Why the Stage is Set for AI in Healthcare and Diagnostics

Ajit Singh, Ph.D.
Partner, Artiman Ventures

Professor, School of Medicine
Stanford University

Executive War College
New Orleans, May 1, 2024

what this presentation is not about

1. large language models

2. chatGPT in healthcare

five

vignettes

1. EWC 2018, 2021, 2024: some anecdotes
2. what trends do these anecdotes signal
3. myth vs reality: what is feasible today
4. what can AI do for you. some use cases
5. back to first principles to implement AI

1. **EWC 2018, 2021, 2024: some anecdotes**
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rewind to May 2018

EWC 2018

Top 10 AI Applications

	APPLICATION	VALUE*
	Robot-Assisted Surgery**	$40B
	Virtual Nursing Assistants	$20B
	Administrative Workflow Assistance	$18B
	Fraud Detection	$17B
	Dosage Error Reduction	$16B
	Connected Machines	$14B
	Clinical Trial Participant Identifier	$13B
	Preliminary Diagnosis	$5B
	Automated Image Diagnosis	$3B
	Cybersecurity	$2B

TOTAL = ~$150B

Algorithm better at diagnosing pneumonia than radiologists

November 16, 2017
by Taylor Kubota, Stanford University Medical Center

Radiologist Matthew Lungren, left, meets with graduate students Jeremy Irvin and Pranav discuss the results of detections made by the algorithm. Credit: L.A. Cicero/Stanford News

next, November 2021

EWC 2021

1.

PR Newswire

Roche announces collaboration with Ibex Medical Analytics to develop artificial intelligence-based digital pathology applications for improved patient care

Roche

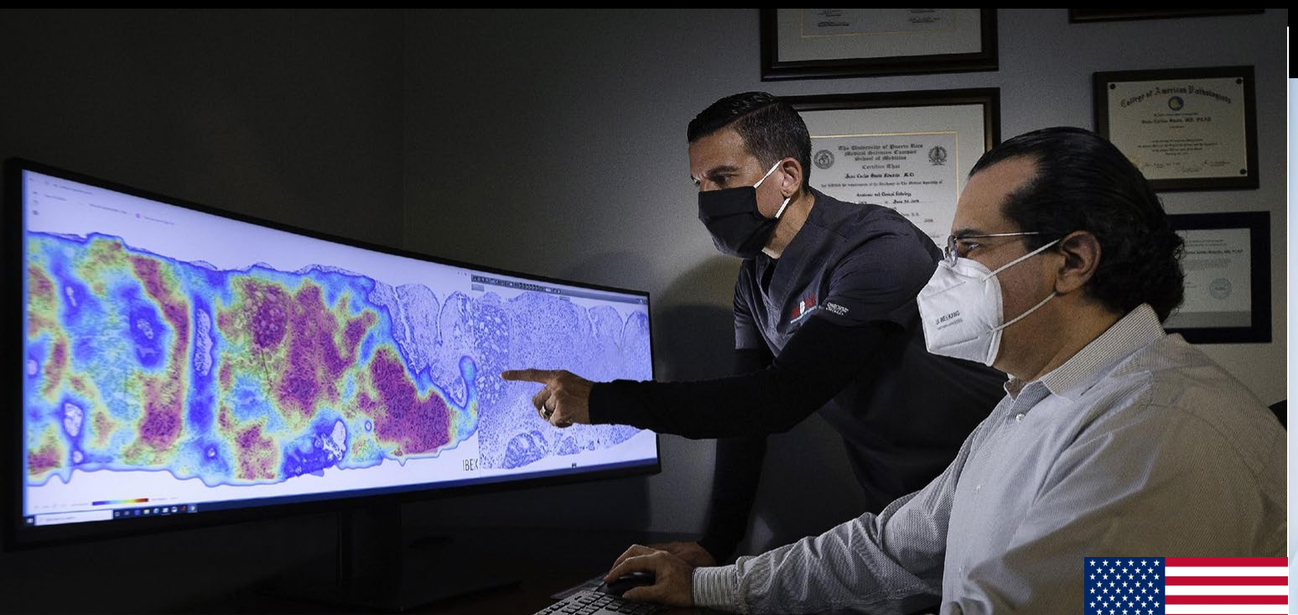
PR Newswire

Ibex Medical Analytics Raises $38 Million to Accelerate Adoption of AI-powered Cancer Diagnostics in Pathology

USA - English

Ibex's AI technology helps physicians and providers diagnose cancer with greater real-time accuracy by reducing error and misdiagnosis

