HealthCare
GILL HEART & VASCULAR INSTITUTE
Network

INTELLIGENCE AT WORK: AI MEETS CARDIOLOGY

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FACULTY DISCLOSURE

- I have no relevant financial relationships with ineligible companies to disclose.

OBJECTIVES

- After completing this educational activity participants will be able to:

  - Differentiate between key AI concepts, including, foundational models, generative and non-generative AI
  - Evaluate the utility and limitations of new AI-powered tools
  - Discuss the regulatory landscape and clinical validation challenges for AI-augmented medicine

EXPECTED OUTCOME & EDUCATIONAL NEED/ PRACTICE GAP

Expected Outcome

By the end of this session, participants will be able to:

- Differentiate between key AI concepts, including machine learning, deep learning, and foundational models.
- Identify current and future AI applications in cardiology, from automated CAC scoring to multi-modal analysis.
- Discuss the regulatory landscape and clinical validation challenges for AI-powered tools.

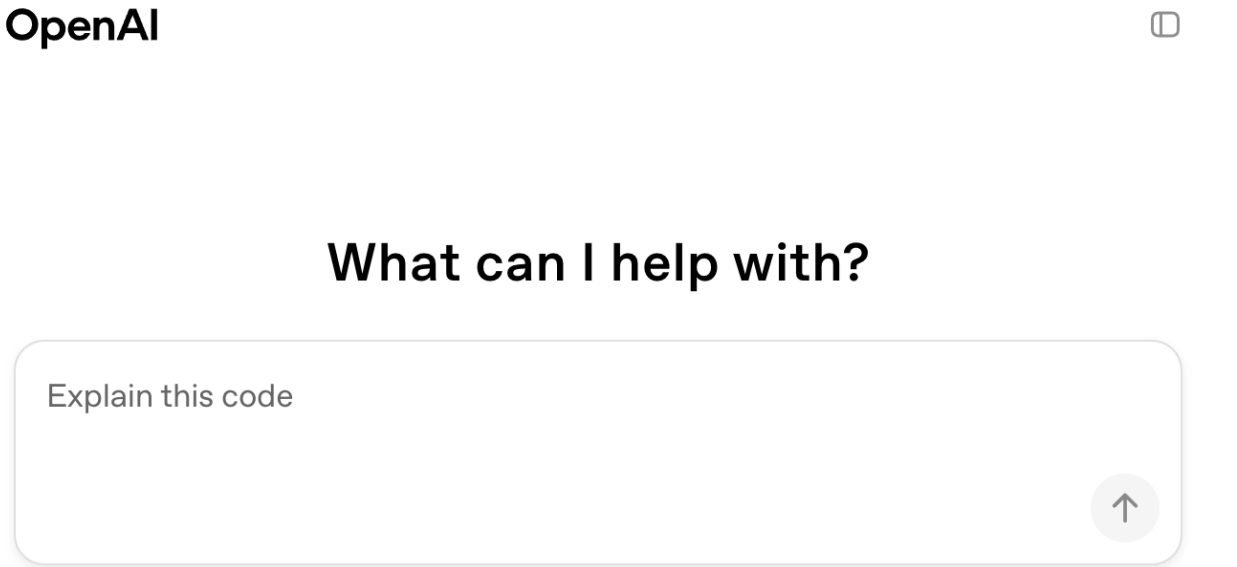
Educational Need

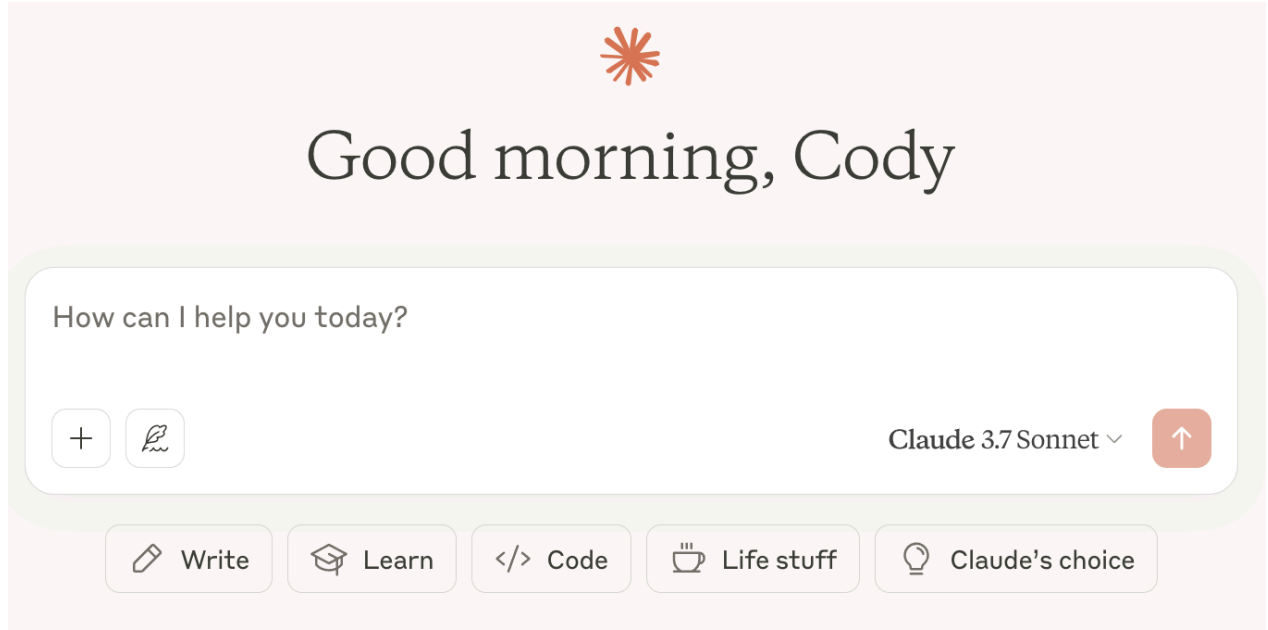
Cardiologists require an updated understanding of AI's rapid evolution from narrow tools to generative foundational models. This session addresses the gap between AI's promise and its practical application, enabling clinicians to critically evaluate and integrate new technologies.

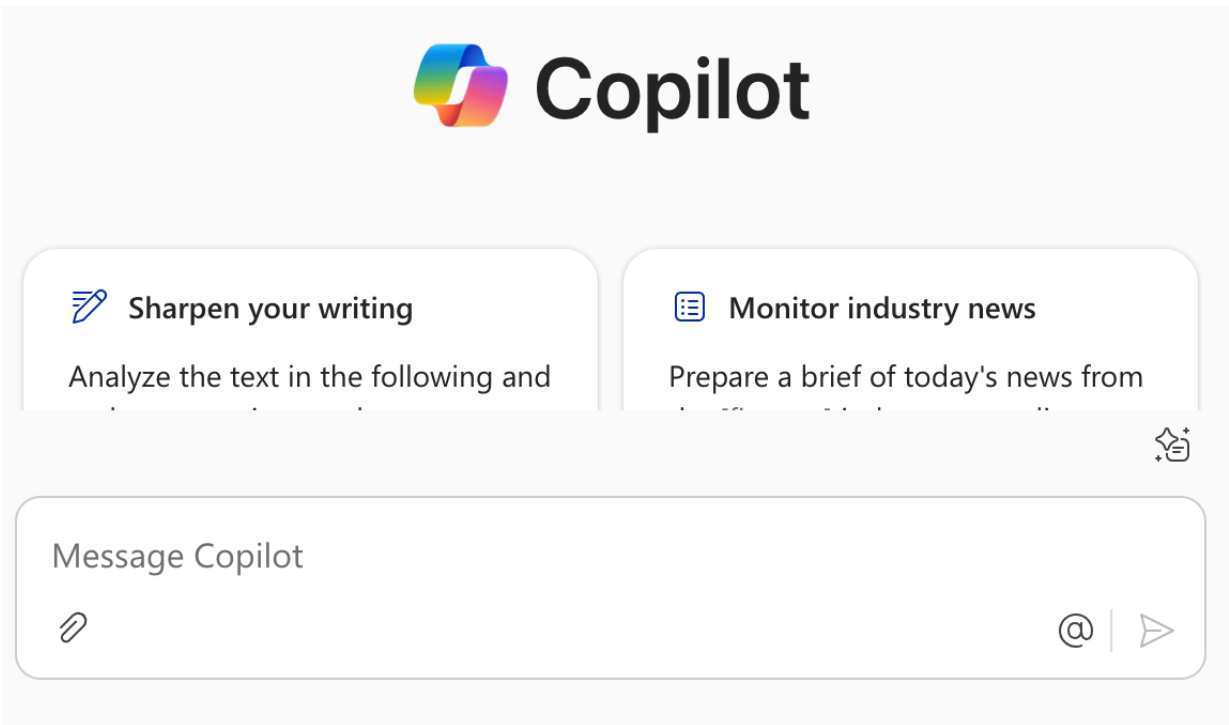
Practice Gap

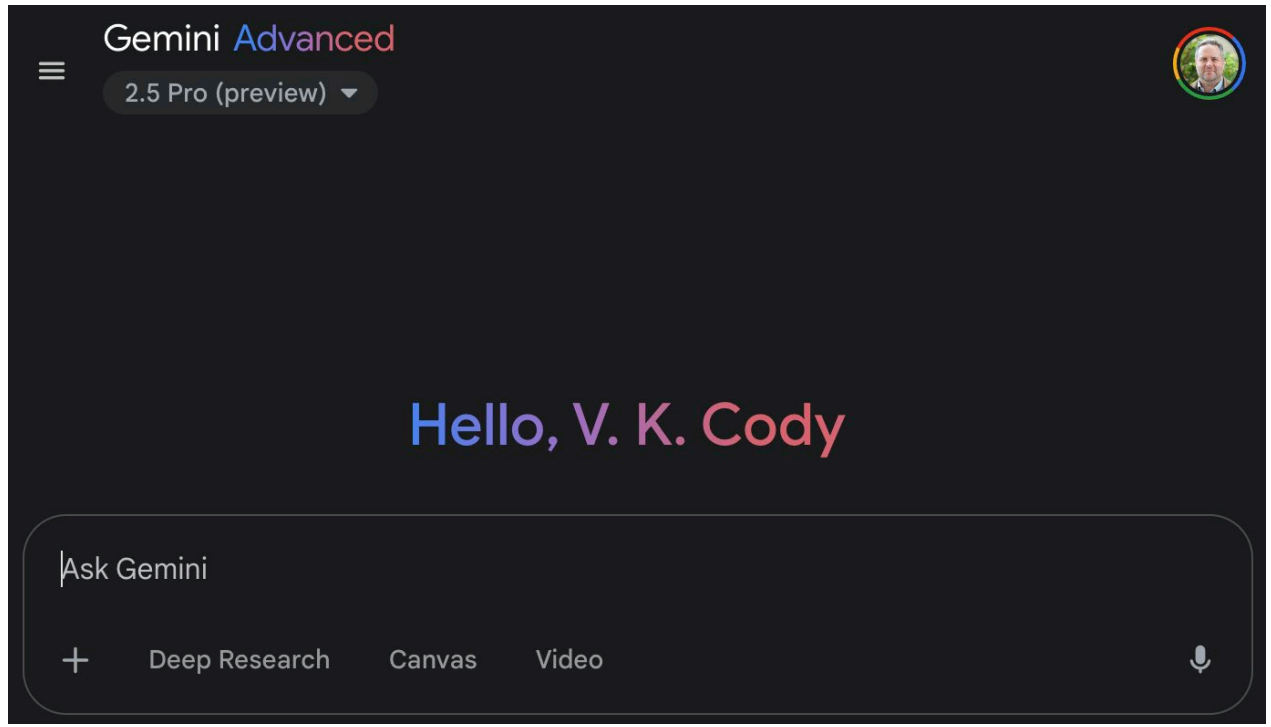
A gap exists between AI's current limited use and its optimal state. This session demonstrates how AI bridges this gap to:

- Enhance Diagnostics: Use opportunistic screening (e.g., non-gated CAC) and find subtle imaging patterns.
- Improve Understanding: Shift from "black-box" to "glass-box" models for explainable insights.
- Personalize Treatment: Synthesize multi-modal data (imaging, genomics, notes) for a holistic patient view.


