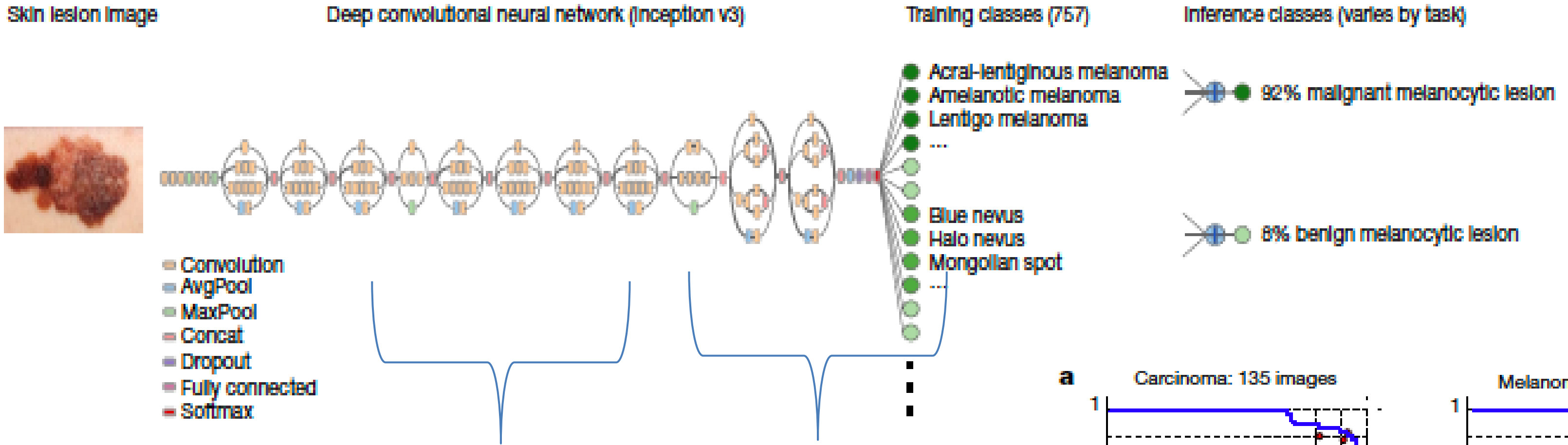
ARTICLE
https://doi.org/10.1038/s41467-019-12397-x OPEN

Democratized image analytics by visual programming through integration of deep models and small-scale machine learning

Primož Godec[1,7], Matjaž Pančur[1,7], Nejc Ilenič[1,7], Andrej Čopar[1], Martin Stražar[1], Aleš Erjavec[1], Ajda Pretnar[1], Janez Demšar[1], Anže Starič[1], Marko Toplak[1], Lan Žagar[1], Jan Hartman[1], Hamilton Wang[2], Riccardo Bellazzi[3], Uroš Petrovič[4,5], Silvia Garagna[6], Maurizio Zuccotti[6], Dongsu Park[2], Gad Shaulsky[2] & Blaž Zupan[1,2*]

Convolutional Nnets **already learned** on the **ImageNet 2012 Challenge** validation data set.

		Predicted		
		NSN	SN	Σ
Actual	NSN	32	3	35
	SN	2	48	50
	Σ	34	51	85

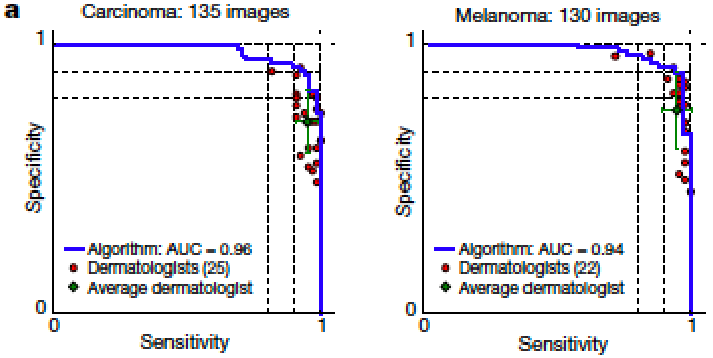


Google inception v3

1.28 million images over 1,000 generic object classes

Dati dei ricercatori

129,450 skin lesions comprising 2,032 different diseases.



LETTER

doi:10.1038/nature21056

Dermatologist-level classification of skin cancer with deep neural networks

Andre Esteva[1]*, Brett Kuprel[1]*, Roberto A. Novoa[2,3], Justin Ko[2], Susan M. Swetter[2,4], Helen M. Blau[5] & Sebastian Thrun[6]

