



The Expanding Role of Artificial Intelligence in Oncology

A presentation for HealthTrust
Members
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Conflicts of Interest

- The presenter has no relevant financial relationships with ineligible companies to disclose
- None of the planners for this educational activity have relevant financial relationships to disclose with ineligible companies whose primary business is producing, marketing, selling, re-selling, or distributing healthcare products used by or on patients

Objectives

1. Recall the three main components of artificial intelligence (AI) including machine learning, neural networks, and deep learning

2. Identify the five "Vs" of big data

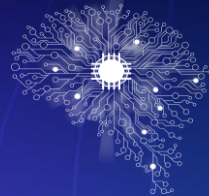
3. Recognize the clinical impact of AI in various cancer types



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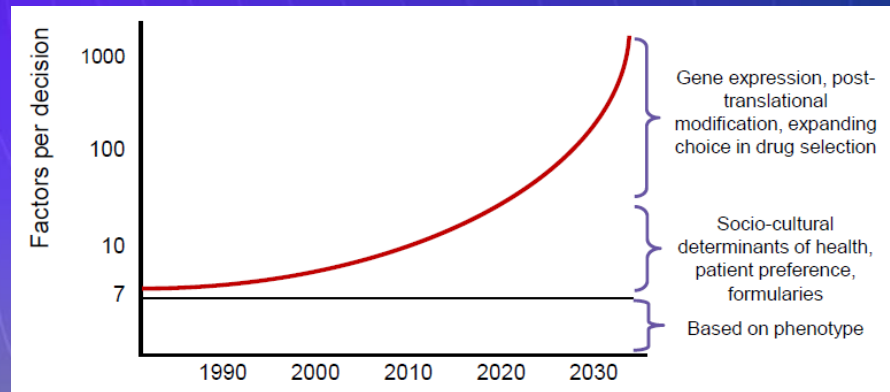
01

What is AI?



Why?

Human cognitive capacity is 7 ± 2



Adapted from William Stead



What is AI?

AI describes a computer system's ability to perform a task that would normally require human cognition

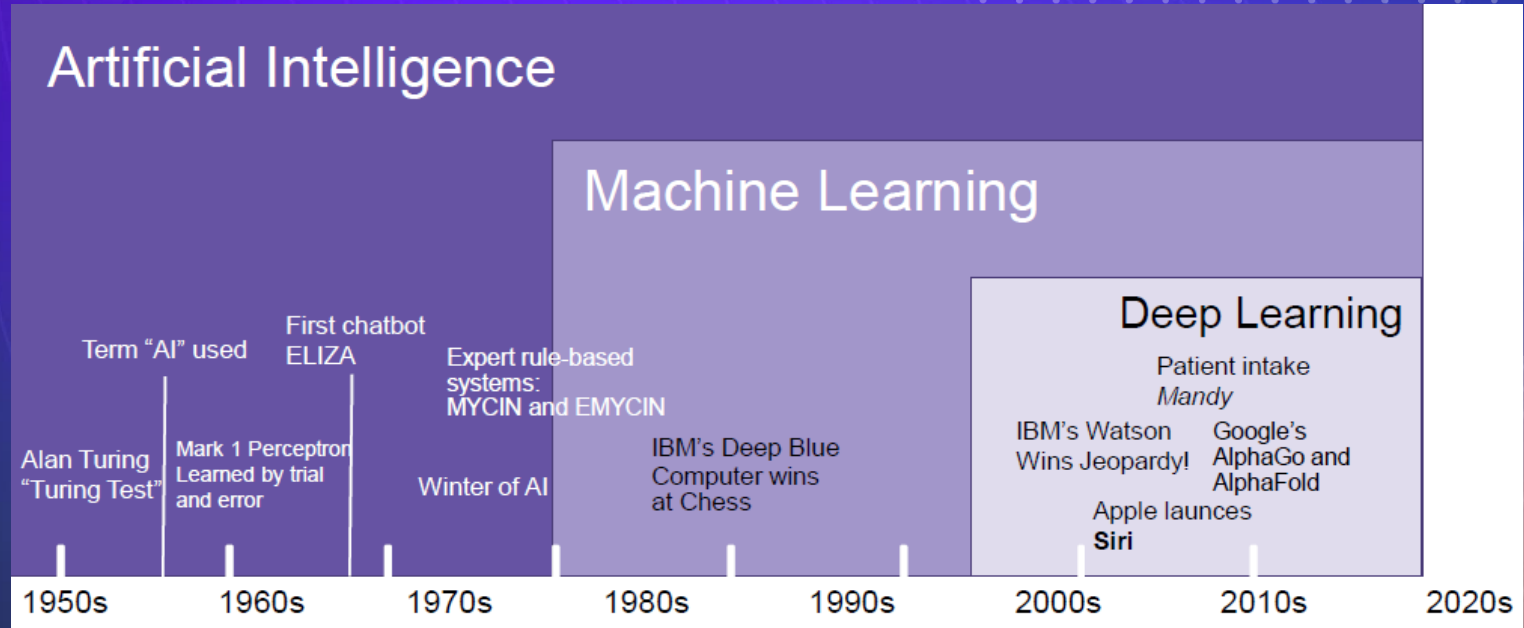
- Perception, language processing, learning, planning, problem solving, etc.