IBEX



CORE PLUS
SPECIALTY PATHOLOGY SERVICES

- 1st lab in US for routine AI
- 100% AI: Prostate & Breast

LDPATH
LONDON DIGITAL PATHOLOGY

- 1st lab in UK for routine AI
- AI QC & AI Audits for Prostate

MEDIPATH
Médecins pathologistes indépendants

- Deployed network wide
- 100% AI: Prostate & Breast

Maccabi
The Best Healthcare in Israel

- 1st lab in World w/ AI QC
- 100% AI: Prostate & Breast

Prostate

Breast

Maccabi
The Best Healthcare in Israel

AUC	SPEC	SENS	# cases
0.99	96%	98%	3,466

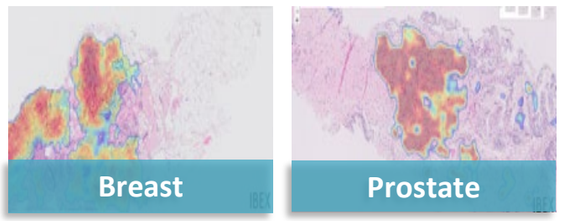
Invasive cancer

AUC	SPEC	SENS	# cases
0.99	98%	99%	1,129

DCIS

AUC	SPEC	SENS	# cases
0.99	97%	98%	951

First-ever cancers diagnosed by AI in a live clinical setting

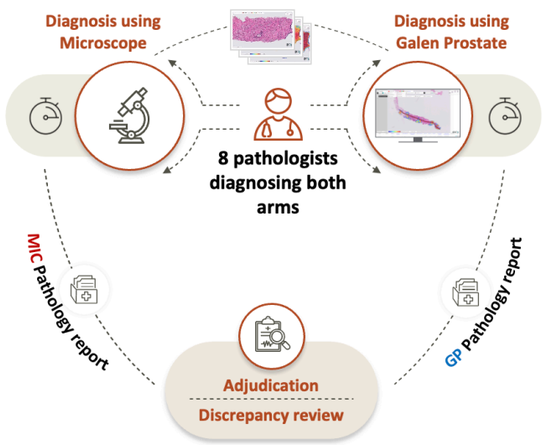


MEDIPATH
Médecins pathologistes indépendants

AUC	SPEC	SENS	# slides
0.99	97%	99%	1,142

Identified 12% missed cancers

Measured 37% productivity gains



UPMC
LIFE CHANGING MEDICINE

AUC	SPEC	SENS	# slides
0.99	98.5%	97%	1,627

3 missed cancers
15 diagnostic/grading errors

Blinded Independent test	
Test	**Performance**
Cancer	AUC = 0.99
G7+	AUC = 0.94
G5	AUC = 0.97
Perineural	AUC = 0.96
Cancer size	Correlation = 0.88

THE LANCET
Digital Health

CE IVD

AUC	SPEC	SENS	# slides
0.997	95.6%	98.6%	860

AUC	SPEC	SENS	# slides
0.991	93.5%	96.3%	829

Multi lab

Multi scanner

Multi pathologist

AUC = 0.9973

Remarkable accuracy for Artificial Intelligence in Pathology

Viewpoint | Innovations in Health Care Delivery

December 13, 2016

Adapting to Artificial Intelligence

Radiologists and Pathologists as Information Specialists

Saurabh Jha, MBBS, MRCS, MS[1]; Eric J. Topol, MD[2]

» Author Affiliations

JAMA. 2016;316(22):2353-2354. doi:10.1001/jama.2016.17438

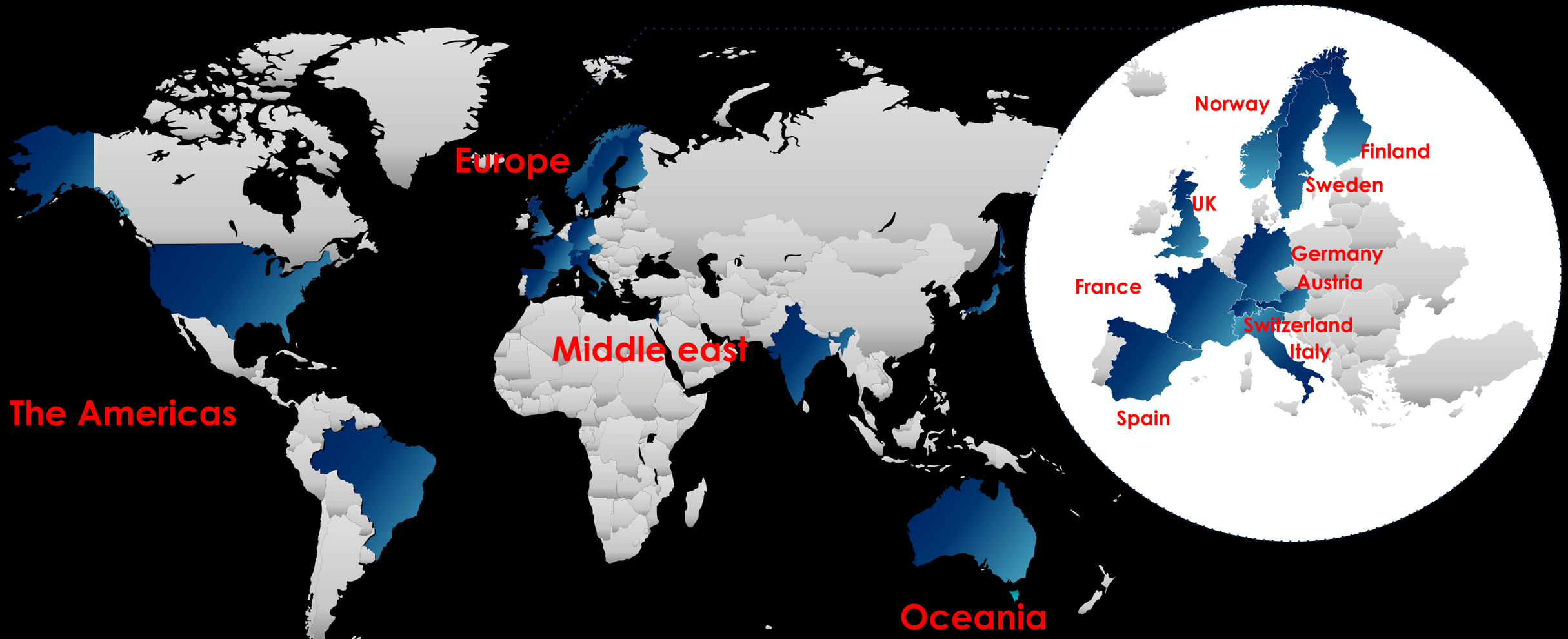
Editorial Comment

Artificial intelligence—the mimicking of human cognition by computers—was once a fable in science fiction but is becoming reality in medicine. The combination of big data and artificial intelligence, referred to by some as the fourth industrial revolution,[1] will change radiology and pathology along with other medical specialties. Although reports of radiologists and pathologists being replaced by computers seem exaggerated,[2] these specialties must plan strategically for a future in which artificial intelligence is part of the health care workforce.