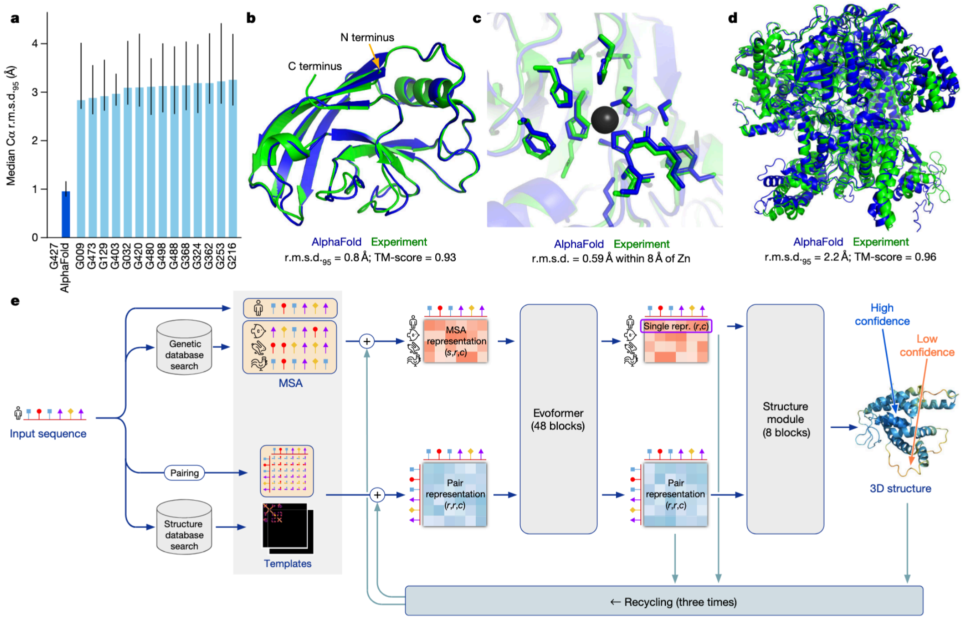


Fig. 1 | AlphaFold produces highly accurate structures. a, The performance of AlphaFold on the CASP14 dataset ($n = 87$ protein domains) relative to the top-15 entries (out of 146 entries), group numbers correspond to the numbers assigned to entrants by CASP. Data are median and the 95% confidence interval of the median, estimated from 10,000 bootstrap samples. **b**, Our prediction of CASP14 target T1049 (PDB 6Y4F, blue) compared with the true (experimental) structure (green). Four residues in the C terminus of the crystal structure are *B*-factor outliers and are not depicted. **c**, CASP14 target T1056 (PDB 6YJ1). An example of a well-predicted zinc-binding site (AlphaFold has accurate side chains even though it does not explicitly predict the zinc ion). **d**, CASP target T1044 (PDB 6VR4)—a 2,180-residue single chain—was predicted with correct domain packing (the prediction was made after CASP using AlphaFold without intervention). **e**, Model architecture. Arrows show the information flow among the various components described in this paper. Array shapes are shown in parentheses with *s*, number of sequences (N_{seq} in the main text); *r*, number of residues (N_{res} in the main text); *c*, number of channels.

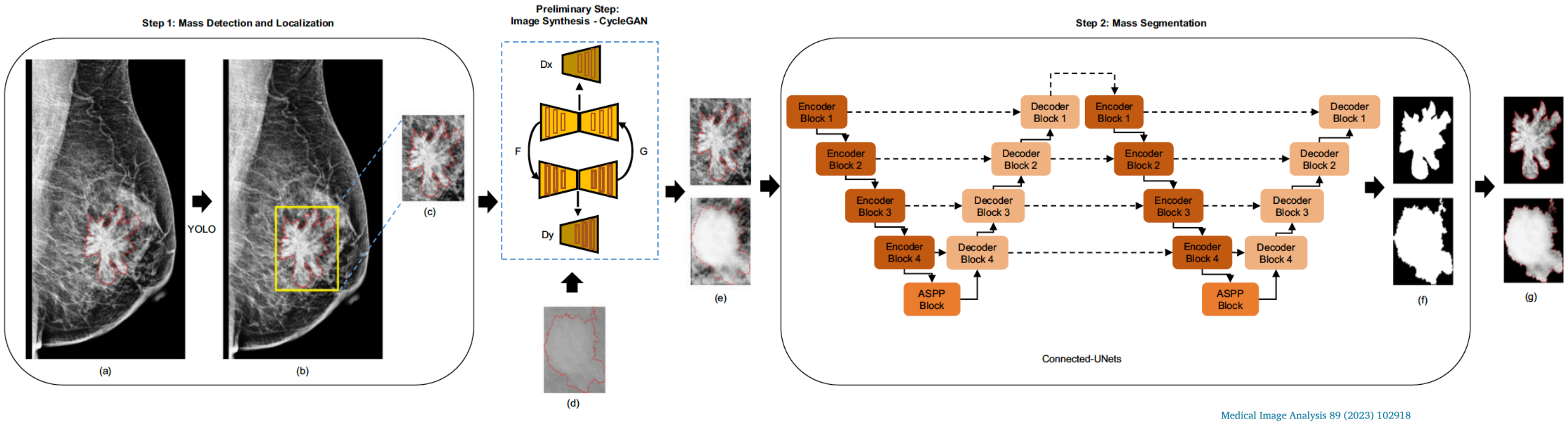
Article

Highly accurate protein structure prediction with AlphaFold

https://doi.org/10.1038/s41586-021-03819-2
Received: 11 May 2021
Accepted: 12 July 2021
Published online: 15 July 2021
Open access
Check for updates