OpenAI
What can I help with?
Explain this code


Good morning, Cody
How can I help you today?
Claude 3.7 Sonnet
Write
Learn
Code
Life stuff
Claude's choice


Copilot
Sharpen your writing
Analyze the text in the following and
Monitor industry news
Prepare a brief of today's news from
Message Copilot


Gemini Advanced
2.5 Pro (preview)
Hello, V. K. Cody
Ask Gemini
Deep Research
Canvas
Video

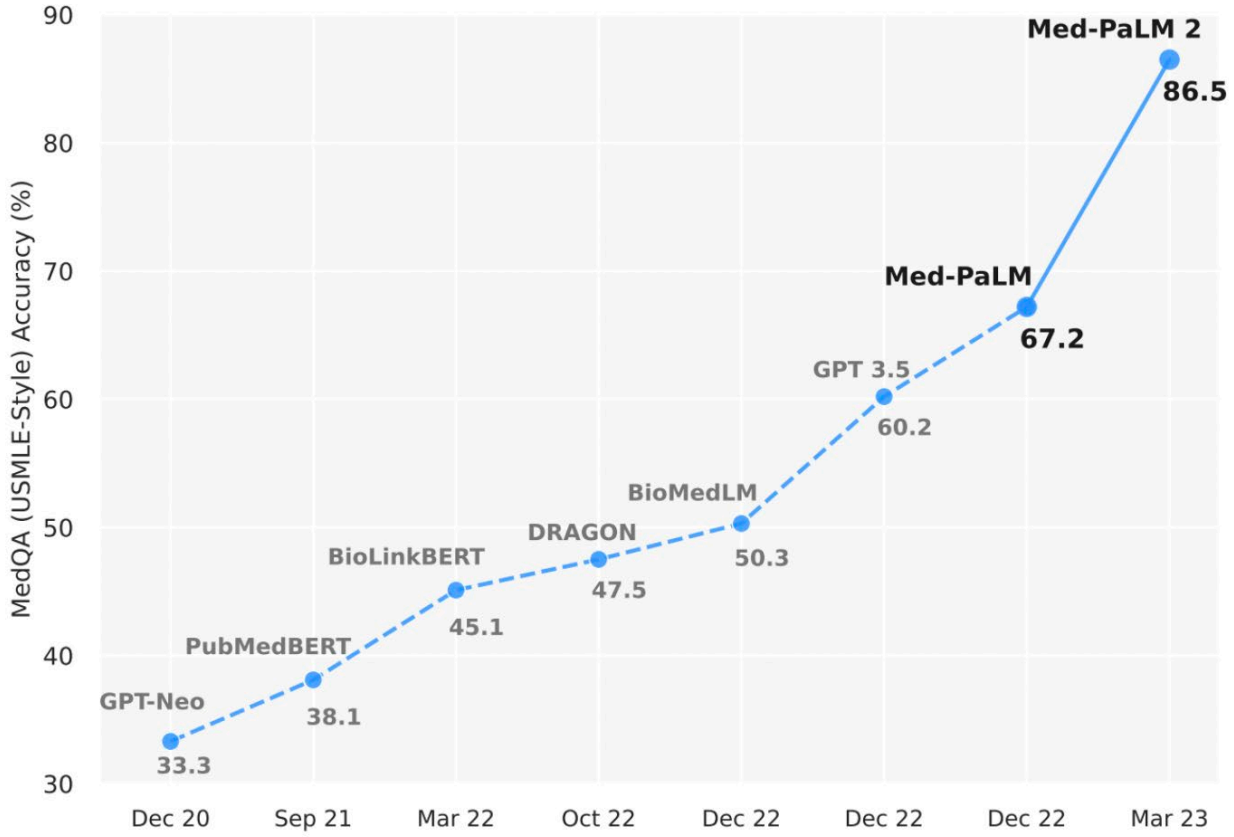
nature portfolio

Toward expert-level medical question answering with large language models

•A Google-created medical AI model, Med-PaLM 2, scored an impressive 86.5% on questions styled after the US Medical Licensing Examination.

•The AI model's answers were also rated by actual doctors to be better than doctor-generated responses in 8 of 9 dimensions.

•This advancement signals a potential paradigm shift in healthcare as AI models are increasingly capable of working in complex fields.



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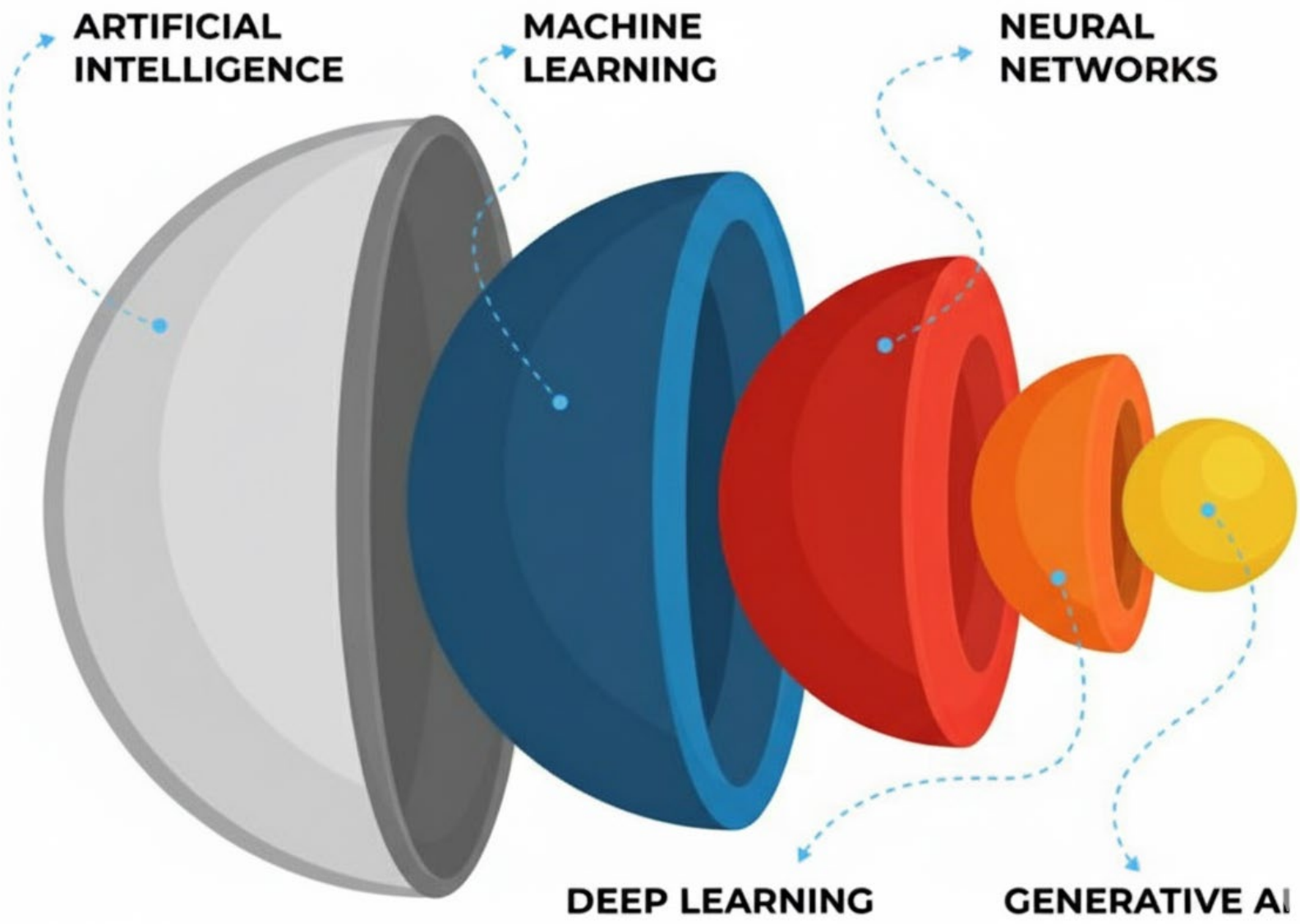
Nat Med. 2025 Jan 8;31(3):943–950. doi: 10.1038/s41591-024-03423-7

PMCID: PMC11922739 PMID: 39779926

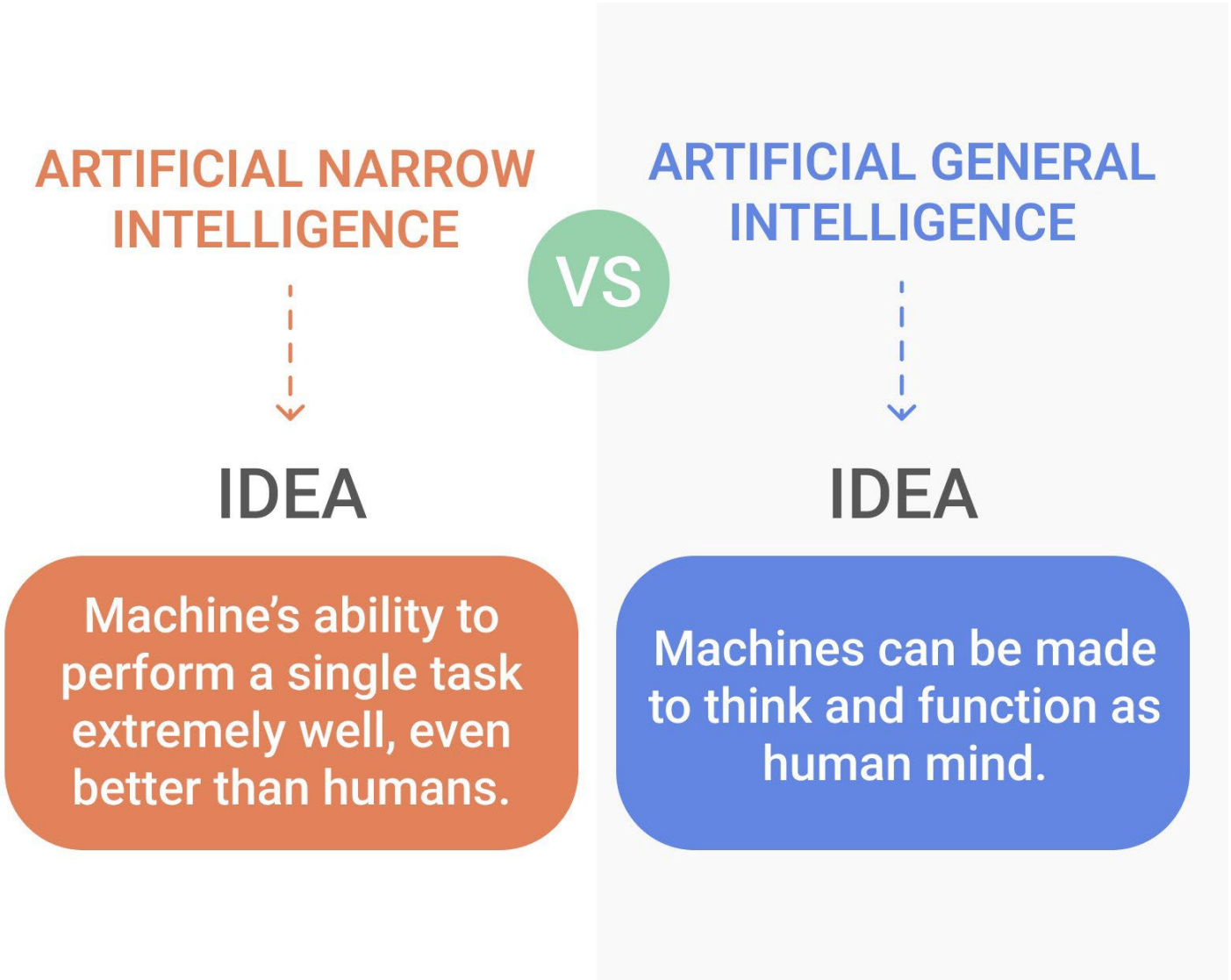


AI: Programmed logic

ML: AI without programming

NN: Learning complex underlying patterns from data

GAI: Generates new data from learned patterns



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Non-generative / Narrow (AI):

- **Often used for a single task and data type**
- **Understands and can describe patterns in data**
- **Diagnostic: Arrhythmia yes/no?**
- **FDA-authorized AI Medical Devices**

Generative AI (GenAI):

- **Seemingly cognitive capabilities and contextual understanding across a broader range of inputs (language, vision, etc.)**
- **AI Agent: Personalized health companion, collect, assess, report**

FDA U.S. FOOD & DRUG ADMINISTRATION

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

July 10th, 2025:

- 1247 FDA authorized devices
- 76% Radiology
- 11% Cardiovascular

05/27/2025	K250932	DeepRhythmAI	Medicalgorithmics S.A.
05/21/2025	K243866	InVision Precision Cardiac Amyloid	InVision Medical Techno
05/09/2025	K243812	Volta AF-Xplorer	Volta Medical
05/02/2025	K242583	AT-Patch (ATP-C130/ATP-C70)	ATsens Co.,Ltd.