Narrow AI is most common

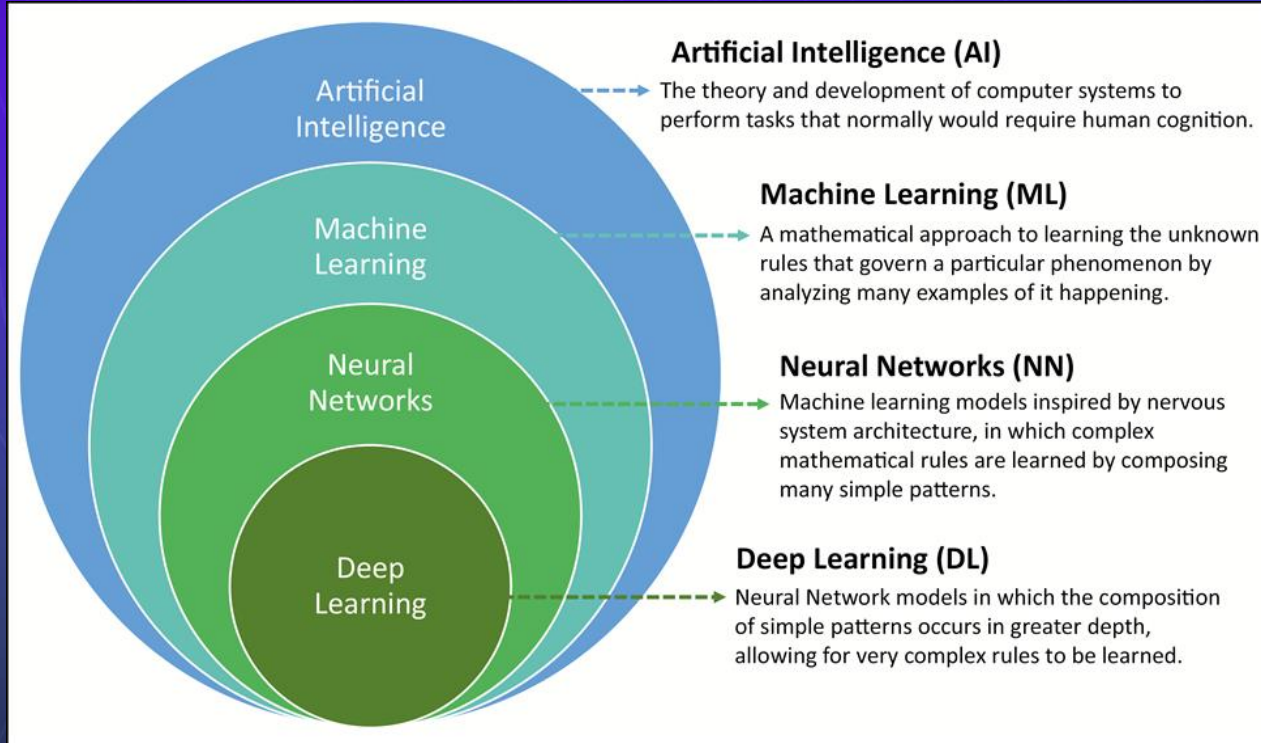
- Can do one well-defined task, but that's it