John Jumper[1,4]✉, 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 Nikolov[1,4], Rishub Jain[1,4], Jonas Adler[1], Trevor Back[1], Stig Petersen[1], David Reiman[1], Ellen Clancy[1], Michal Zielinski[1], Martin Steinegger[2,3], Michalina Pacholska[1], Tamas Berghammer[1], Sebastian Bodenstein[1], David Silver[1], Oriol Vinyals[1], Andrew W. Senior[1], Koray Kavukcuoglu[1], Pushmeet Kohli[1] & Demis Hassabis[1,4]✉

AI per image processing e classificazione



npj | Breast Cancer
www.nature.com/npjbcancer

ARTICLE OPEN

Check for updates

Connected-UNets: a deep learning architecture for breast mass segmentation

Asma Baccouche[1], Begonya Garcia-Zapirain[2], Cristian Castillo Olea[2] and Adel S. Elmaghraby[1]

Medical Image Analysis 89 (2023) 102918
Contents lists available at ScienceDirect
Medical Image Analysis
journal homepage: www.elsevier.com/locate/media
ELSEVIER

Segment anything model for medical image analysis: An experimental study

Maciej A. Mazurowski [a,b,c,d], Haoyu Dong [b,*], Hanxue Gu [b], Jichen Yang [b], Nicholas Konz [b], Yixin Zhang [b]
[a] Department of Radiology, Duke University, Durham, NC, 27708, USA
[b] Department of Electrical and Computer Engineering, Duke University, Durham, NC, 27708, USA
[c] Department of Computer Science, Duke University, Durham, NC, 27708, USA
[d] Department of Biostatistics & Bioinformatics, Duke University, Durham, NC, 27708, USA

AIEOP ASSOCIAZIONE ITALIANA EMATOLOGIA ONCOLOGIA PEDIATRICA

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Bologna 2-4 Ottobre 2023

scientific reports

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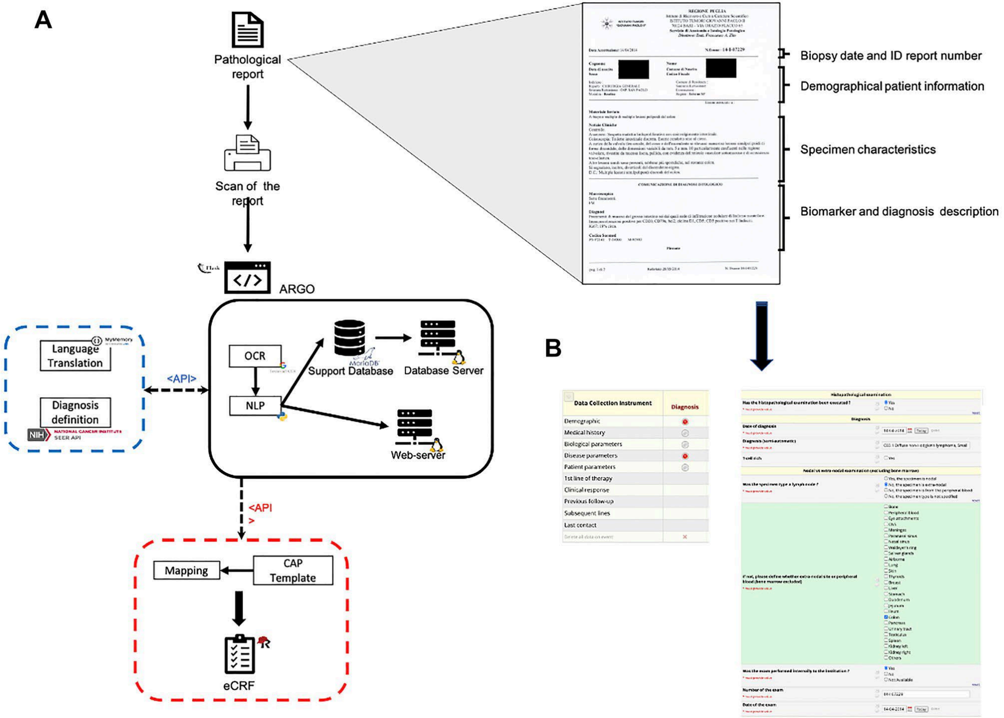
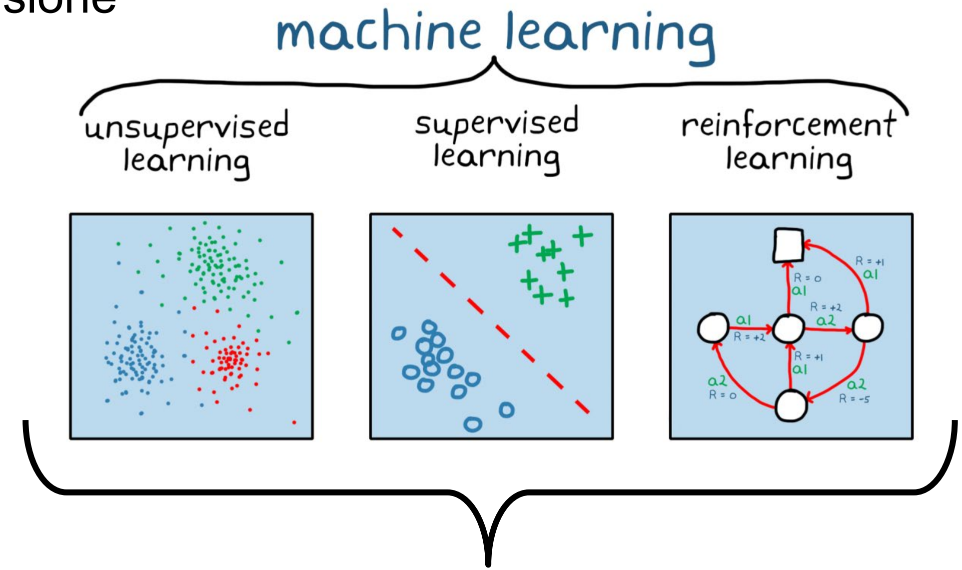
OPEN