and now, May 2024

EWC 2024

…over 50 installations globally



let’s go back to May 2018

EWC 2018

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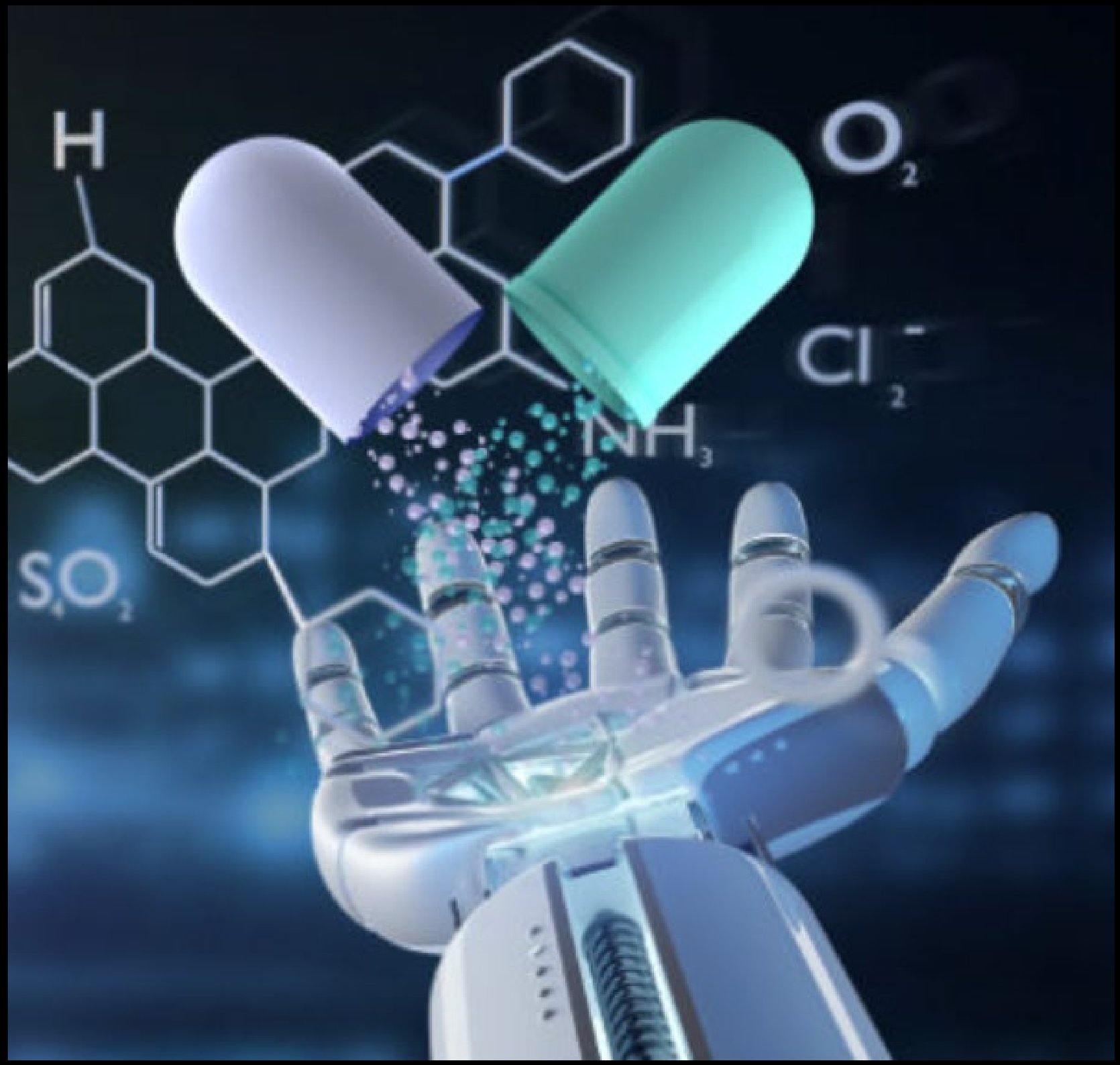
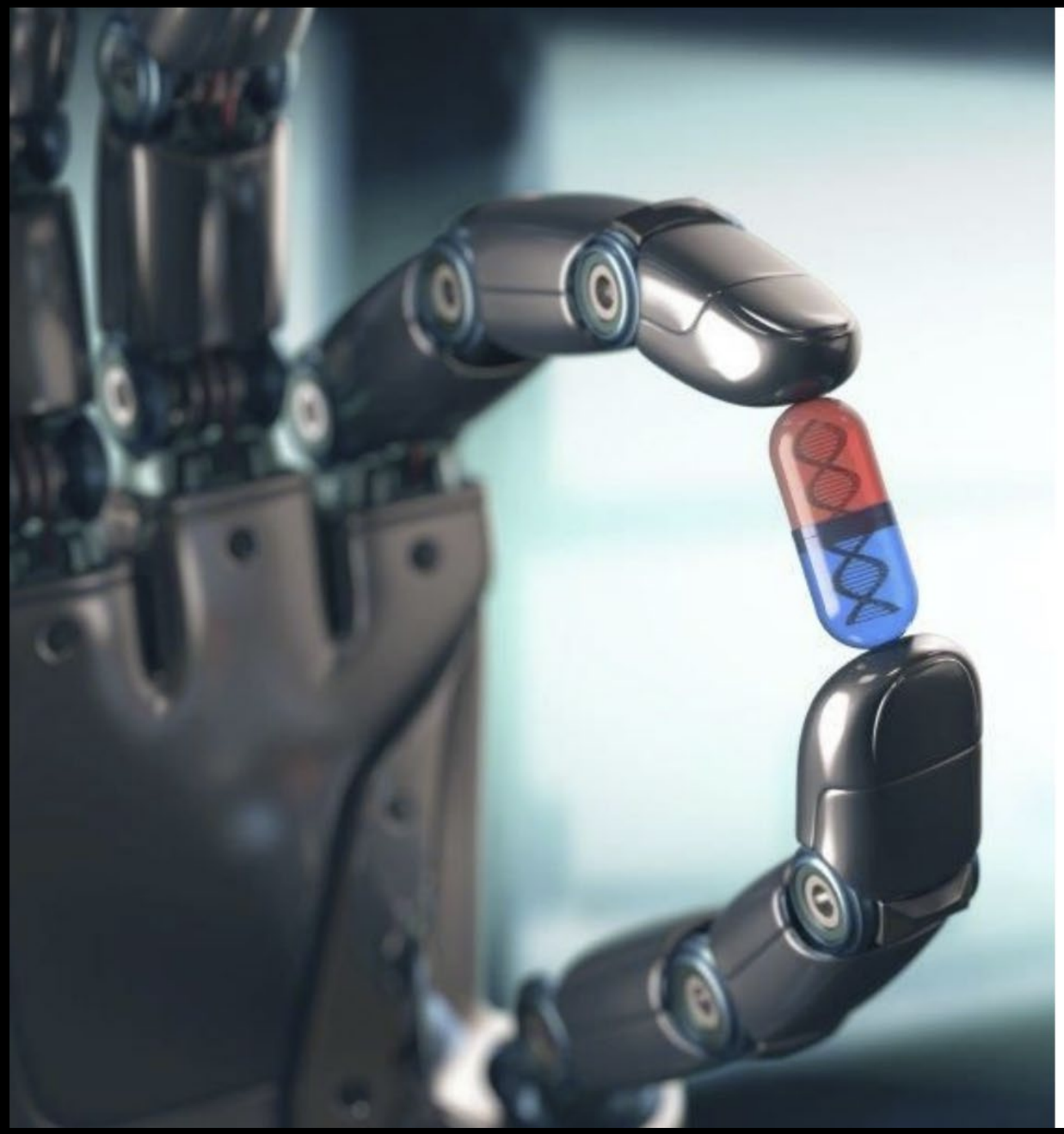