Brief Timeline



Hierarchy of AI



Assessment Question 1

- What is the difference between "neural networks" and "deep learning"?
 - A. A neural network contains an input layer, a hidden layer, and an output layer, but deep learning contains several hidden layers on massive amounts of data
 - B. A neural network makes decisions based on what has been learned only, and deep learning arranges algorithms in layers that can learn and make decisions on its own
 - C. A neural network arranges algorithms in layers that can learn and make decisions on its own, and deep learning makes decisions based on what has been learned only
 - D. A neural network is the idea that a machine can mimic human intelligence, and deep learning teaches a machine to perform a specific task and provide accurate results

Assessment Question 1

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Let's ask ChatGPT the definitions



Please describe the concept of "machine learning" and give a funny example.



Machine learning is a subfield of artificial intelligence (AI) that involves developing algorithms and statistical models that enable computers to learn from data, identify patterns, and make predictions or decisions without being explicitly programmed.



In simpler terms, it is the process of teaching a computer to learn and improve on a task by providing it with data, feedback, and examples. This allows the machine to identify patterns and make predictions based on that data, which can be applied to a wide range of tasks, from image recognition and natural language processing to fraud detection and recommendation systems.

Now, for a funny example: Imagine a machine learning algorithm tasked with predicting which animal is most likely to be the "office pet" in a company. The algorithm is fed data on various animals, such as their cuteness, playfulness, and adaptability to indoor environments. After analyzing the data, the algorithm predicts that a sloth would be the best office pet because of their relaxed demeanor and lack of need for exercise. However, the employees quickly realize that a sloth would be too slow and unexciting, and instead opt for a hyperactive Jack Russell terrier, much to the algorithm's confusion.

Let's ask ChatGPT the definitions



Please describe the concept of "neural networks" and give a funny example.



Neural networks are a type of machine learning algorithm that are modeled after the structure and function of the human brain. They are composed of layers of interconnected nodes or "neurons" that process and transmit information.



The basic idea behind neural networks is that they learn by adjusting the strength of the connections between neurons in response to feedback from input data. By doing so, they can identify patterns and relationships within the data and make predictions or classifications based on that analysis.

Now, for a funny example: Imagine a neural network trained to generate pickup lines for humans to use on each other. The algorithm is fed data on successful pickup lines, along with various attributes such as humor, confidence, and sincerity. After many iterations, the algorithm produces a set of lines that it believes are most likely to be effective. However, when tested on a group of human subjects, the lines are deemed to be overly cheesy and ineffective. In response, the algorithm decides to adjust its connections to produce more "sophisticated" pickup lines, such as "Excuse me, but do you have a moment to talk about the existential crisis of modern society?" The humans are left scratching their heads, wondering where it all went wrong.

Let's ask ChatGPT the definitions



Please describe the concept of "deep learning" and give a funny example



Deep learning is a subset of machine learning that involves the use of artificial neural networks with multiple layers to analyze and process complex data. It is a more advanced and complex form of machine learning that can be used for tasks such as image recognition, natural language processing, and speech recognition.



Deep learning algorithms work by breaking down the input data into multiple layers of abstract representations, with each layer learning to identify more complex patterns and features. The output of one layer serves as the input for the next, allowing the algorithm to learn increasingly complex relationships between the input and output data.