Electronic case report forms generation from pathology reports by ARGO, automatic record generator for onco-hematology

Gian Maria Zaccaria[1✉], Vito Colella[2], Simona Colucci[2], Felice Clemente[1], Fabio Pavone[1], Maria Carmela Vegliante[1], Flavia Esposito[1,3], Giuseppina Opinto[1], Anna Scattone[4], Giacomo Loseto[1], Carla Minoia[1], Bernardo Rossini[1], Angela Maria Quinto[1], Vito Angiulli[5], Luigi Alfredo Grieco[2], Angelo Famà[6], Simone Ferrero[7,8], Riccardo Moia[9], Alice Di Rocco[10], Francesca Maria Quaglia[11], Valentina Tabanelli[12], Attilio Guarini[1] & Sabino Ciavarella[1]



Un'ulteriore dimensione



***Self-supervised learning**:*

- *Dati con poche o nessuna etichetta preassegnata manualmente*
- *Adatto ad analizzare sequenze (di parole, di immagini, di eventi, …)*
- *Modelli «generativi»*

Large AI Models: Key Features and New Paradigm Shift

A. Model Size
There has been a trend of increasing the number of parameters of a model (tens of billions is common for LLMs)

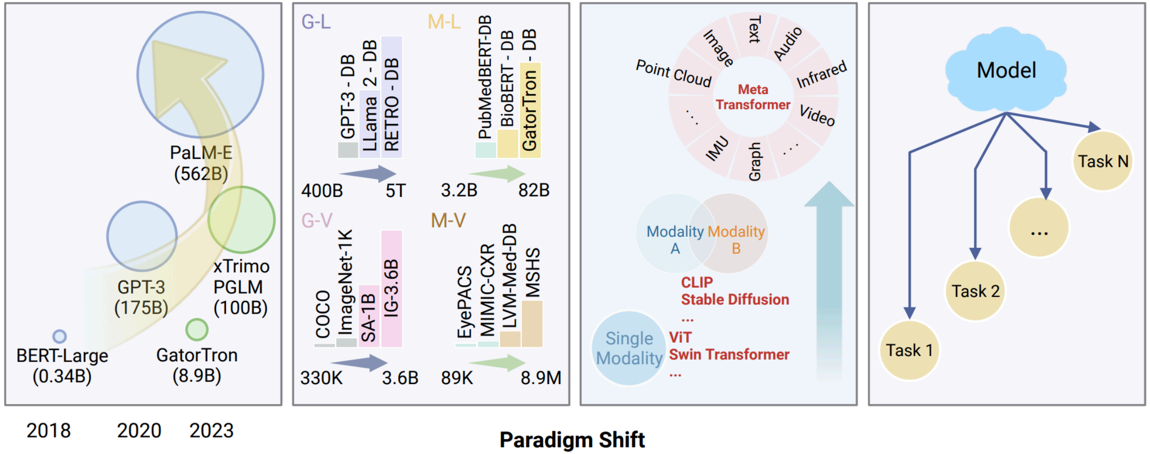
: Large AI Models in General Domain
: Large AI Models in Health Informatics

B. Data Scale
Data has been scaled up, but the medical data scale is much smaller than that of general domain data

G-L : General Lang. M-L : Medical Lang.
G-V : General Vision M-V : Medical Vision

C. Number of Modalities
With increased model capacity, and advances in multi-modal learning, the number of modalities a large AI model can process is expanding

D. Versatility on Downstream Tasks
As often called foundation models, large AI models can exhibit generalist /emergent intelligence, and show impressive performance in multiple downstream tasks, esp. zero-shot, one-shot, and few-shot tasks



Paradigm Shift

Before:
1) Limited-scale model size; 3) Limited generalization.
2) Limited-scale training/pre-training;

Large AI Models:
1) Large-scale model size; 3) Large generalization.
2) Large-scale training/pre-training;