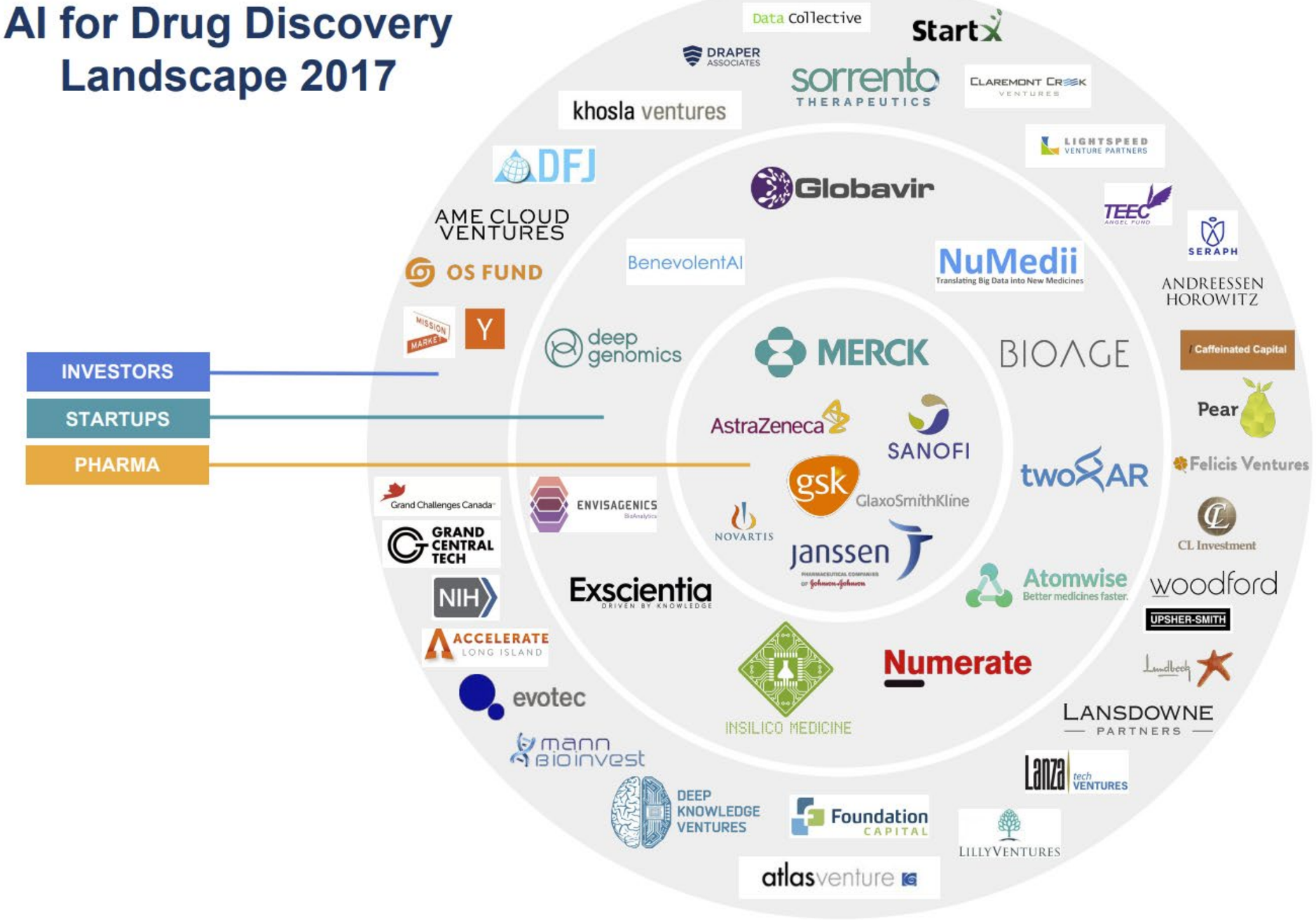


AI for Drug Discovery Landscape Overview 2017

www.dkv.global

DEEP KNOWLEDGE VENTURES

AI for Drug Discovery Landscape 2017



next, November 2021

EWC 2021

3.

Lantern Pharma's Proprietary A.I. Platform for Precision Oncology Drug Development, RADR®, Surpasses 10 Billion Datapoints - Significantly Enhancing Precision Medicine Capabilities & Expanding Potential for Biopharma Collaborations and Partnerships

- Represents a 10-fold increase in the number of datapoints from one year ago, November 2020, and a 37-fold increase since the June 2020 IPO

- Accelerates the discovery of new indications for Lantern's existing drug candidates, as well as the identification of new drug candidates and combination therapies

- Data growth was largest in bladder, pancreatic, brain and blood cancers

Global AI In Pharma Market Report 2021

Research and Markets

Tue, November 2, 2021, 9:53 AM · 6 min read

Dublin, Nov. 02, 2021 (GLOBE NEWSWIRE) -- The market is expected to grow by $9.14 billion according to the "AI In Pharma Global Market Opportunities and Strategies to 2030: COVID-19 Growth and Change" report that has been added to **ResearchAndMarkets.com's** offering.