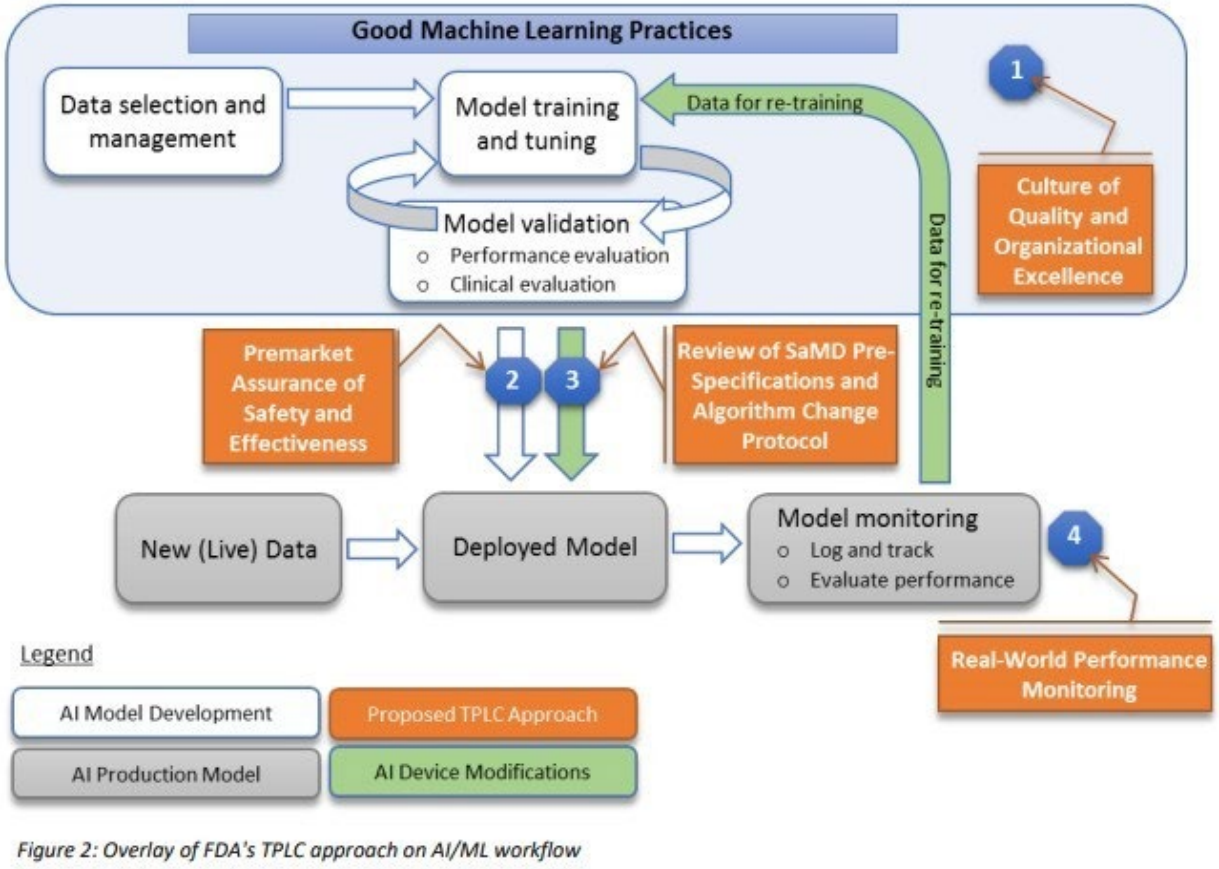

Figure 2: Overlay of FDA's TPLC approach on AI/ML workflow

https://www.fda.gov/medical-devices/software-medical-device-samd/artificial-intelligence-and-machine-learning-aiml-enabled-medical-devices

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nature medicine

Article | Published: 15 July 2019

Clinical-grade computational pathology using weakly supervised deep learning on whole slide images

Gabriele Campanella, Matthew G. Hanna, Luke Geneslaw, Allen Miraflor, Vitor Werneck Krauss Silva, Klaus J. Busam, Edi Brogi, Victor E. Reuter, David S. Klimstra & Thomas J. Fuchs

Nature Medicine **25**, 1301–1309 (2019) | Cite this article

2019

Sep 22, 2021 8:00 AM Eastern Daylight Time

Paige Receives First Ever FDA Approval for AI Product in Digital Pathology

Share

Paige Prostate was granted de novo marketing authorization from the FDA to aid in the primary diagnosis of prostate cancer

2021

PAIGE's funding and investors

PAIGE has raised a total funding of $241M over 8 rounds. Its first funding round was on Feb 05, 2018. Its latest funding round was a Series C round on Jan 11, 2023 for $19.5M. 1 investor participated in its latest round, lead by Microsoft.

PAIGE has 9 institutional investors including Goldman Sachs, Casdin Capital and Johnson & Johnson Innovation – JJDC. Jim Breyer and 1 other are Angel Investors in PAIGE.

2023

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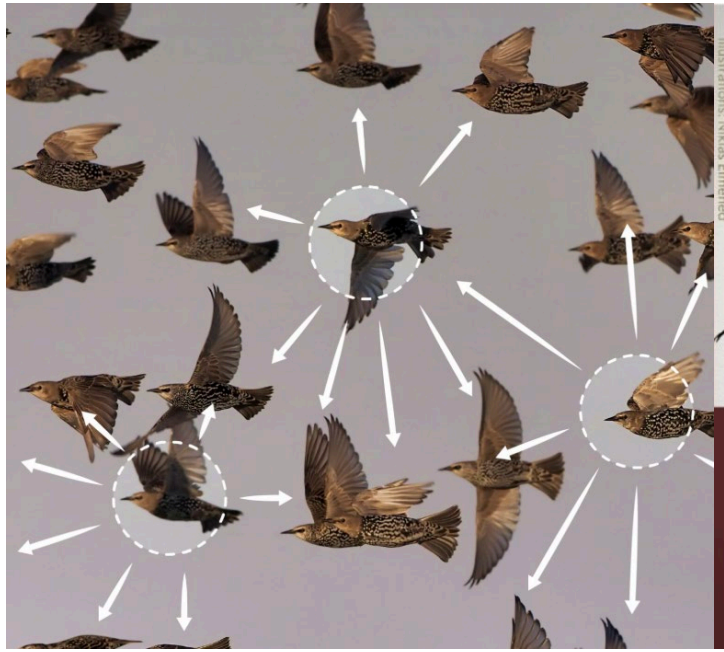
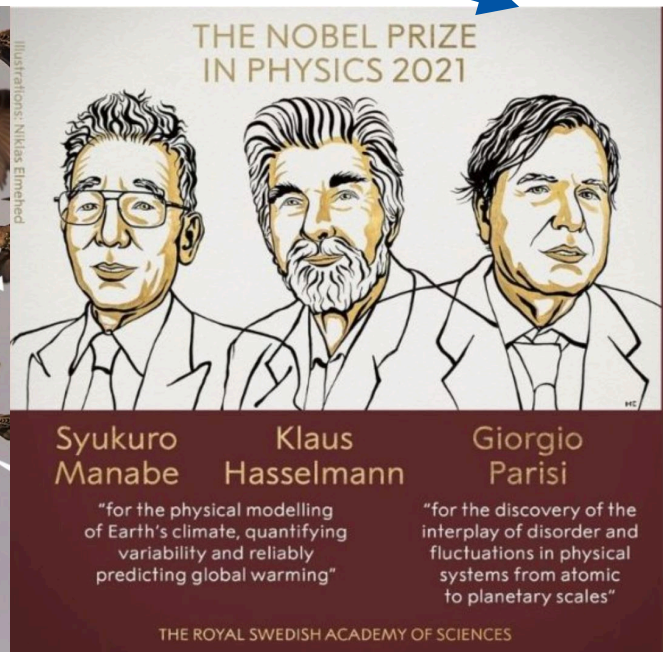
Tempus inks $81M Paige buyout to support AI model development

2025

Interaction Ruling Animal Collective Behaviour Depends on Topological rather than Metric Distance: Evidence from a Field Study

M. Ballerini[1,2], N. Cabibbo[3,4], R. Candelier[3]†, A. Cavagna[1,5]★, E. Cisbani[2], I. Giardina[1,5], V. Lecomte[6]†, A. Orlandi[1], G. Parisi[1,3,4], A. Procaccini[1,3], M. Viale[3]† & V. Zdravkovic[1]





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THE PSYCHOLOGICAL REVIEW

THE MAGICAL NUMBER SEVEN, PLUS OR MINUS TWO: SOME LIMITS ON OUR CAPACITY FOR PROCESSING INFORMATION [1]