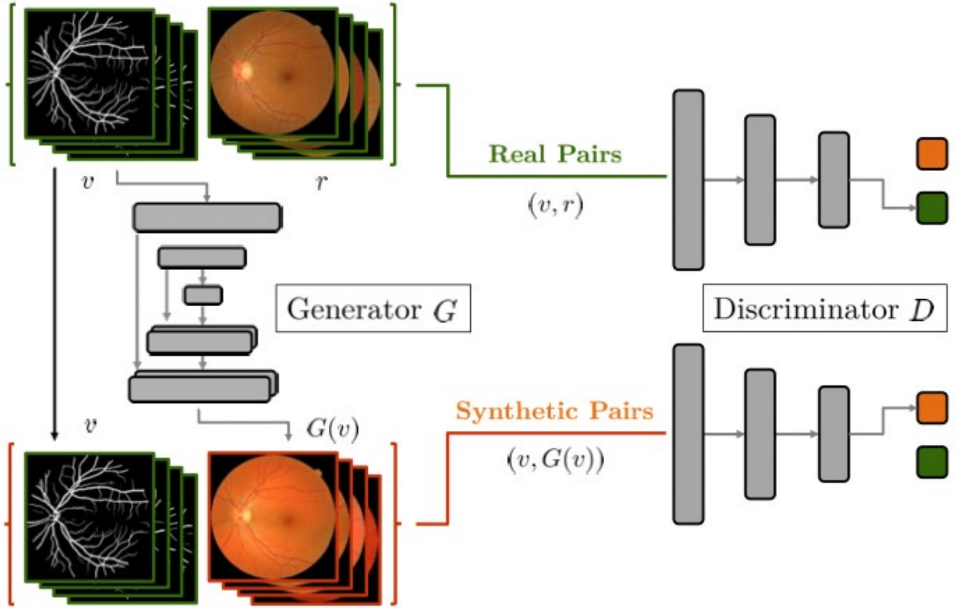
IEEE J Biomed Health Inform. 2023 Sep 22;PP. doi: 10.1109/JBHI.2023.3316750.
Online ahead of print.

Large AI Models in Health Informatics: Applications, Challenges, and the Future

Jianing Qiu, Lin Li, Jiankai Sun, Jiachuan Peng, Peilun Shi, Ruiyang Zhang, Yinzhao Dong, Kyle Lam, Frank P-W Lo, Bo Xiao, Wu Yuan, Ningli Wang, Dong Xu, Benny Lo

PMID: 37738186 DOI: 10.1109/JBHI.2023.3316750

Generazione dei dati



Medical Image Generation

19 papers with code • 2 benchmarks • 3 datasets

Towards Adversarial Retinal Image Synthesis

P. Costa **A. Galdran** **M.I. Meyer**
INESC TEC Porto, Instituto de Engenharia de Sistemas e Computadores - Tecnologia e Ciência
Porto, E-4200, Portugal
{pedro.costa, adrian.galdran, maria.i.meyer}@inesc.pt

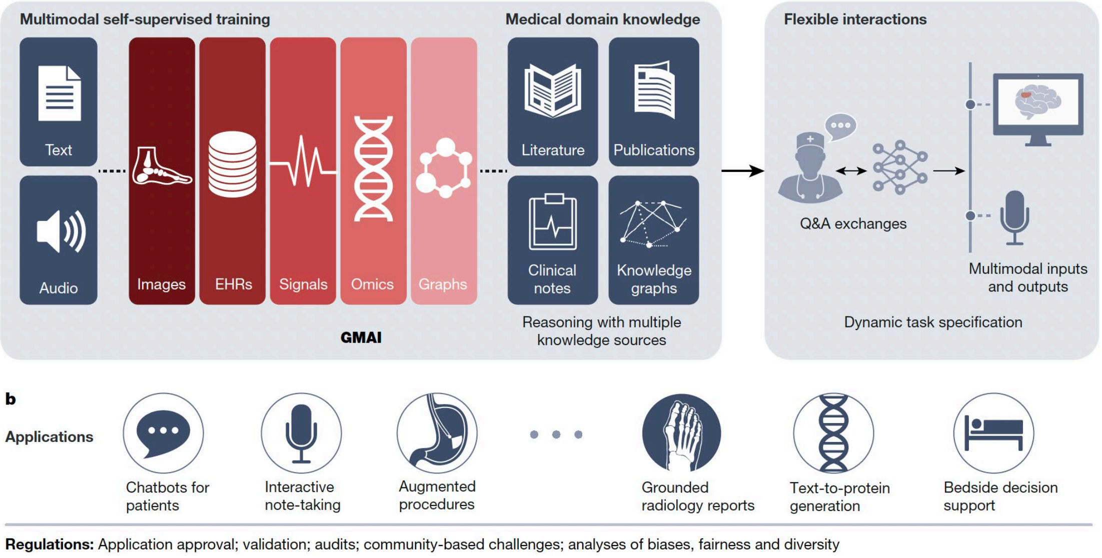
Foundation models for generalist medical artificial intelligence