The global AI in pharma market reached a value of nearly $699.3 million in 2020, having increased at a compound annual growth rate (CAGR) of 31.8 % since 2015. The market is expected to grow from $699.3 million in 2020 to $2,895.5 million in 2025 at a rate of 32.9%. The market is then expected to grow at a CAGR of 25.9% from 2025 and reach $9,142.7 million in 2030.

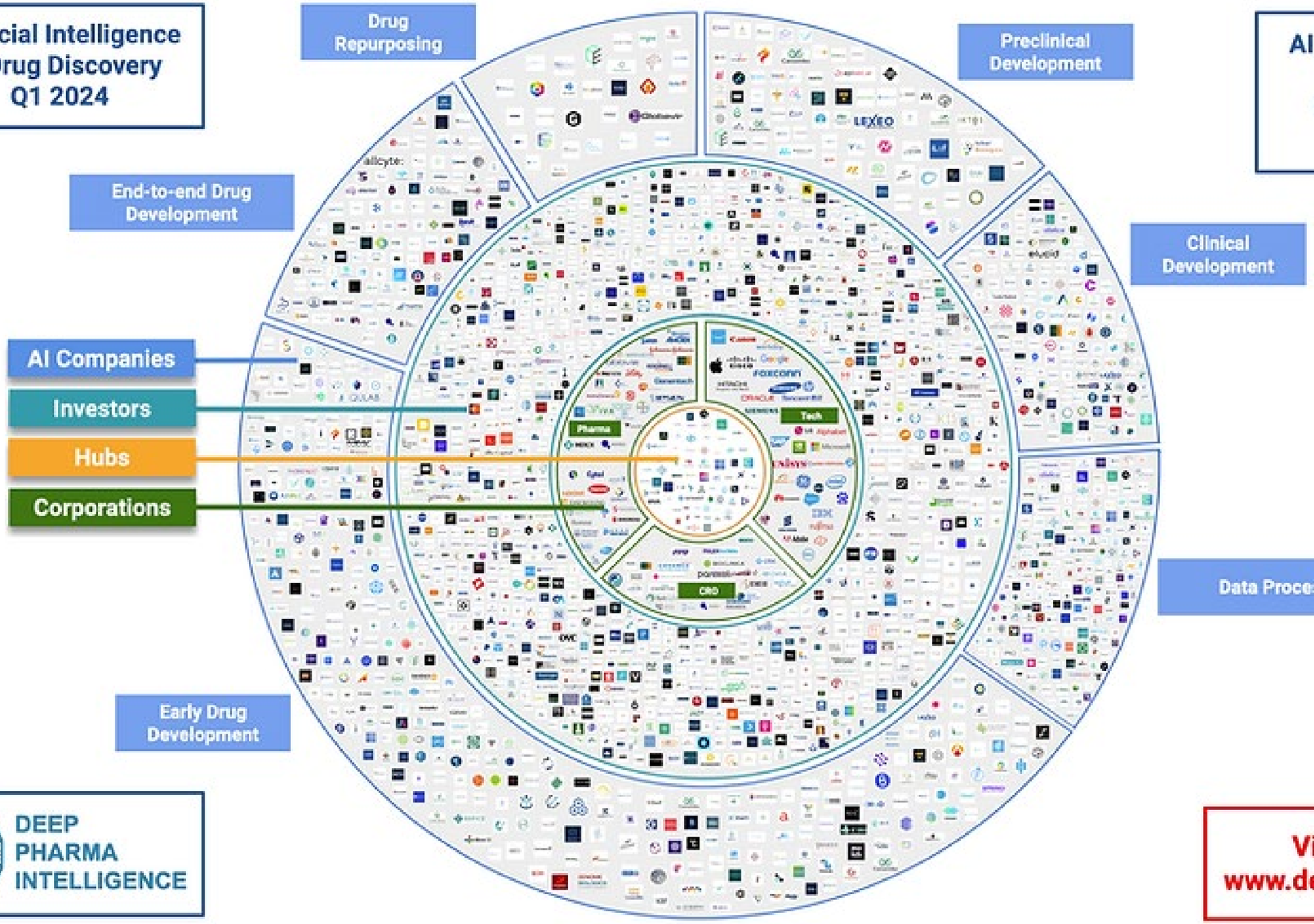
and now, May 2024

EWC 2024

Artificial Intelligence In Drug Discovery Q1 2024

Beta Version

AI Companies — 950
Investors — 2,100
Corporations — 90
Hubs — 50



DEEP PHARMA INTELLIGENCE

View More at www.deep-pharma.tech

Artificial I
In Drug I
Q1 :