GEORGE A. MILLER

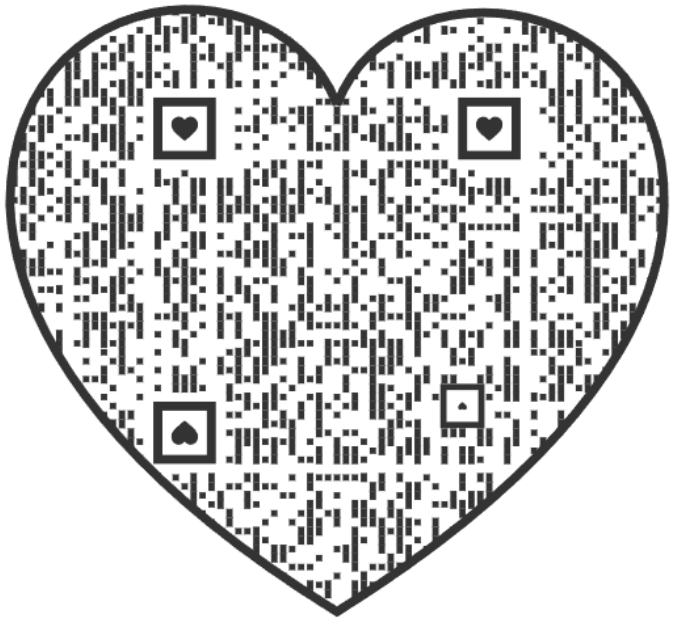
Harvard University

Date of Final Decision	Submission Number	Device	Company	Panel (lead)	Primary Product Co.
5/27/25	K250932	DeepRhythmAI	MedicalgorithmicsS.A.	Cardiovascular	DQK
5/21/25	K243866	InVision Precision Cardiac Amyloid	InVision Medical Technology Corp	Cardiovascular	QSD
5/9/25	K243812	VoltaAF-Xplorer	Volta Medical	Cardiovascular	DQK
5/2/25	K242583	AT-Patch (ATP-C130/ATP-C70)	ATaxia Co.,Ltd.	Cardiovascular	DSH
4/17/25	K242129	VitalRhythm	VitalConnect,Inc.	Cardiovascular	DQK
2/25/25	K242967	Loss of Pulse Detection	Fibli	Cardiovascular	SDY
12/4/24	K241197	DeepRhythmAI	MedicalgorithmicsS.A.	Cardiovascular	DQK
11/18/24	K241633	Informed Vital Core Application (VC App)	MindsetMedical, Inc.	Cardiovascular	QME
11/15/24	K240860	EchoGo Amyloidosis (1.0)	Ultromics Limited	Cardiovascular	QDI
9/23/24	K240013	EchoGo Heart Failure (2.0)	Ultromics Limited	Cardiovascular	QUO
8/16/24	K233755	HeartKey-AI Rhythm	B-Secur Limited	Cardiovascular	DQK
8/2/24	K233984	Acumen Assisted Fluid Management (AFM) Software Feature	Edwards Lifesciences, LLC	Cardiovascular	DHS
6/21/24	K233253	eCARTv5 Clinical Deterioration Suite (=eCART=)	AgileMD, Inc.	Cardiovascular	QNL
6/21/24	K233549	Tempus ECG-AF	Tempus AI, Inc.	Cardiovascular	QEQ
6/7/24	K232035	Impulo	AliveCor, Inc.	Cardiovascular	DPS
6/7/24	K231010	Corvair	AliveCor, Inc.	Cardiovascular	MWI
5/7/24	K233864	ASSURE Wearable ECG	Keetra Medical Technologies, Inc.	Cardiovascular	MWI
4/5/24	K233249	APPHASE-HRI	The Surgeon General, Department o	Cardiovascular	SAR
4/5/24	K233666	CorVista System with PH Add-On	Analytics for Life, Inc.	Cardiovascular	SAT
3/28/24	K233409	Eko Low Ejection Fraction Tool (ELEFT)	Eko Health, Inc.	Cardiovascular	QYE
1/13/24	K232216	CLEWICU System	Clew Medical Ltd.	Cardiovascular	QNL
12/6/23	K233162	LINQ II Insertable Cardiac Monitor	Medtronic, Inc.	Cardiovascular	MXD
10/25/23	K230842	SignalAF (MK038)	Implicity Inc.	Cardiovascular	QNL
10/6/23	K223905	Vivio -AI LVEDP System	Avicena, LLC	Cardiovascular	QUO
9/28/23	K232699	Low Ejection Fraction AI-ECG Algorithm	Anumana, Inc.	Cardiovascular	QYE
9/27/23	K232616	VoltaAF-Xplorer	Volta Medical	Cardiovascular	DQK
9/8/23	K232646	CorVista AI System	CorVista Health, Inc.	Cardiovascular	DSK
9/8/23	K231335	Cleerly ISCHEMIA	Cleerly, Inc.	Cardiovascular	QKZ
9/7/23	K231207	CARTO+3 3 EP Navigation System Software V8.0 (FG-5400-00, FG-5400-00	Biosense Webster, Inc.	Cardiovascular	DQK
9/1/23	K223622	Fazeheart Vitals Software Development Kit (Private SDK)	Fazeheart Corp.	Cardiovascular	QME
8/23/23	K230812	Withings Scan Monitor 2.0	Withings	Cardiovascular	DPS
8/3/23	DEN230003	Viz HCM	Viz.ai, Inc.	Cardiovascular	QEO
7/26/23	K231038	Global Hypertension Index (GHI) Algorithm	Edwards Lifesciences, LLC	Cardiovascular	QNL
7/21/23	K231173	Irregular Rhythm Notification Feature (IRN)	Apple Inc.	Cardiovascular	QDB
7/12/23	K230823	AuscultiCor ACC	AuscultiCor Oy	Cardiovascular	DQD
5/25/23	K230273	Sanan as Early Blood Monitoring System	Sanan as Inc.	Cardiovascular	QFJ
5/2/23	K230292	Samsung ECG Monitor Application with Irregular Heart Rhythm Notification	Samsung Electronics Co., Ltd	Cardiovascular	QDA
4/26/23	K230553	LINQ II Insertable Cardiac Monitor, Cardiatek SmartSync LINQ II ICM Application	Medtronic, Inc.	Cardiovascular	MXD
4/6/23	K223630	Reveal LINQ Insertable Cardiac Monitor, LINQ Insertable Cardiac Monitor, Acc	Medtronic, Inc.	Cardiovascular	MXD
3/17/23	K223073	Aile	Aile, Inc.	Cardiovascular	DRO
2/15/23	K222389	ZEUS System	Rhythm Technologies, Inc.	Cardiovascular	DQK
1/21/23	K223516	VX1+	Volta Medical	Cardiovascular	DQK
12/1/22	K220786	STAR Apollo Mapping System	Rhythm ALLIE	Cardiovascular	DQK
10/31/22	P210015	AvivoAutomated External Defibrillator (AED) System	Avivo Solutions, Inc.	Cardiovascular	MKJ
10/14/22	K213857	HeartFlow Analysis	HeartFlow, Inc.	Cardiovascular	PIA
8/25/22	K221962	LINQ II Insertable Cardiac Monitor	Medtronic, Inc.	Cardiovascular	MXD
7/27/22	K210822	DeepRhythmAI	MedicalgorithmicsS.A.	Cardiovascular	DQK
7/19/22	K213357	Study Watch with Irregular Pulse Monitor (Home), Study Watch with Irregular	Verily Life Sciences LLC	Cardiovascular	DXH
7/19/22	K213469	ZEUS System (Zio Watch)	Rhythm Technologies, Inc.	Cardiovascular	DQK
7/14/22	K221203	AHI System	Fifth Eye Inc.	Cardiovascular	QNV
6/29/22	K213794	Eko Murmur Analysis Software (EMAS)	Eko Devices, Inc.	Cardiovascular	DQD
6/3/22	K213971	Atrial Fibrillation History Feature	Apple Inc.	Cardiovascular	DQB
5/31/22	K220766	eMurmur HeartAI	CSD Labs GmbH	Cardiovascular	DQD
4/29/22	K220699	Oxehealth Vital Signs	Oxehealth Limited	Cardiovascular	QME
4/26/22	K212662	AliveCor QT Service	AliveCor, Inc.	Cardiovascular	DQK
4/1/22	K213657	DEEPVESSELFFR	KeyMed NA Inc.	Cardiovascular	PIA
12/3/21	K212219	AHI System	Fifth Eye Inc.	Cardiovascular	QNV
11/3/21	K210543	IM007	Implicity, Inc.	Cardiovascular	DQK
10/22/21	K212516	RIM-App	Apple Inc.	Cardiovascular	QDB
9/8/21	DEN210030	FEops HEARTguide	FEops NV	Cardiovascular	QQI
7/30/21	K211906	Vital Signs	Oxehealth Limited	Cardiovascular	QME
6/11/21	K210484	LINQ II Insertable Cardiac Monitor, Zeto AI ECG Classification System	Medtronic, Inc.	Cardiovascular	MXD
5/21/21	K202527	Zio ECG Utilization Software (ZEUS) System	Rhythm Technologies, Inc.	Cardiovascular	DQK
4/1/21	DEN210038	GB Pro Bio Sensor (also known as "iGlu Bio Sensor System™)	Centrillus Biomed co.Ltd.	Cardiovascular	DQK
3/26/21	DEN200019	Oxehealth Vital Signs	Oxehealth Limited	Cardiovascular	QME
3/1/21	DEN200022	Analytic for Hemodynamic Instability (AHI)	Fifth Eye Inc.	Cardiovascular	QNV
1/8/21	K200717	CLEWICU System (ClewCUServer and ClewCUnitor)	CLEW Medical Ltd.	Cardiovascular	QNL
1/8/21	K203329	HeartFlow Analysis	HeartFlow, Inc.	Cardiovascular	PIA
11/12/20	K201985	KardiaAI	AliveCor, Inc.	Cardiovascular	DQK
10/9/20	K193631	StethoPro 1, StethoPro Software System	M3DICINE Pty Ltd.	Cardiovascular	DQD
9/16/20	K201298	VX1	Volta Medical	Cardiovascular	DQK
9/2/20	K200833	RX-1 Rhythm Express Remote Cardiac Monitoring System	VivaQuant Inc.	Cardiovascular	MLO
3/26/20	K192732	BodyGuardian Remote Monitoring System	Preventice Technologies, Inc.	Cardiovascular	DSI
3/20/20	K200036	AI-ECG Tracker	Shenzhen Carewell Electronics Co.,	Cardiovascular	DPS
1/17/20	K192415	Study Watch with Irregular Pulse Monitor	Verily Life Sciences LLC	Cardiovascular	DXH
1/15/20	K192004	Eko Analysis Software	Eko Devices Inc	Cardiovascular	MWI
12/9/19	K192442	FFRangio	CathWorks Ltd	Cardiovascular	QEK
11/25/19	K190529	SQIO	Imped Med Limited	Cardiovascular	QIB
11/1/19	K190334	MIMOSA Imager	MIMOSA Diagnostics Inc	Cardiovascular	MUD
9/11/19	K183376	Pera Mobile and Pera Watch	Pera Health, Inc.	Cardiovascular	MWI
8/23/19	K190593	Zio XT ECG Monitoring System, Zio AT ECG Monitoring System	Rhythm Technologies, Inc.	Cardiovascular	DQK
8/15/19	K190925	HeartFlow FFR CT Analysis	HeartFlow, Inc.	Cardiovascular	PIA
8/15/19	K183282	Biovitals Analytics Engine	Biosurmis Singapore Pte. Ltd	Cardiovascular	PLB
7/10/19	K183322	physiQ Heart Rhythm and Respiratory Module	physiQ, Inc	Cardiovascular	DPS
5/21/19	K183646	Acumen Hypotension Prediction Index with EV1000 Clinical Platform, Acume	Edwards Lifesciences, LLC	Cardiovascular	QAQ
4/17/19	K181968	eMurmur ID	CSD Labs GmbH	Cardiovascular	DQD
3/29/19	K181352	Loop System	Spry Health, Inc	Cardiovascular	DQA
3/11/19	K181823	KardiaAI	AliveCor, Inc.	Cardiovascular	DQK
3/7/19	K182344	RhythmAnalytics	Biosurmis Singapore Pte. Ltd.	Cardiovascular	DQK
2/16/19	K183704	RX-1 Rhythm Express Remote Cardiac Monitoring System	VivaQuant Inc.	Cardiovascular	DXH
1/17/19	K182456	Study Watch	Verily Life Sciences LLC	Cardiovascular	DXH
12/19/18	K182149	FFRangio System	CathWorks Ltd	Cardiovascular	QEK
12/14/18	K182790	Cardio-TriTrace® 5	Cardio-Phoenix Inc.	Cardiovascular	DPS
12/6/18	K182035	FFRct	HeartFlow, Inc	Cardiovascular	PIA
11/19/18	K180432	AI-ECG Platform	Shenzhen Carewell Electronics, Ltd	Cardiovascular	DQK
9/28/18	K173872	FibriCheck	Qompium nv	Cardiovascular	DXH
8/29/18	K181502	Zio AT ECG Monitoring System, ZEUS System	Rhythm Technologies, Inc.	Cardiovascular	DQK
5/1/18	K172959	PeraObserve and PeraHeart	Pera Health, Inc.	Cardiovascular	MWI
4/16/18	K180126	SQIO	Imped Med Limited	Cardiovascular	QBH
3/16/18	DEN180044	Acumen Hypotension Prediction Index (HPI) Feature Software	Edwards Lifesciences LLC	Cardiovascular	QAQ
1/4/18	K171656	WAVE Clinical Platform	Excel Medical Electronics, LLC	Cardiovascular	MWI
12/22/17	K172507	SQIO	Imped Med Limited	Cardiovascular	DSB
11/7/17	K163694	Root Rx ECG Event Recorder, Root Link APP Software	Root Labs Ltd.	Cardiovascular	DRG
9/27/17	K171936	Peerbridge Cor(TM) System	Peerbridge Health Inc.	Cardiovascular	DSH
8/17/17	K163339	SPECTRALMD DEPVIEW WOUND IMAGING SYSTEM 2.0	SPECTRALMD, INC.	Cardiovascular	DPT
8/11/17	K172122	SQIO	Imped Med Limited	Cardiovascular	QBH
6/26/17	K170568	Cardiologs ECG Analysis Platform	Cardiologs Technologies	Cardiovascular	DPS
2/23/17	K162855	Reveal LINQ	Medtronic, Inc.	Cardiovascular	MXD
10/19/16	K160401	Tyto Stethoscope	Tyto Care Ltd.	Cardiovascular	DQD
8/24/16	K161772	FFRct	HEARTFLOW, INC.	Cardiovascular	PIA
7/15/16	K160116	Sleth ID	STRATOSGENOMIC, INC.	Cardiovascular	DQD
1/13/16	K152733	FFRct	HEARTFLOW, INC.	Cardiovascular	PIA
6/15/15	K142512	Personalized Physiology Analytics Engine software	VOBio, Inc. (DBA PhysiQ)	Cardiovascular	PLB
9/4/13	K131044	SENSICARDIAC MOBI DIAGNOSTIC HEART MURMUR APPLICATION	DIACOUSTIC MEDICAL DEVICES (F	Cardiovascular	DQD
7/27/12	K121617	SENSICARDIAC	DIACOUSTIC MEDICAL (PTY)	Cardiovascular	DQD
7/17/08	K081140	VSENDA	OBS MEDICAL	Cardiovascular	MWI

The AI Revolution in Cardiovascular Medicine: A Market Landscape Analysis of FDA-Cleared Technologies

WARNING: AI GENERATED CONTENT

Google Gemini Pro 2.0 (Deep Research) on 10/21/2025



Category	Count
Tabular	84
Imaging	23
Text	0
Multi-modal	10

?

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Tabular: Time-series or numeric data. Consists of technologies that interpret electrocardiograms (ECG/EKG), PPG for rhythm and rate, heart sounds, and other numeric signals, EMR, etc.

Imaging: This includes devices that process coronary CT angiograms (CCTA), echocardiograms, standard angiography images, and those that use optical cameras for non-contact vital sign measurement or tissue perfusion imaging.

Text: This category is for tools that would involve Natural Language Processing (NLP) or other forms of text analysis. None of the devices on the list had a primary function that fit this description.