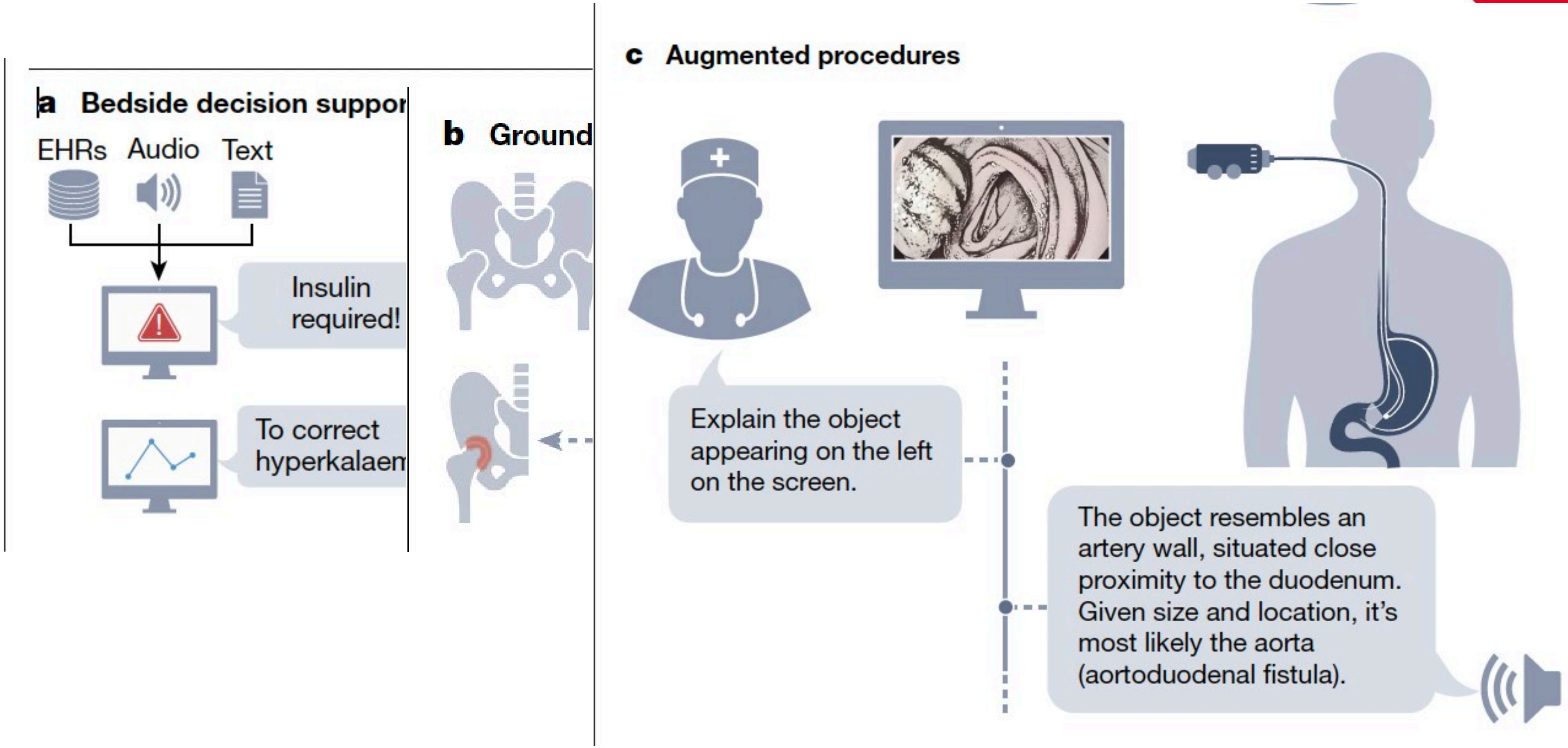
Nature | Vol 616 | 13 April 2023 | 265

https://doi.org/10.1038/s41586-023-05881-4
Received: 3 November 2022
Accepted: 22 February 2023
Published online: 12 April 2023
Check for updates

Michael Moor[1,6], Oishi Banerjee[2,6], Zahra Shakeri Hossein Abad[3], Harlan M. Krumholz[4], Jure Leskovec[1], Eric J. Topol[5,7] ✉ & Pranav Rajpurkar[2,7] ✉

The exceptionally rapid development of highly flexible, reusable artificial intelligence (AI) models is likely to usher in newfound capabilities in medicine. We propose a new paradigm for medical AI, which we refer to as generalist medical AI (GMAI). GMAI




a Bedside decision suppor
EHRs
Audio
Text
Insulin required!
To correct hyperkalaem
b Ground
c Augmented procedures
Explain the object appearing on the left on the screen.
The object resembles an artery wall, situated close proximity to the duodenum. Given size and location, it's most likely the aorta (aortoduodenal fistula).

Journal of Biomedical Informatics 113 (2021) 103637
Contents lists available at ScienceDirect
Journal of Biomedical Informatics
journal homepage: www.elsevier.com/locate/yjbin

Original Research

Language models are an effective representation learning technique for electronic health record data

Ethan Steinberg *, Ken Jung, Jason A. Fries, Conor K. Corbin, Stephen R. Pfohl, Nigam H. Shah
Stanford University, 450 Serra Mall, Stanford, CA 94305, USA

scientific reports

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OPEN

EHR foundation models improve robustness in the presence of temporal distribution shift

Lin Lawrence Guo[1], Ethan Steinberg[2], Scott Lanyon Fleming[2], Jose Posada[3], Joshua Lemmon[1], Stephen R. Pfohl[2], Nigam Shah[2], Jason Fries[2,5] & Lillian Sung[1,4,5]