AI

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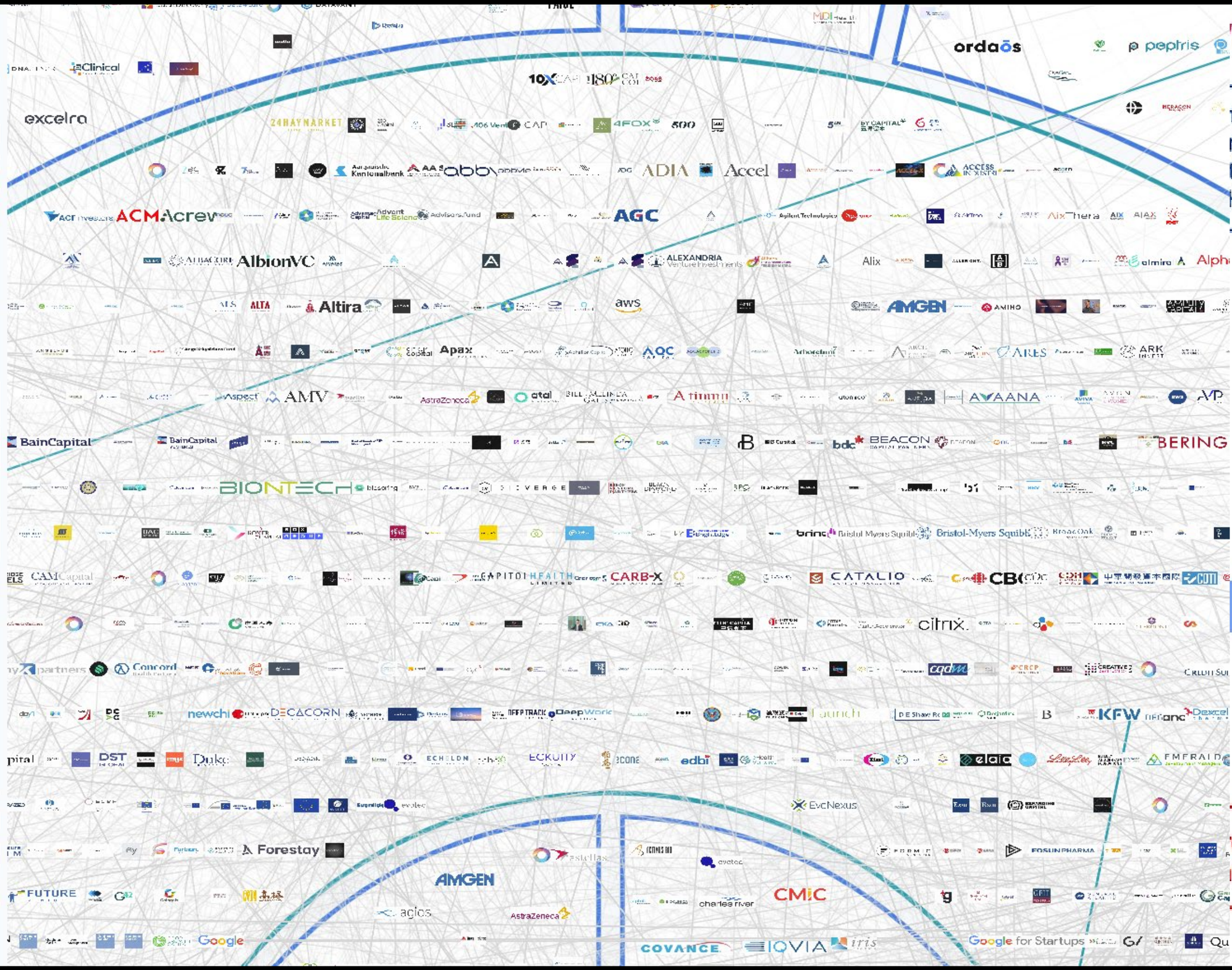

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first, some

caution

the plural of

anecdote

is not trend

AI in Healthcare - Summary (1/2)

Top Companies

- **Medidata** (1999, United St.., $21.5M)
- **GE Healthcare** (1892, United St.., $29.1M)
- **HealthTap** (2010, United St.., $37.9M)
- **Modernizing Medicine** (2010, United St.., $329M)
- **EXL** (1999, United St.., $10.0M)
- **CitiusTech** (2005, United St.., $112M)
- **Wellframe** (2011, United St.., $45.1M)
- **Innovaccer** (2014, United St.., $228M)

Key Stats

5,755 Companies

2,412 Funded Companies

$30.8B Total Funding

$17.0B Funding in last 2 years

149 Acquisitions

45 IPOs

Scope of Feed

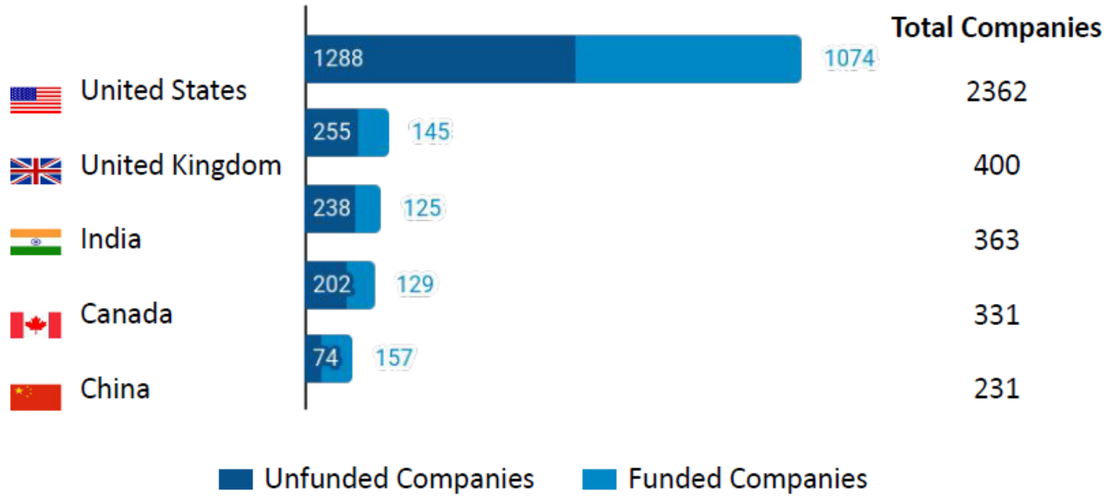
What is included

AI-enabled solutions including IoT devices, apps, software with applications across the entire Healthcare industry including Life Sciences, Healthcare Services, and Consumer Health

What is not included

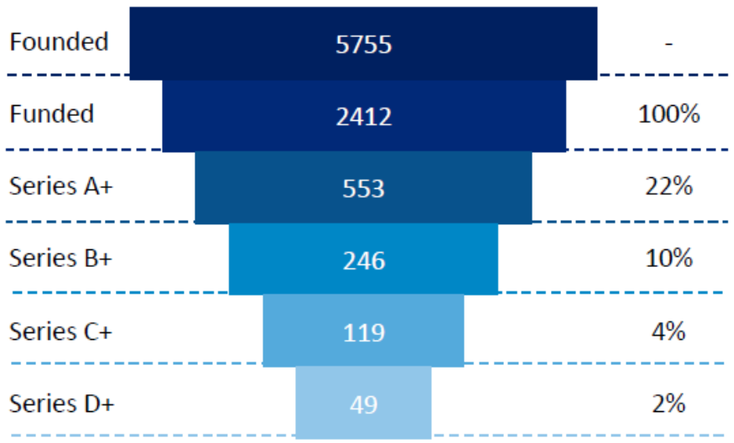
Healthcare Analytics companies working with big data without using any AI tools. Healthcare outsourcing companies offering custom app development, consultancy, etc. focused on AI, and labs and research institutes are also excluded.