Now, for a funny example: Imagine a deep learning algorithm tasked with predicting the likelihood of a person sneezing based on various inputs such as time of day, weather conditions, and allergy data. The algorithm is trained on a vast amount of data, and after many iterations, it finally comes up with a prediction model that is highly accurate. However, it turns out that the algorithm is not accounting for the fact that a person might sneeze simply because someone said "bless you" nearby, throwing off the accuracy of its predictions. The algorithm's creators then have to add a new layer to account for this unexpected factor, much to the amusement of their colleagues.



Little Data

Stems from patients and end users
(Ex: Data points from a patient chart)



Big Data

Aggregation of data from all sources of
little data (Ex: Health-system EHR)



02

Big Data





Big Data

- Data sets so large, complex, multisource, and multifaceted that conventional software and storage solutions are unable to analyze and create visualizations of the data
- Single data set from a large academic medical center's EHR can surpass the maximum row limit of Microsoft Excel
- AI leverages big data to provide meaningful information and make decisions



Abbreviations: EHR = Electronic Health Record

Source: Malone PM, et al. Drug Information: A Guide for Pharmacists, 7e. McGraw Hill; 2022

The Five V's of Big Data



V

Volume

Sheer amount of data that is being generated

V

Velocity

Speed at which data continues to be generated



V

Variety

Large number of types of data and sources of data

V

Veracity

Validity of data being generated and the presence or lack of bias

V

Value

Utility of data to influence clinical outcomes

Assessment Question 2

- What does "veracity" mean as one of the five "Vs" of big data?
 - A. The sheer amount of data being generated and collected
 - B. The speed at which data is generated and collected
 - C. The diverse types of data being collected
 - D. The quality and accuracy of data being collected
 - E. The usefulness that can be derived from analyzing big data

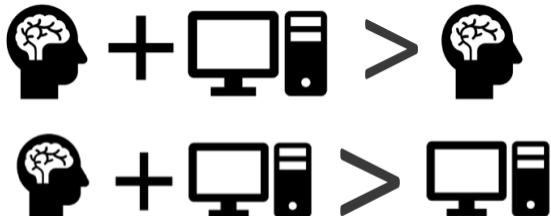
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Will AI or Robots replace me?

"Augmented Intelligence"



Fundamental Theorem of Informatics

"Augmented Intelligence"

Pharmacists excel	AI systems excel
Common sense	Pattern identification
Compassion	Endless capacity
Context	Natural language processing
Dilemmas	Locating knowledge
Morals	Machine learning
Imagination	Minimizing bias
Abstraction	
Generalization	

Considerations

Gap:

- The clinicians who understand the problems
- The developers who create the models
- The administrators who make the decisions about which AIs to support

Implementation:

- Beware of bias
- Beware of model drift
- Who takes responsibility?
- What will be done with the extra time?



03

Case Studies

Oncology

Introduction

- AI is currently reshaping the landscape and horizons of oncology, opening new important opportunities for improving the management of cancer patients
- Oncology is well suited for AI technologies because of the complex and data-intensive processes required

As of October 5, 2022, the FDA had approved 521 medical devices using AI/machine learning

Oncology Patient Timeline



Case Study 1

Context

- Breast cancer is the most common cancer in women and is a major cause for cancer-related mortality accounting for ~600,000 deaths annually

Problems

- Population-based breast cancer screening programs using mammography are regarded as effective in reducing breast cancer mortality
- Current screening programs are highly labor intensive, especially in Europe
- Up to 25% of mammographically visible cancers are not detected during screening

Transpara



Training

The AI system is trained, validated, and tested using a database containing over 189,000 mammograms



About

Created by two world renowned professors to use AI to help radiologists detect breast cancer as early as possible