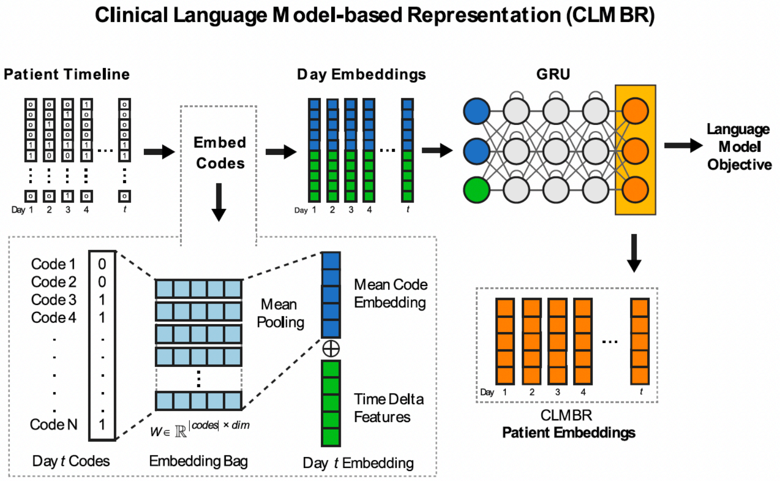

Fig. 4. The figure shows how patient representations were constructed using the CLMBR language model. Representations for individual patients were created by extracting fixed length vectors generated by the linear layer after the GRU.

Table 3
Difference in AUROC of clinical prediction models trained on different representations.

Outcome name	Counts	Relative compared to counts baseline			
		Word2Vec	LSI	CLMBR	End-to-end GRU
Inpatient mortality	0.834	−0.010 ± 0.006	−0.046 ± 0.007	**0.018 ± 0.006**	−0.030 ± 0.008
Long admission	0.783	−0.020 ± 0.002	−0.055 ± 0.002	**0.009 ± 0.002**	−0.013 ± 0.002
ICU transfer	0.792	−0.041 ± 0.006	−0.086 ± 0.007	**0.045 ± 0.005**	0.039 ± 0.006
30-day readmission	0.809	−0.018 ± 0.002	−0.051 ± 0.003	**0.005 ± 0.002**	−0.001 ± 0.002
Abnormal HbA1c	0.700	0.015 ± 0.015	−0.011 ± 0.016	**0.056 ± 0.013**	−0.019 ± 0.017

ATTENZIONE AL PIFFERAIO MAGICO

Correspondence | Published: 13 April 2023

Potential pitfalls in the use of real-world data for studying long COVID

Harrison G. Zhang, Jacqueline P. Honerlaw, Monika Maripuri, Malarkodi Jebathilagam Samayamuthu, Brendin R. Beaulieu-Jones, Huma S. Baig, Sehi L'Yi, Yuk-Lam Ho, Michele Morris, Vidul Ayakulangara Panickan, Xuan Wang, Griffin M. Weber, Katherine P. Liao, Shyam Visweswaran, Bryce W. Q. Tan, William Yuan, Nils Gehlenborg, Sumitra Muralidhar, Rachel B. Ramoni, The Consortium for Clinical Characterization of COVID-19 by EHR (4CE), Isaac S. Kohane, Zongqi Xia, Kelly Cho, Tianxi Cai & Gabriel A. Brat

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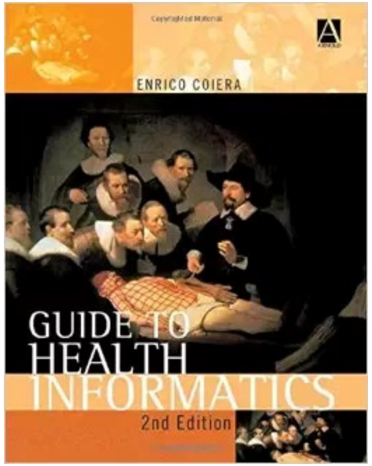
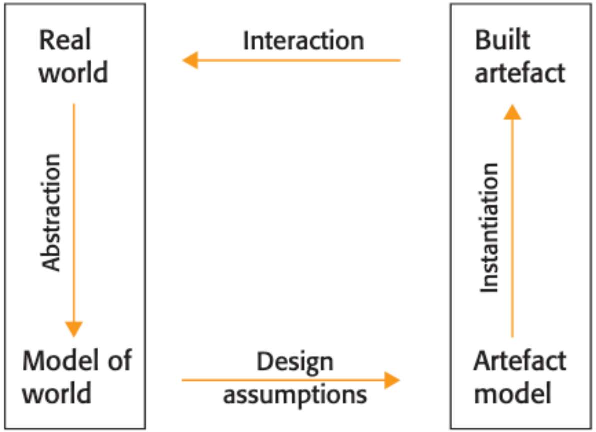
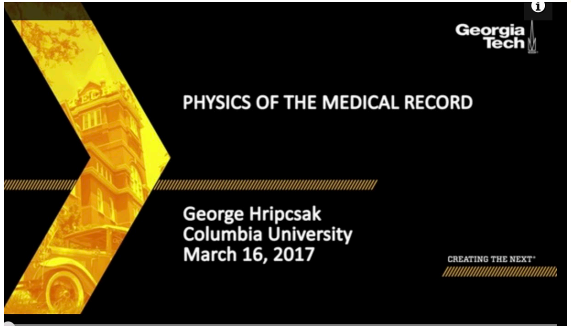
We are an international consortium that has operationalized definitions of long COVID using health-agency guidelines, and established a chart-review procedure based on these definitions[5]. During this process, we identified three major challenges in using real-world data to study long COVID: ambiguity and heterogeneity in clinical coding of long COVID; inadequacy of diagnostic codes in capturing the constellation of symptoms; and biases in EHR data arising from variability in the number and kind of contacts with the healthcare system. These challenges warrant special attention if the clinical community wishes to arrive at a robust understanding of long COVID using evidence derived from real-world data.