Top Geographies by Companies



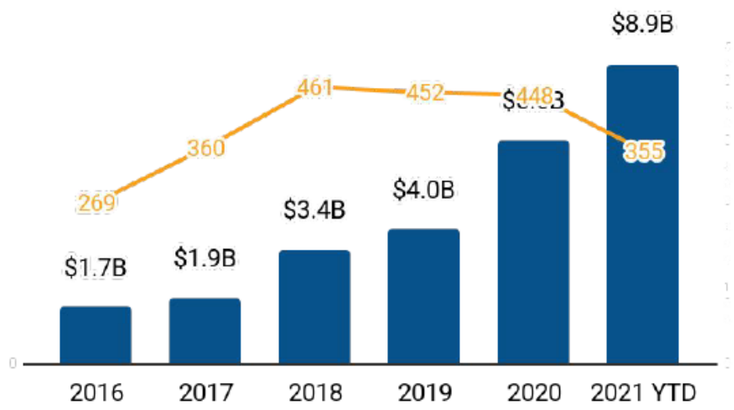
AI in Healthcare - Summary (2/2)

Companies by Stage

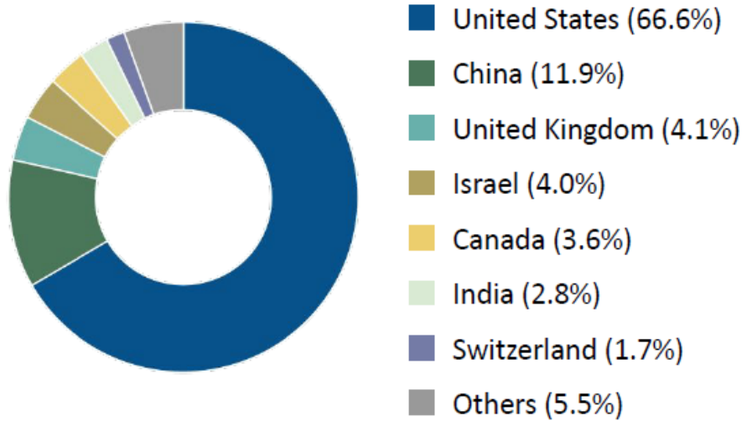


Y-o-Y Funding

Total Funding: $30.8B



$ Funding by Country



Top Funding Rounds in last 2y

Company	Round Details
Insitro (2018, United States, $643M)	$400M-Series C
XtalPi (2014, United States, $785M)	$400M-Series D
Olive (2012, United States, $902M)	$400M-Series H
XtalPi (2014, United States, $785M)	$319M-Series C
Workrise (2015, United States, $750M)	$300M-Series E

Top Investors

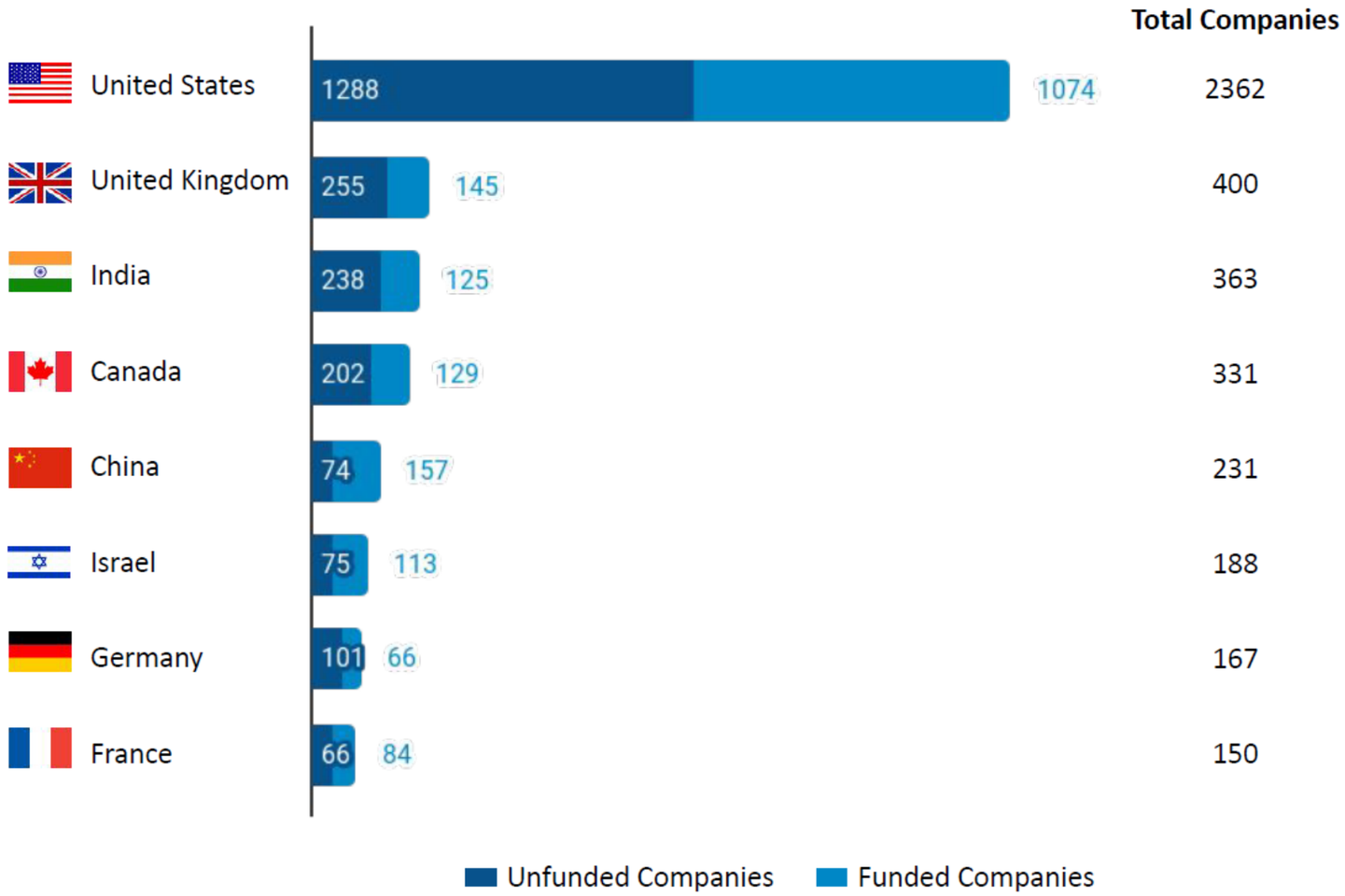
Stage	Investor	# Portfolio
Seed Stage	Plug and Play Tech C..	35
	Y Combinator	31
	MassChallenge	30
Early Stage	Plug and Play Tech C..	30
	Y Combinator	15
	StartX	14
Late Stage	Deep Learning	10
	Sequoia Capital	9
	Founders Fund	6