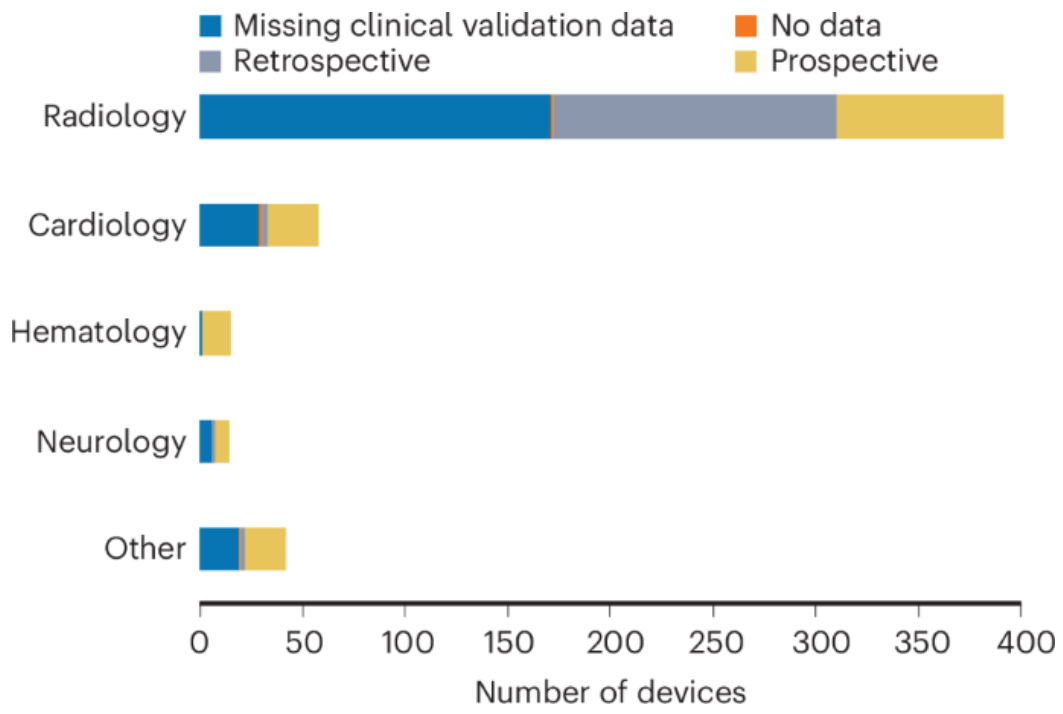
Multi-modal: This category includes devices that explicitly combine and analyze data from different modalities to generate an output, such as fusing ECG (electrical signals) with heart sounds (acoustic signals) or accelerometer data (motion).

Comment | Published: 26 August 2024

Not all AI health tools with regulatory authorization are clinically validated

Sammy Chouffani El Fassi, Adonis Abdullah, Ying Fang, Sarabesh Natarajan, Awab Bin Masroor, Naya Kayali, Simran Prakash & Gail E. Henderson

Nature Medicine **30**, 2718–2720 (2024) | Cite this article



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FDA

November 20 – 21, 2024

Total Product Lifecycle Considerations for Generative AI-Enabled Devices

Foundation Model Transparency: Manufacturers must provide detailed information about a device's underlying foundation model, including its architecture, training methods, and datasets. This can be challenging when using third-party models.

New Evaluation Methods: Current quantitative performance evaluation methods may not be enough. New approaches, including qualitative assessments, will likely be needed to fully characterize the device's performance.

Postmarket Monitoring: Because GenAI models can be dynamic and non-deterministic, robust postmarket monitoring is critical to ensure the devices remain safe and effective after they are deployed.

https://www.fda.gov/media/182871/download

NEJM AI

DATASETS, BENCHMARKS, AND PROTOCOLS

Assessment of Large Language Models in Clinical Reasoning: A Novel Benchmarking Study

Authors: Liam G. McCoy, M.D., M.Sc. , Rajiv Swamy, S.M. , Nidhish Sagar, S.M. , Minjia Wang, M.Eng. , Stephen Bacchi, M.B.B.S., Ph.D. , Jie Ming Nigel Fong, M.R.C.P. , Nigel C.K. Tan, M.S.-H.P.Ed., F.R.C.P.(Edin). , +6 , and Adam Rodman, M.D., M.P.H. Author Info & Affiliations

Published September 25, 2025 | NEJM AI 2025;2(10) | DOI: 10.1056/AIdbp2500120
VOL. 2 NO. 10 | Copyright © 2025

Benchmark of 750 SCT questions drawn from 10 datasets spanning multiple specialties. Each item presents a clinical vignette and asks how added data change the likelihood of a diagnosis or management option, scored against 1070 medical students

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- Although current models can match or exceed medical student performance on many SCT tests, they **consistently fall short of senior resident and expert clinician performance**.

- Our analysis of model response patterns reveals that even state-of-the-art LLMs exhibit striking **overconfidence**, disproportionately favoring **extreme belief shifts** and **failing to recognize when new information should not alter clinical hypotheses**.

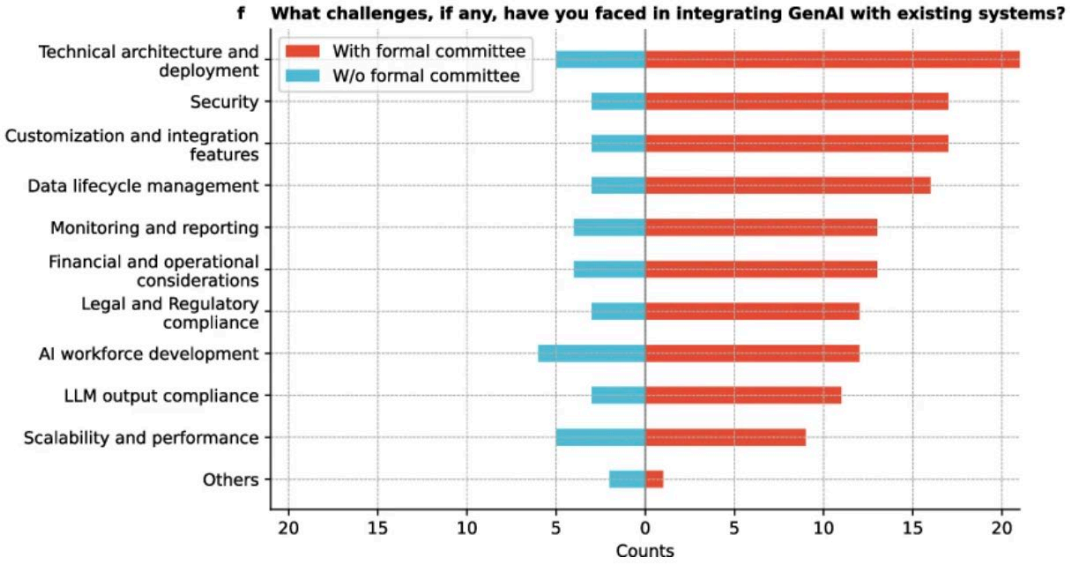
- These results highlight **broader challenges in evaluating AI systems** as they approach human-level performance in medicine, particularly in domains where expert disagreement is both common and clinically appropriate.

npj | health systems

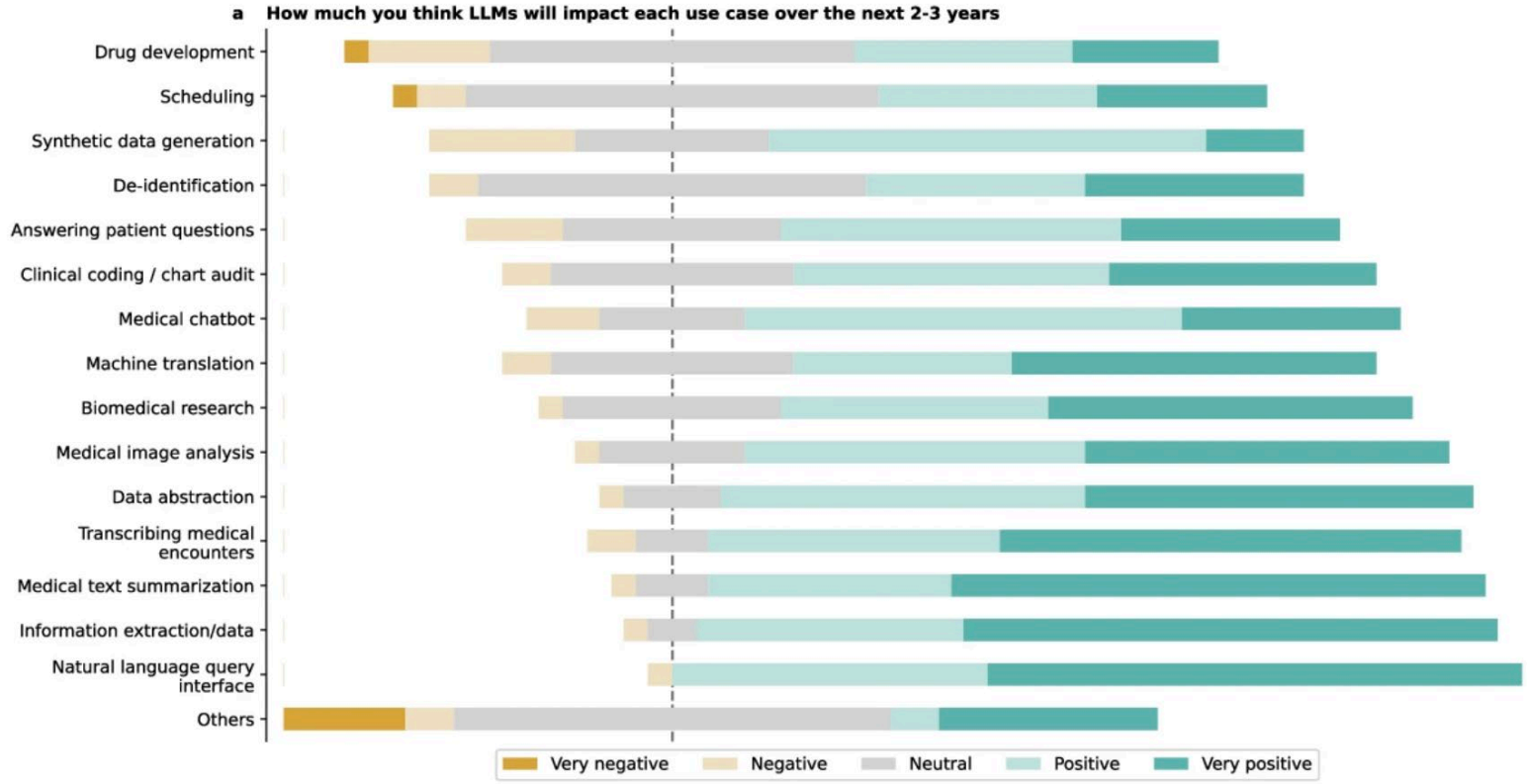
Environment scan of generative AI infrastructure for clinical and translational science

Betina Idnay, Zihan Xu, ... Yifan Peng + Show authors

npj Health Systems **2**, Article number: 4 (2025) | Cite this article



Scan of the generative AI (GenAI) infrastructure in the national network for clinical and translational science across 36 institutions supported by the CTSA Programs in the United States. Key findings indicate a diverse range of institutional strategies, **with most organizations in the experimental phase** of GenAI deployment.



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STRUCTURED DATA

CLASSify: A Web-Based Tool for Machine Learning

Aaron D Mullen [1], Samuel E Armstrong [1], Jeff Talbert [1], VK Cody Bumgardner [1]

AMIA Jt Summits Transl Sci Proc. 2024 May 31;2024:364–373.