DL

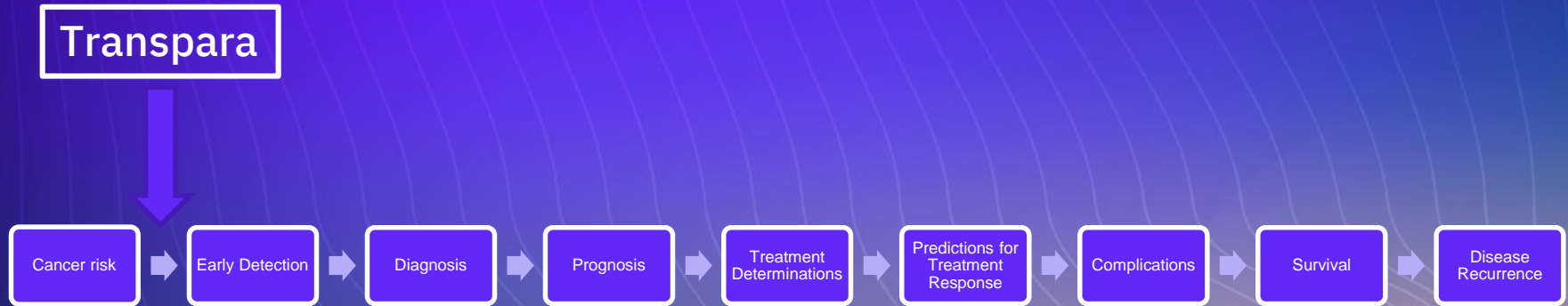
Convolutional neural networks, and image analysis algorithms to detect calcifications and soft tissue lesions

Stand-Alone AI Study

Stand-Alone Artificial Intelligence for Breast Cancer Detection in Mammography: Comparison with 101 Radiologists

Design + Methods	Transpara retroactively analyzed digital mammography exams from nine datasets yielding 2652 exams and interpretations by 101 radiologists. The AI system provides a continuous score ranging between 1 and 10 indicating the level of suspicion of cancer.
Results	<ul style="list-style-type: none">• The performance of the Transpara was statistically noninferior to that of the average of 101 radiologists• The AI system had an area under the ROC curve of 0.840 (95% CI, 0.820-0.860) compared to the average of radiologists of 0.814 (95% CI, 0.787-0.841)
Conclusions	AI can potentially reduce costs and increase efficiency in breast cancer screening compared to radiologists. However, the performance and impact of an AI system in clinical practice needs further investigation.

Impact of AI-based Screening



Key Takeaway: AI systems can achieve high sensitivity and specificity in detecting breast cancers and can potentially reduce costs and improve efficiency when used in combination with a clinician

Case Study 2

Context

- Drug doses are typically determined using dose escalation or dose expansion to reach a maximum tolerated dose

Problems

- Finding the optimal doses for combination therapies using conventional approaches can be challenging
- Patient's response to treatment depends on several factors including the time-dependent, dose-dependent, and patient-specific nature of drug synergy

CURATE.AI



Drug Dosing

CURATE.AI is an indication-agnostic, mechanism independent, personalized dosing platform



About

Created by researchers from National University of Singapore, whose goal is to allow clinicians to prescribe optimal doses of chemotherapy for patients



Small Data

Each patient is given varied doses of a drug and their responses are measured to create a digital profile for each patient

Precision Dosing

PRECISE CURATE.AI: A prospective feasibility trial to dynamically modulate personalized chemotherapy dose with artificial intelligence

Design + Methods

Open-label, multicenter, single-arm, prospective feasibility trial in ten patients diagnosed with advanced solid tumors and treated with capecitabine. The AI system generated a second-order correlation between patient-specific variation of doses and the corresponding tumor marker (CEA, CA19-9, or CA-125)