Top Exits

Type	Company	Acq. Price/IPO Mcap
Acq.	Medidata (1999, United States, $21.5M)	$5.8B
	IMS Health (1954, United States)	$5.2B
	Cotiviti (1979, United States)	$4.9B
	Siemens Healthineers,siemens-healthineers.com,58de1c7fe4b0d836de6c3a7a,1McRwVn4j759Br676lfdwf7ayWECIEF	

Companies by Geography

Distribution by Country - Companies founded



Top Cities by Companies founded

San Francisco	206
New York City	188
London	181
Toronto	118
Bangalore	118
Cambridge	100
Boston	88
Tel Aviv	85
Singapore	83
Paris	75

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data

(lots of it)

a. Availability of enough data

b. Availability of enough data that covers enough “corner cases”

c. Systemic way to address corner cases (and not “sweep them under the rug”)

d. Systemic elimination of bias – especially at the stage of hypothesis formation

e. Effective selection of use cases to fit the system accuracy and not the other way around.


K ST NW
1100
Google
6HCM166
Google
self-driving car


EXIT
400 B
Palo Alto
NEXT 3 EXITS
6VVE262

The A-List: Things a car needs to be autonomous

Vision-based smart sensor
Smart sensor detects vehicles, pedestrians and other objects for sensor fusion, a software that combines data from several sensors.

Front Lidar*
A 16-layer, 3D Lidar* sensor scans the area within a 100m radius for real-time vehicle localisation using the 3D map created.

High-sensitivity camera
Front-facing mono camera vision sub-system detects and classifies objects of interest for sensor fusion, and extracts important information encoded in the objects' textures (eg., traffic light, traffic signs).

Top Lidar*
A 64-layer, 3D Lidar* sensor on the roof scans the area within a 120m radius for the creation of a 3D map and the environment perception, including the detection of vehicles, pedestrians and kerbs.

GPS antenna
A sensor provides the geo-referenced position of the autonomous vehicle up to the centimetre accuracy in real-time kinetic mode.

Rear radar

Lidar* for 360° object detection

Distance measurement instrument (DMI)
A wheel-speed sensor mounted on the left rear wheel measures the distance travelled by the autonomous vehicle and helps to provide its position on the map accurately.

Front radar
Sensors with two detection ranges – mid and long. Mid-range detection covers 60m in front and has a field of view (FOV) of 45 degrees. It is useful for tracking vehicles cutting in from adjacent lanes and identifies pedestrians crossing in front of the vehicle. Long-range detection covers 174m and has a smaller FOV, of 10 degrees. It is used to maintain a safe distance when cruising.

Lidar* for 360° object detection
Six 8-layer laser scanners combine into a single sub-system to deliver 360-degree coverage and perception of dynamic objects and static obstacles with precise distance measurements.

Inertial measurement unit (IMU)
An inertial sensor, including a 3-axis accelerometer and a 3-axis gyrocope, provides the position and orientation of the vehicle by integrating their measurements over time.

NOTE: *Lidar: Light detection and ranging Source: INSTITUTE FOR INFOCOMM RESEARCH, AGENCY FOR SCIENCE, TECHNOLOGY AND RESEARCH ST GRAPHICS

and sensor data (camera, lidar, etc.) of

2 million miles

only to reach the current capability

# of Google car

(the one you would not like to be stuck behind)

it will take sensor data from

30 million miles

to reach human-like capability

that human drivers are able to achieve in

30,000 miles

why?

humans are able to apply

50+ million years

of learning in pattern-matching

(that’s the power of evolution at work)

let’s extrapolate the self-driving car learning to

breast cancer

diagnosis and therapy selection

how many patients' / healthy people's

correlated data

will we need

seven billion

(that’s almost the entire human population on planet earth)

more importantly

simply

replicating

human knowledge

by learning from humans is a

bad idea

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success factors

1. low dimensionality
2. high Negative Predictive Value
3. initial goal should not to build a system that will be better than the super expert. That's unrealistic.
4. rather, focus on situations where access to experts is a challenge.
5. learn from experts. help non-experts

dichotomy

modeling and capturing

EXISTING

knowledge and making it available

modeling and learning

NET NEW

knowledge to improve human performance

successes

modeling and capturing EXISTING knowledge and making it available

arrhythmia recognition from electrocardiograms

coronary heart disease risk group detection

monitoring prescription of restricted use antibiotics

early melanoma diagnosis

breast cancer diagnosis

promising

CELLWORKS

oncology therapy selection

GENXSYS

decision support for GP

SECONDOPINIONS.COM

radiology second opinion

modeling and learning

NET NEW

knowledge to improve human performance

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2. what trends do they signal
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4. what can AI do for you
5. what can you do for AI

data

a. availability of enough data

b. availability of enough data that covers enough “corner cases”

c. systemic way to address corner cases (and not “sweep them under the rug”)

d. systemic elimination of bias – especially at the stage of hypothesis formation

e. effective selection of use cases to fit the system accuracy and not the other way around.

1. **Low dimensionality**
2. **High Negative Predictive Value**
3. **Initial goal should not to build a system that will be better than the super expert. That's unrealistic.**
4. **Rather, focus on situations where access to experts is a challenge.**
5. **Learn from experts. Help non-experts**

the differences between us and them

emotion
understanding
consciousness
creativity
empathy

the race is on. we need to stay ahead

www.artiman.com