Clustering: Tell me the things that are alike

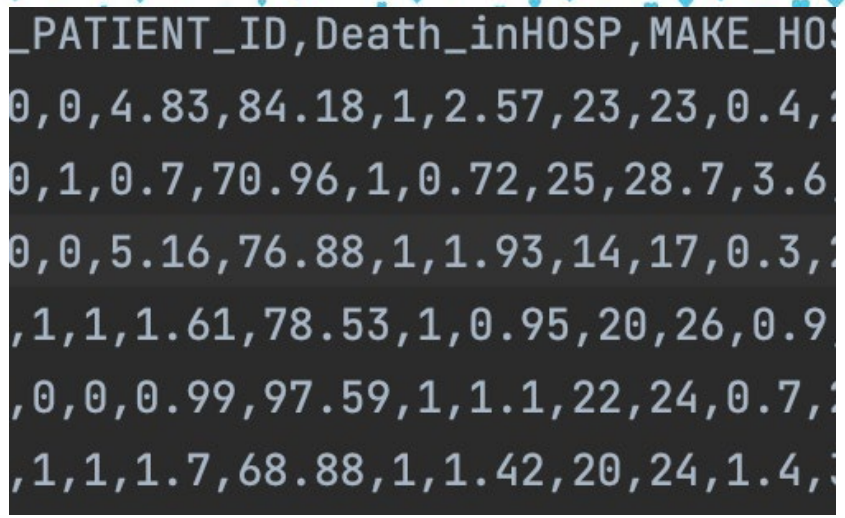
Data: Raw Data

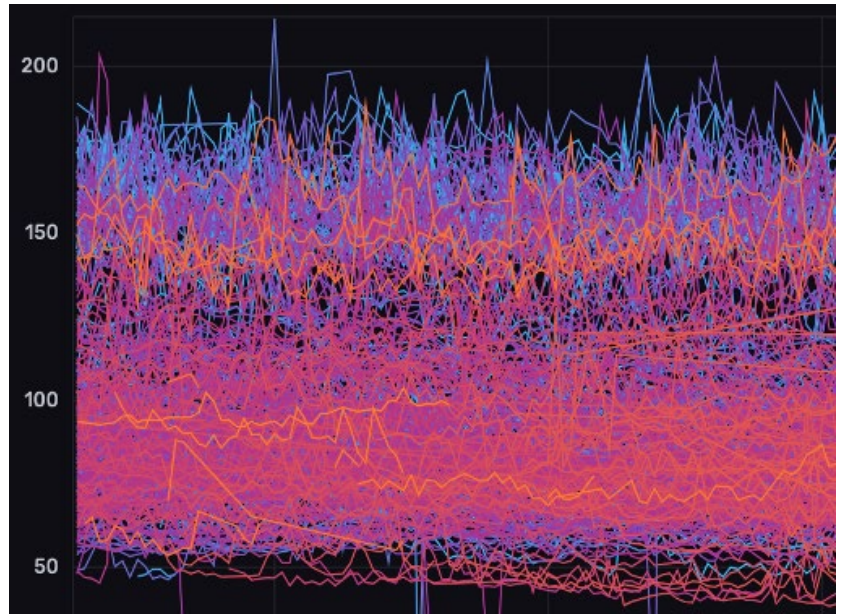
Classification/Regression: Based on some input tell me output

Data: Input data with a label

Forecasting: Based on some input now tell me the future output(s)

Data: Input data /w labels in respect to time





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COMPUTER VISION

Automated Curation and AI Workflow Management System for Digital Pathology

V K Cody Bumgardner [1], Sam Armstrong [1], Alexandr Virodov [1], Caylin Hickey

AMIA Jt Summits Transl Sci Proc. 2023 Jun 16;2023:71–80.

Detection: Find the green box

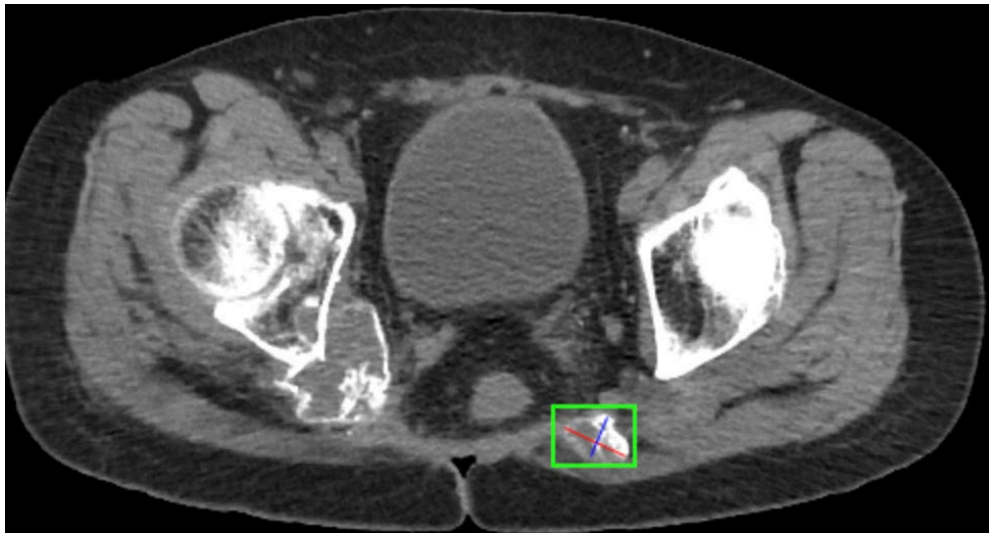
Data: Coordinates of boxes

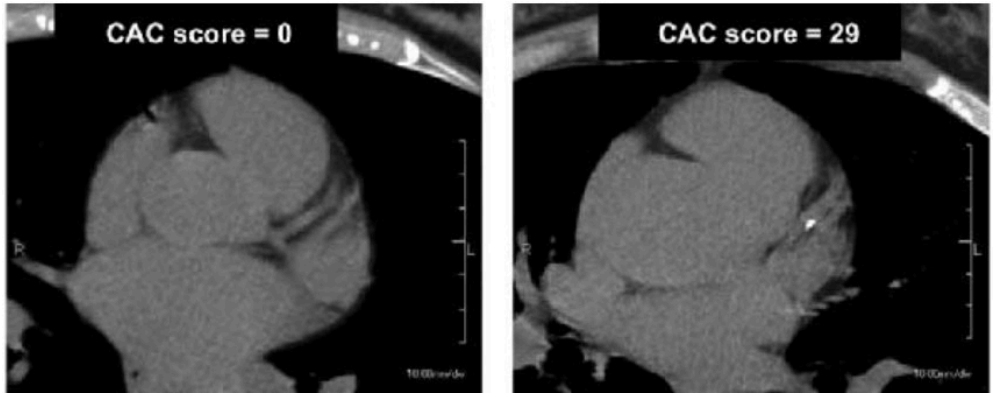
Classification: What is inside the green box

Data: Images with labels

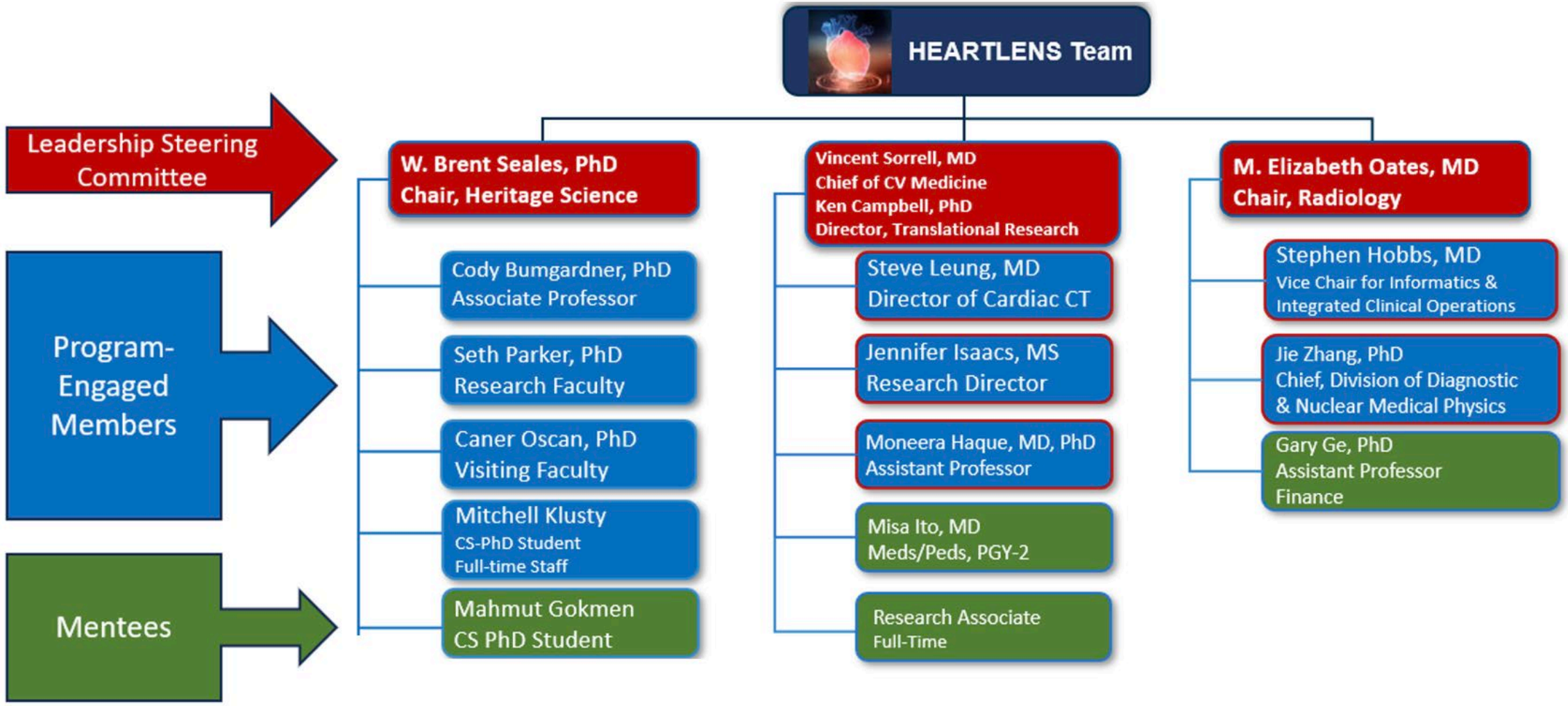
Measurement: Describe what is inside the green box

Data: Mask and measurements





HEARTLENS: CALCIFICATION ANALYSIS



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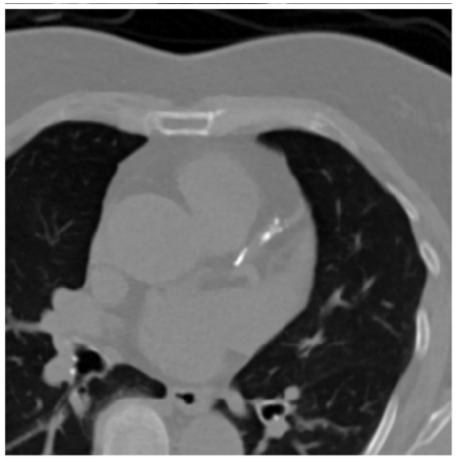
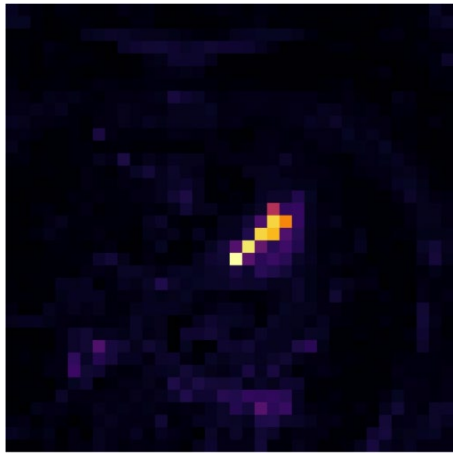
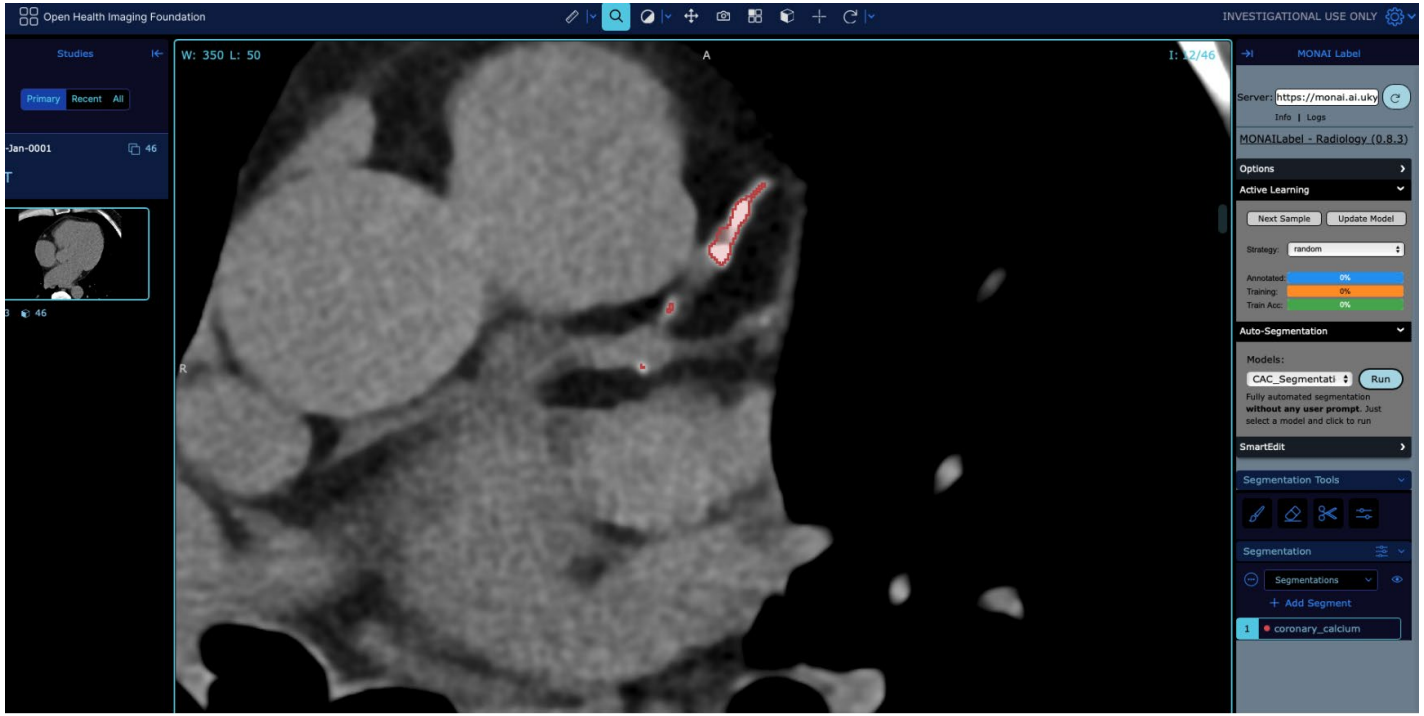
GATED CAC