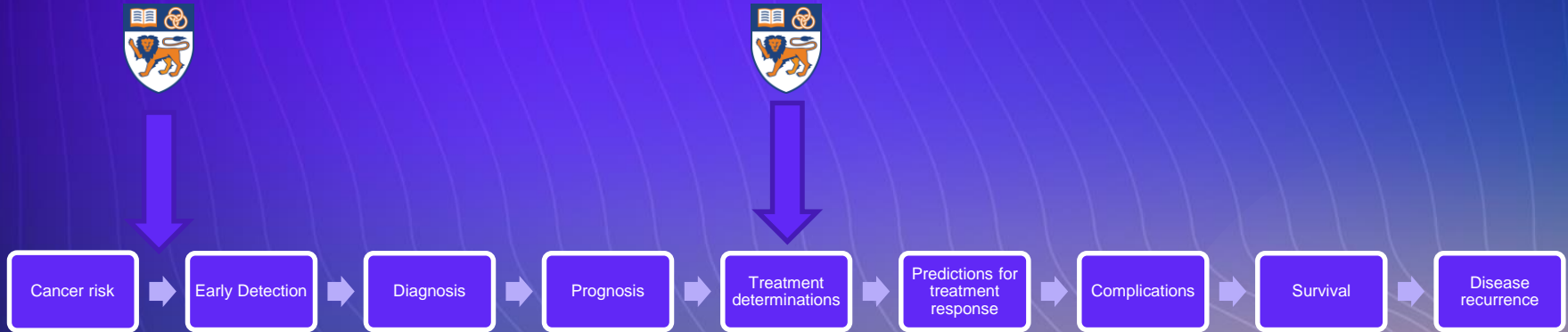
Results

- The prescribed dose was on average reduced by 20% ($\pm 12.8\%$) as compared to the standard of care dosing
- 96.7% of the dosing recommendations by CURATE.AI were accepted by clinicians

Conclusions

AI can be successfully incorporated into clinical workflows, especially with drugs with the potential of dynamic dose selections. The results support the initiation of a larger, randomized clinical trial and potential expansion of indications.

Impact of AI-based CDSS



Key Takeaway: AI-based clinical decision support systems can play a powerful role in clinical practice, identifying recommendations in concordance with the medical team

Case Study 3

Context

- Delays in clinical trial enrollment and difficulties enrolling balanced samples continue to puzzle sponsors, sites, and patients
- Patients may have to search through hundreds of trials on clinicaltrials.gov

Problems

- Ensuring patients from diverse backgrounds join clinical trials is vital to advance health equity
- US Phase I oncology trials are heavily skewed towards Caucasians (84.2%)
- The US spends ~\$2B per year on patient recruitment, yet many clinical trials fail to meet enrollment timelines

Mendel.ai



CDSS

Leverages technology to provide personalized recommendations and improve healthcare delivery



About

Healthcare-focused company founded in 2016 and named after Gregor Mendel



NLP

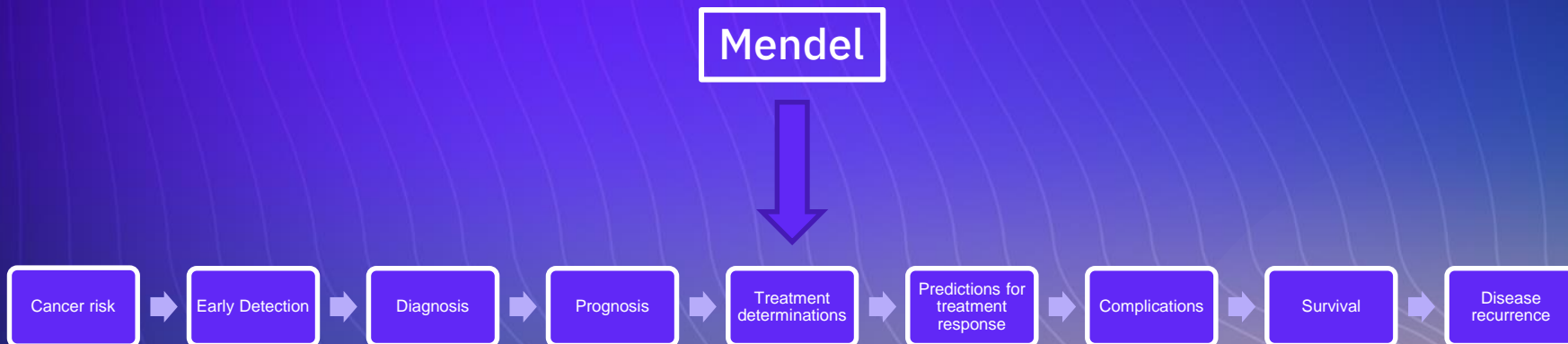
Combs through clinicaltrials.gov data to compare with a patient's medical data with a list of matches