I sistemi informativi contengono dati, sono basati su modelli della realtà e dei processi decisionali che supportano, e sono quindi arbitrari e costruiti per uno scopo (E. Coiera)





Se una cartella clinica elettronica deve supportare il processo di cura dovrebbe contenere solo i dati necessari alle decisioni



Potrò apprendere solo modelli di AI che descrivono il processo di cura e le sue caratteristiche

La mancanza di chiarezza nelle impostazioni progettuali dei sistemi informativi e nelle cartelle cliniche elettroniche genera insuccesso e frustrazione

Scarsa distinzione fra

- Obiettivi di controllo di gestione (SDO)
- Obiettivi di supporto decisionale clinico
- Obiettivi di ricerca (registri, eCRF)
- Ogni raccolta dati consente l’impiego di modelli AI differenti per rispondere a domande diverse

Non esistono sistemi ONE-FITS-ALL anche con infiniti dati

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Guidelines for clinical trial protocols for interventions involving artificial intelligence: the SPIRIT-AI extension

Samantha Cruz Rivera[1,2,3], Xiaoxuan Liu[3,4,5,6,7], An-Wen Chan[8], Alastair K. Denniston[1,3,4,5,6,9] ✉, Melanie J. Calvert[1,2,3,6,10,11,12], The SPIRIT-AI and CONSORT-AI Working Group*, SPIRIT-AI and CONSORT-AI Steering Group and SPIRIT-AI and CONSORT-AI Consensus Group

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MINIMAR (MINimum Information for Medical AI Reporting): Developing reporting standards for artificial intelligence in health care

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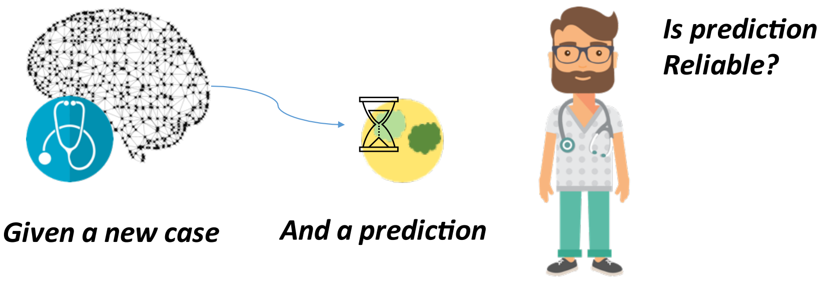
Reporting guidelines for clinical trial reports for interventions involving artificial intelligence: the CONSORT-AI extension

Xiaoxuan Liu[1,2,3,4,5], Samantha Cruz Rivera[5,6,7], David Moher[8,9], Melanie J. Calvert[4,5,6,7,10,11,12], Alastair K. Denniston[2,3,4,5,6,13] ✉ and The SPIRIT-AI and CONSORT-AI Working Group*

Validate, validate, validate

Reliability & Explainability



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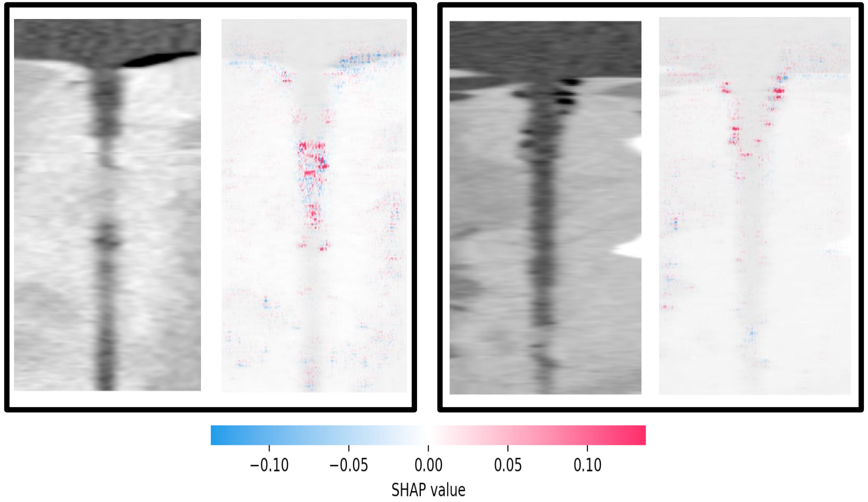
Evaluating pointwise reliability of machine learning prediction

Giovanna Nicora [a,*], Miguel Rios [b], Ameen Abu-Hanna [b], Riccardo Bellazzi [a]



Why an image is classified as positive/negative by a DL model?

Trustworthiness is a property of socio-technical systems

… in a socio-technical system, multiple stakeholders, e.g., engineers, business owners, and customers interact with technologies, such as AI tools, to achieve their goals according to their roles, … over time, and following the rules of the system social institution

The Value of Measuring Trust in AI – A Socio-Technical System Perspective

MICHAELA BENK, ETH Zurich, Switzerland
SUZANNE TOLMEIJER, University of Zurich, Switzerland
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