Segmentation and scoring:

- UK (train) UK (test) 0.91%
- UK (train) Stanford (test): 0.91%







	Heartlens Test Set (Gated)			Stanford Test Set (Gated)		
CAC Score Range	**Precision**	**Recall**	**F1-score**	**Precision**	**Recall**	**F1-score**
0-10	0.98	0.93	0.95	0.94	0.82	0.88
11-100	0.84	0.88	0.86	0.91	0.90	0.90
101-400	0.84	0.86	0.85	0.85	0.91	0.88
400+	0.91	0.95	0.94	0.92	0.97	0.95
Overall Accuracy		0.910			0.91	
Total Cases		468			443	

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NON-GATED CAC SURPRISE

AI Opportunistic Coronary Calcium Screening at Veterans Affairs Hospitals

Authors: Raffi Hagopian, M.D. , Timothy Strebel, M.A.D.S. , Simon Bernatz, M.D. , Gregory A. Myers, M.A.D.S. , Erik Offerman, M.D. , Eric Zuniga, M.D., M.B.A. , Cy Y. Kim, M.D. , +9 , and Hugo J.W.L. Aerts, Ph.D. Author Info & Affiliations

Published May 16, 2025 | NEJM AI 2025;2(6) | DOI: 10.1056/AIoa2400937
VOL. 2 NO. 6 | Copyright © 2025

Heartlens (CARD-ViT) was trained on only gated data, the AI-CAC (ENJM) model was trained directly on a large corpus of non-gated data.

This is the power of foundational models

CAC Score Range	Method	Precision	Recall	F1-score
0-10	CARD-ViT	0.802	0.886	0.842
	AI-CAC[8]	0.800	0.876	0.836
11-100	CARD-ViT	0.500	0.439	0.468
	AI-CAC[8]	0.514	0.463	0.487
101-400	CARD-ViT	0.545	0.375	0.444
	AI-CAC[8]	0.542	0.406	0.464
400+	CARD-ViT	0.677	0.778	0.724
	AI-CAC[8]	0.724	0.778	0.750
Overall Accuracy	CARD-ViT		0.702	
	AI-CAC[8]		0.707	
Total Cases	CARD-ViT		205	
	AI-CAC[8]		205	

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https://ai.nejm.org/doi/full/10.1056/AIp2500709

NATURAL LANGUAGE PROCESSING

Local Large Language Models for Complex Structured Tasks

V K Cody Bumgardner [1], Aaron Mullen [1], Samuel E Armstrong [1], Caylin Hickey [1], Victor Marek [1], Jeff Talbert [1]

AMIA Jt Summits Transl Sci Proc. 2024 May 31:2024:105-114.

Classification/Sentiment Analysis:

Tell me what the text represents

Data: Text with a label

Entity extraction:

Tell me something specific about the text

Data: Text with entity labels

Procedure: A clinically unspecified (procedure) ; B partial colectomy (procedure) ; C clinically unspecified (procedure)

OMENTUM (location) (A): METASTATIC HIGH-GRADE CARCINOMA (condition)

(consistent with urothelial carcinoma)

COLON (location) (B): METASTATIC HIGH-GRADE CARCINOMA (condition)

(consistent with urothelial carcinoma) PERICOLONIC ADIPOSE TISSUE

(focally present at margin)

COLON (location) (C):

METASTATIC HIGH-GRADE CARCINOMA (condition)

(consistent with urothelial carcinoma) PERICOLONIC ADIPOSE

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GENERATIVE TEXT MODELS (LLM)

- Text generation became common after the release of BERT by Google in 2018 (e.g. Generate N tokens)
- Trained on huge volumes of data (reportedly GPT5 was trained on 70T tokens)
- Special tokens used to manage token generation

Training Data

CALPHURNIA
When beggars die there are no comets seen;
The heavens themselves blaze forth the death of princes.

CAESAR
Cowards die many times before their deaths;
The valiant never taste of death but once. Of all the wonders that I yet have heard, It seems to me most strange that men should fear,

Inference/Generation

text_generator(”Cowards die many times"), tokens=14)

[{'generated_text': ‘before their deaths, The valiant never taste of death but once'}]

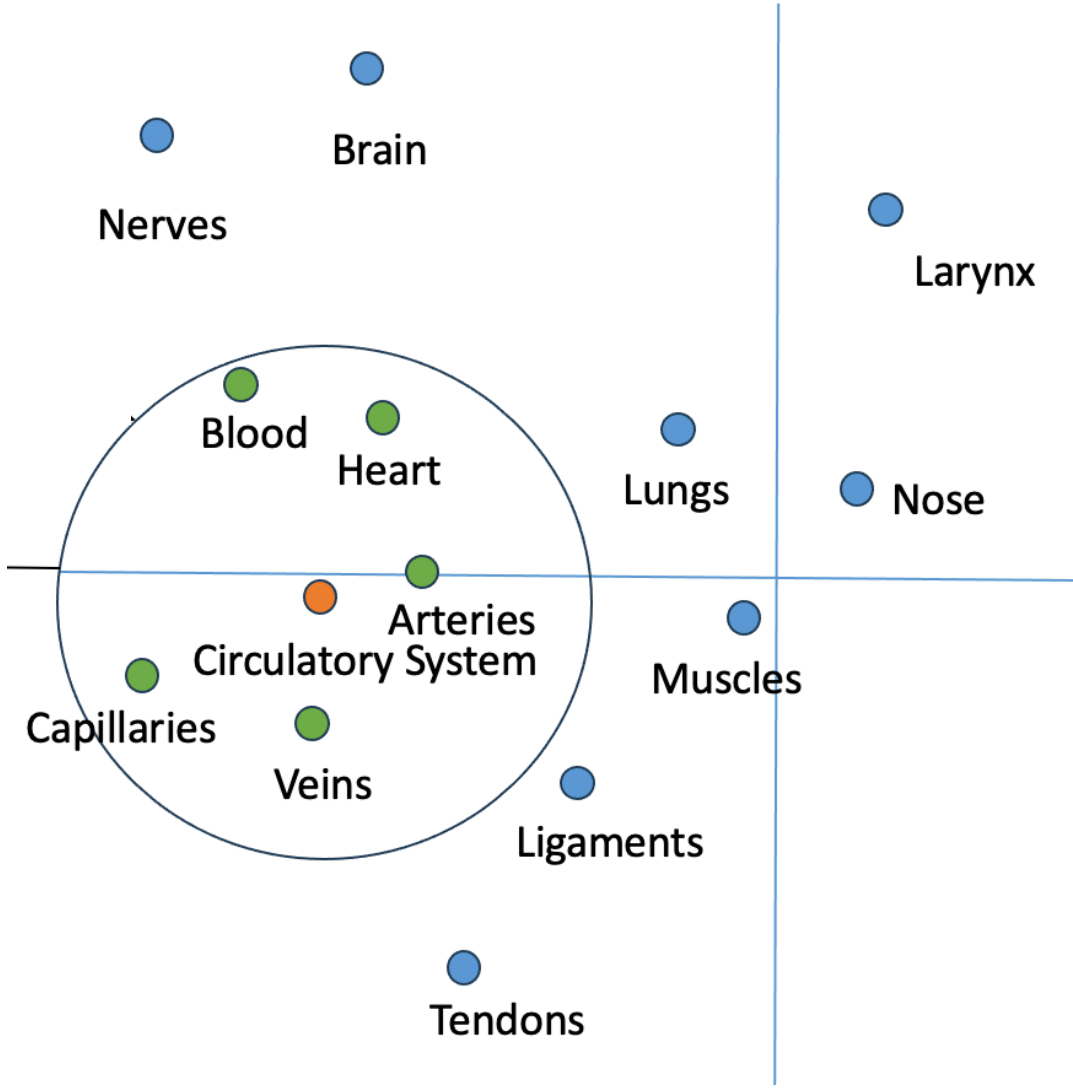
LANGUAGE MODEL TRAINING

Institutional Platform for Secure Self-Service Large Language Model Exploration

V K Cody Bumgardner [1], Mitchell A Klusty [1], W Vaiden Logan [1], Samuel E Armstrong [1], Caroline N Leach [1], Caylin Hickey [1], Jeff Talbert [1]

AMIA Jt Summits Transl Sci Proc. 2025 Jun 10:2025:105-114.

- Secure access to LLMs
  - HIPAA Compliance
  - Secure tunneling for communication
- Customized utilization of models
  - Retrieval Augmented Generation (RAG)
  - Tool Calling



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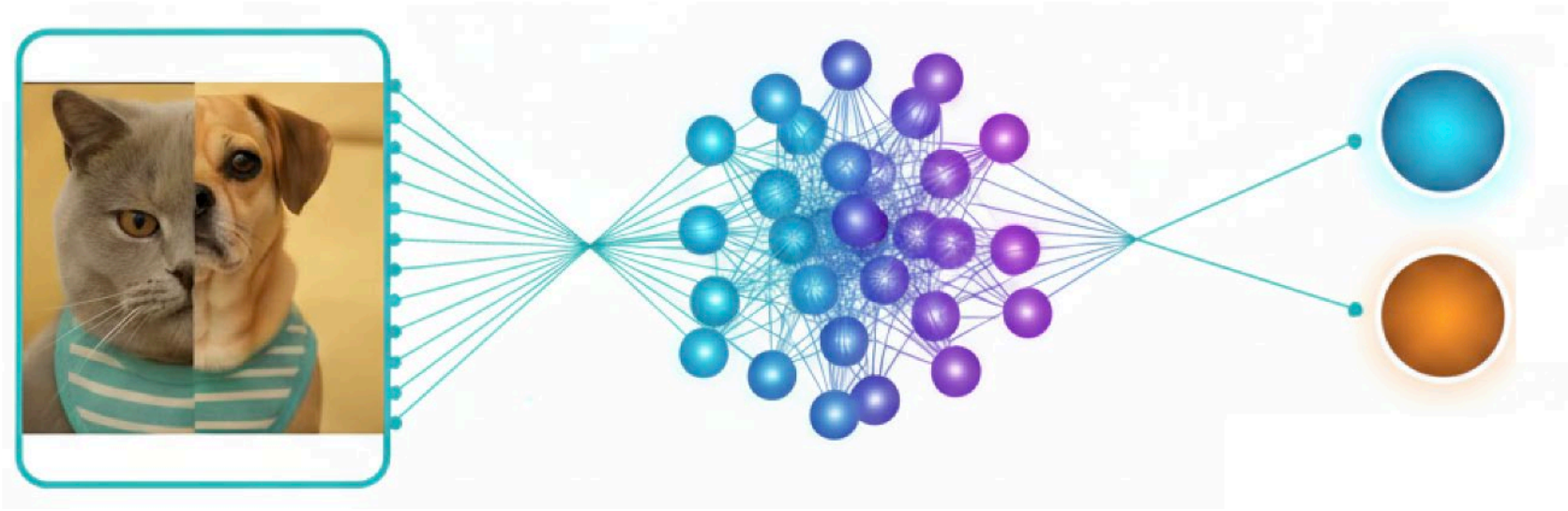
NARROW (DIAGNOSTIC) FOCUSED MODELS