Clinical Trial Matching Study

Improving Clinical Trial Participant Prescreening With AI: A Comparison of the Results of AI-Assisted vs Standard Methods in Three Oncology Trials

Design + Methods	Retroactive study with Mendel.ai applied to two completed oncology studies (one breast, one lung), and one study that failed to enroll (lung)
Results	<ul style="list-style-type: none">• For each trial that enrolled, use of Mendel.ai resulted in a 24% to 50% increase in # of patients correctly identified as potentially eligible• No patients correctly identified by standard practices were missed by Mendel.ai• For the non-enrolling trial, both approaches failed to identify suitable # of patients
Conclusions	Augmentation with human resources in combination with artificial intelligence can yield substantial improvements over standard practice alone in the patient prescreening process, and in feasibility, site selection, and trial selection.

Impact of Clinical Trial Matching



Key Takeaway: Clinicians who are aware of these resources can help to assist patients who are seeking clinical trials

Case Study 4

Context

- Advances in computer vision and deep learning have the potential to improve the ability to provide detailed pathologic data

Problems

- Colorectal carcinoma (CRC) is morphologically heterogeneous
- Several factors such as grade, mucinous morphology, and mismatch repair deficiency have associations with outcomes
- Image-based biomarkers have been developed using histology to predict outcomes

QuantCRC



Quantitative

Proof of concept was to convert an image into a set of numbers that is unique to that tumor



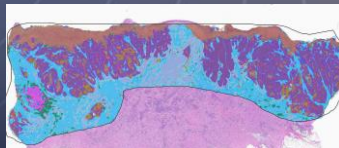
About

Mayo Clinic research team developed and validated the model which was trained on 24,157 annotations made on 559 images



DL

Deep learning segmentation algorithm to quantify 15 features from a CRC image to improve prediction of recurrence



Predictive Analytics

- One of the most commonly leveraged forms of AI in healthcare is predictive analytics
 - Utilizes big data to create insights from historical patient data
 - Based on statistical analysis including logistic regression models against hundred of patient specific variables

Concordance Statistic (C-statistic)

$$c = \frac{\# \text{ concordant pairs}}{\# \text{ concordant pairs} + \# \text{ discordant pairs}}$$

Range: $0.5 < c < 1.0$

- Predicts the risk of a patient having an event
- A C-statistic around 0.75 is considered a high
- Static predictive models can become outdated

Predictive Modeling Study

Quantitative Pathologic Analysis of Digitized Images of Colorectal Carcinoma Improves Prediction of Recurrence-Free Survival

Design + Methods	QuantCRC was applied to 6468 digitized slides of CRC. A prognostic model was developed to predict recurrence-free survival using data from the internal cohort (n = 1928) and validated on an internal test (n = 483) and external cohort (n = 938)
Results	<ul style="list-style-type: none">• The prognostic model incorporating stage, mismatch repair, and QuantCRC yielded a C-statistic of 0.714 in the internal test and 0.744 in the external cohort• The predicted median 36-month recurrence rate for high-risk stage III CRCs was 32.7% vs 13.4% for low-risk stage III and 15.8% for high-risk stage II vs 5.4% for low-risk stage II CRCs
Conclusions	QuantCRC can be a powerful adjunct to routine pathologic reporting of CRC. The prognostic model can improve prediction of recurrence-free survival.