Train: Image + Label Input
Inference: Image

Model

Binary Output



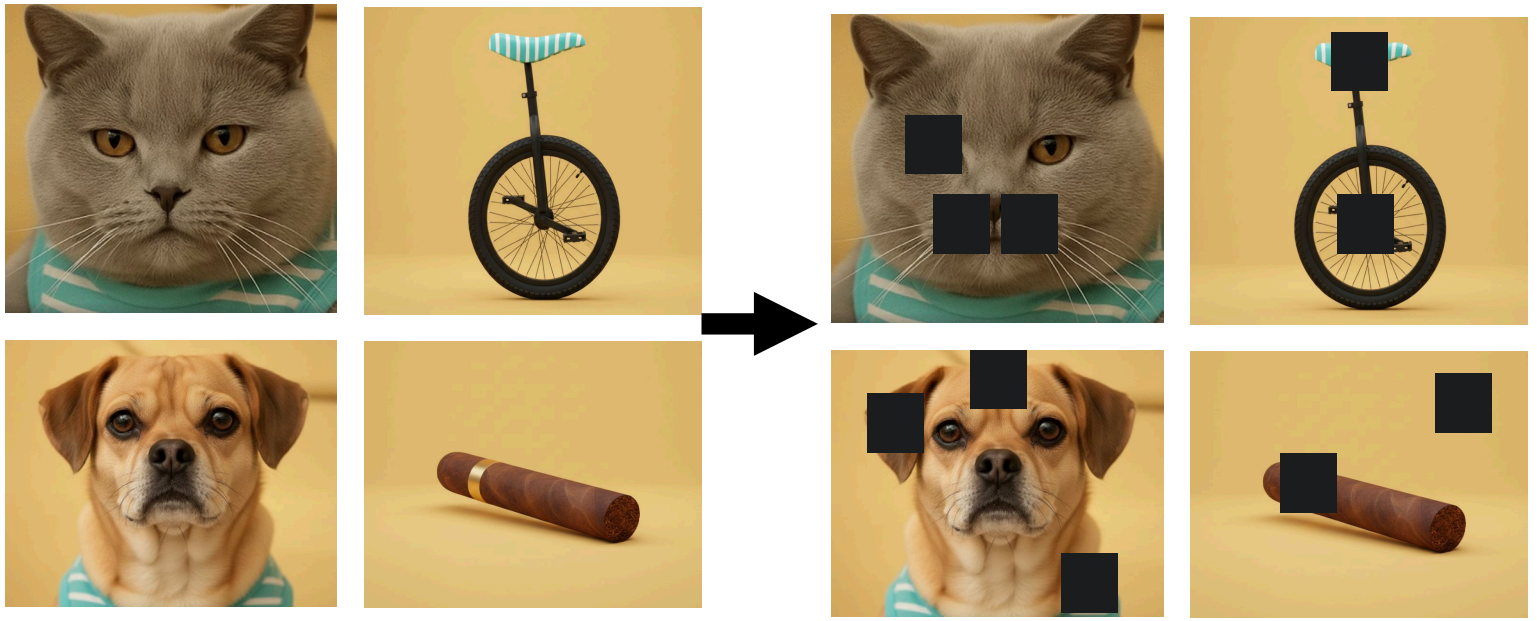
- **The model learns to differentiate between options, based on classes**
- **Not all problems can be distilled into classes**

FOUNDATIONAL MODELS

Train: Image
Inference: Image

Self-Supervision

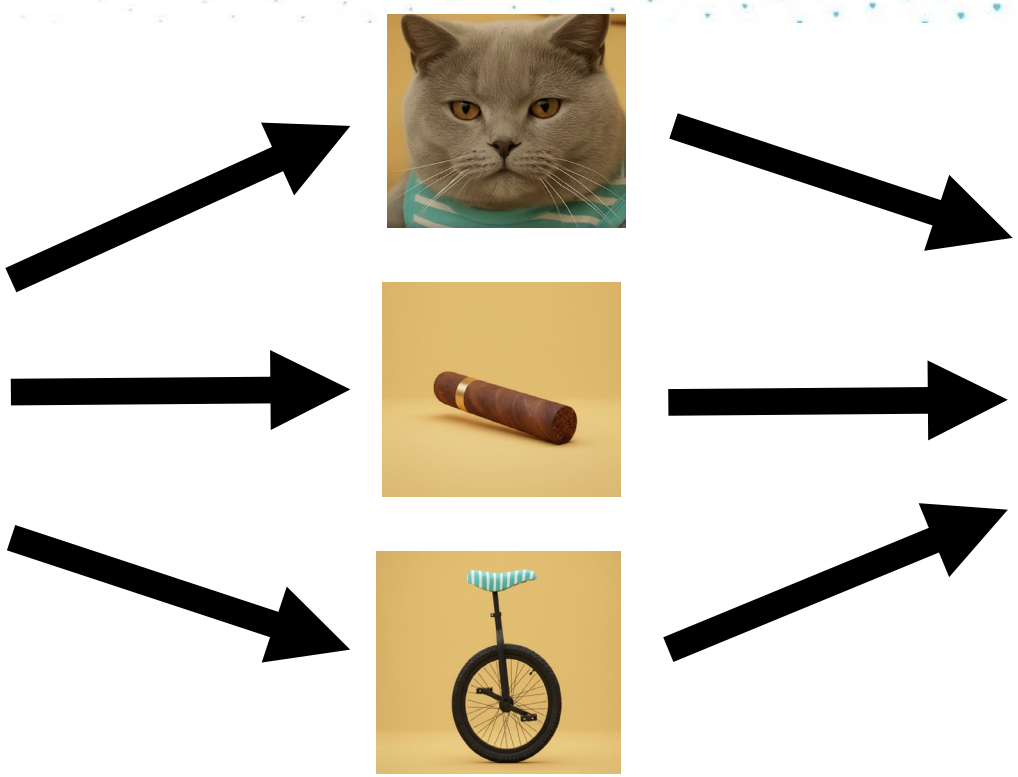
Vector Output



f_0	f_1	...	f_767
0.019998	-0.0219	0.52670592	0.098922
0.110704	-0.31142	-0.0074099	-0.06965
-0.20204	0.098922	0.01999803	-0.00741
0.526706	-0.20204	0.11070408	0.019998
-0.06965	0.019998	-0.0219024	-0.31142
-0.31142	-0.20204	0.11070408	0.526706
0.098922	-0.06965	-0.0219024	-0.20204

- **The model learns to describe data, resulting in numerical features**
- **Features can be used for binary problems with class labels**
- **Features can also be used for much more, with or without class labels**

FOUNDATIONAL MODELS



f_0	f_1	...	f_767
0.019998	-0.0219	0.52670592	0.098922
0.110704	-0.31142	-0.0074099	-0.06965
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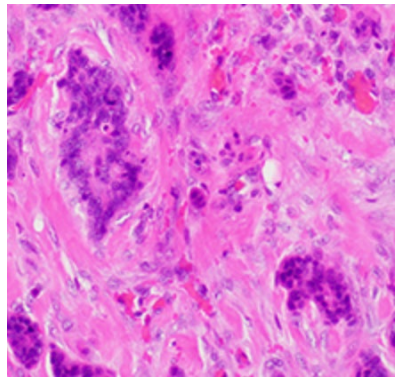
0.526706	-0.20204	0.11070408	0.019998
-0.06965	0.019998	-0.0219024	-0.31142
-0.31142	-0.20204	0.11070408	0.526706
0.098922	-0.06965	-0.0219024	-0.20204

- **Features are descriptions of data that the model has observed**
- **They are not like labels and can represent approximations of classes**
- **Models can describe complex combinations of features that have never been observed**

MULTI-MODAL LLMS: PUTTING IT TOGETHER

Inputs

- Text, imaging, timeseries (EKG, eICU), genomics, etc.
- Observe large volumes of data and provide numeric characterizations of inputs (Heart Disease, Cancer, Alzheimer's, etc. features)
- Allows us to holistically leverage medical data across disciplines



age	sex	race	alb	tlc	f_0	f_1	...	f_767
35	0	1	3.2	0.58	0.019998	-0.0219	0.52670592	0.098922
66	0	1	2.9	0.72	0.110704	-0.31142	-0.0074099	-0.06965
43	1	1	1.2	1.7	-0.20204	0.098922	0.01999803	-0.00741
68	1	1	3.3	0.91	0.526706	-0.20204	0.11070408	0.019998
40	1	1	1.6	1.12	-0.06965	0.019998	-0.0219024	-0.31142
27	1	1	3.7	2.02	-0.31142	-0.20204	0.11070408	0.526706
31	0	1	2.8	0.87	0.098922	-0.06965	-0.0219024	-0.20204

Case Data

Image + Genomic

FUTURE OF FOUNDATIONAL TRAINING

Self-Supervision: A Multi-Goal Domain-Specific Approach

We use a combination of learning objectives (loss functions) that work together to create a powerful and robust model. Each objective has a specific biological or data-centric purpose:

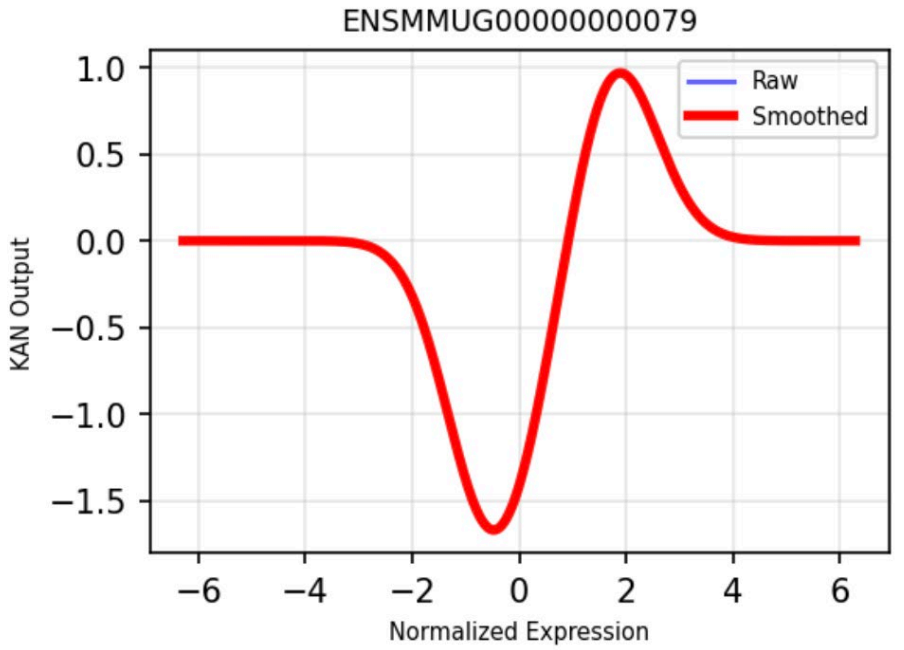
- **Reconstruction Loss (Alpha):** Preserves the core gene expression signature that defines a cell's fundamental identity.
- **Masked Prediction Loss (Beta):** Learns the relationships between genes by predicting missing ones, helping to overcome data sparsity and biological "dropouts."
- **Contrastive Loss (Gamma):** Organizes the cells by pushing representations of similar cells together and dissimilar cells apart, revealing the underlying biological structure.
- **Prototype Loss (Delta):** Identifies and solidifies distinct groups or populations of cells, which is analogous to discovering different cell types or states.
- **Leiden Pseudo-Label Loss (Epsilon):** Uses the natural clustering of cells (cell communities) to create self-generated labels, which refines the model's understanding of these groups.
- **Gram Loss (W_Gram):** Stabilizes the training process, ensuring the model builds upon its knowledge consistently without "forgetting" what it has already learned about cell biology.

--- Comprehensive Evaluation Report: Hybrid Embeddings ---

Metric	Current Value	Best So Far	Baseline (PCA)	vs. Baseline
k-NN Accuracy	0.7730	0.7788	0.7478	(+3.37%)
Silhouette Score	0.4466	0.4466	-0.1204	(+0.57 abs)
Adjusted Mutual Info (AMI)	0.6387	0.6398	0.3992	(+60.00%)
Significance-Adjusted ARI	0.5596	0.5596	0.1552	(+260.51%)

FUTURE: FROM BLACK TO GLASS BOX

- **The Goal: Transferring Knowledge**
  - We use a large, pre-trained "teacher" MLP to train a smaller, transparent "student" KAN model transferring the powerful patterns learned by the black-box MLP into an interpretable KAN architecture
- **The Result: True Explainability**
  - Visualize Relationships: We can simply plot a spline to see the exact, non-linear interaction the model has learned for any given gene
  - **Mathematically Explain**: Use curve fitting to find equation
- **The Discovery : Bi-phasic switch**
  - This gene acts as a concentration-dependent switch, inhibiting (from -4 to about 0.9) at low expression, and activating (from ~0.9 upwards), at high a behavior, functioning as a mathematically explainable regulatory mechanism



$$y = (e^x - 2.4199)e^{(x-0.3117)(-0.1128-0.4484x)}$$

CLOSING

- **AI in healthcare is about reducing the size of and complexity of information to a scale providers can interpret, and patients can understand**
- Where it is useful, AI in the broader sense, is and will continue to be used
- A shift from diagnostics to generative companions is taking place
- The global development, study, evaluation, and monitoring of domain-specific foundational models is a necessity in the advancement of AI
- Personal health assistants, both virtual and robotic, can inform and potentially physically assist

HealthCare
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Network

THANK YOU!

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