Impact of Predictive Modeling



Key Takeaway: Prognostic models have been developed and validated with promising utility, but successful operationalization into clinical workflows is limited

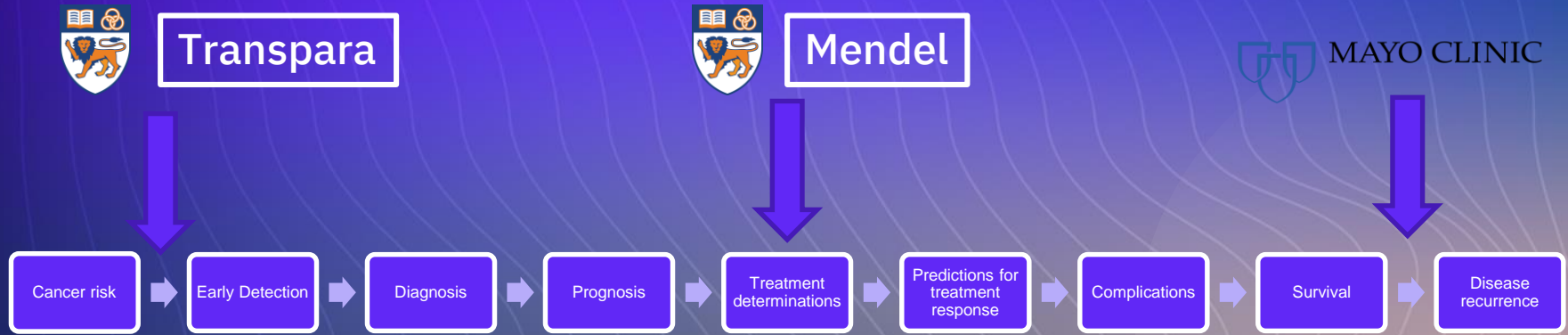
Assessment Question 3

- Which application of AI in healthcare utilizes the concordance statistic?
 - A. Clinical trial matching
 - B. Chatbots
 - C. Diagnosis
 - D. Predictive analytics
 - E. Medication adherence

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Oncology Patient Timeline Summary



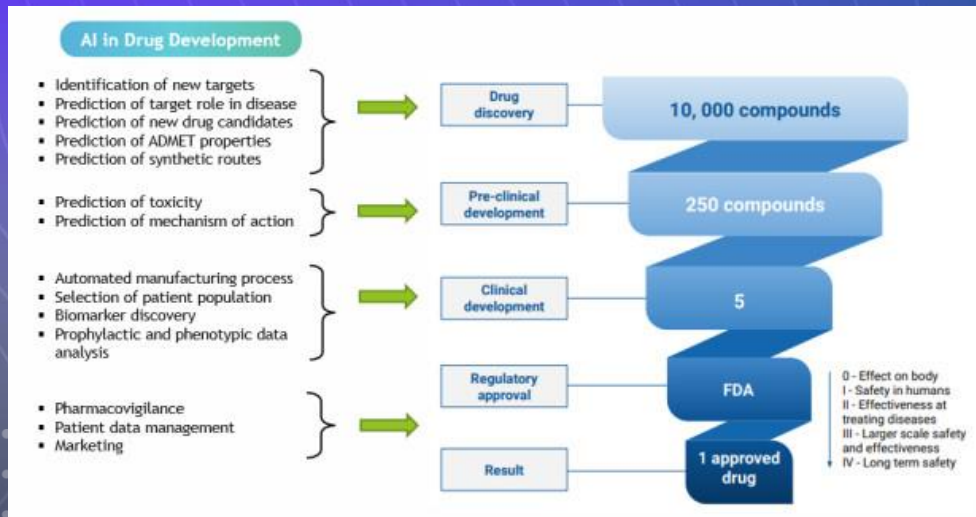


04

Other Applications of AI



Drug Development





COVID-19 vaccines

Pfizer utilized Machine Learning to review COVID-19 vaccine trial data within ~22 hours after meeting primary efficacy counts

Moderna utilized AI algorithms to go from manually creating ~30 mRNAs per month to being able to create over 1000 per month

Medication Adherence



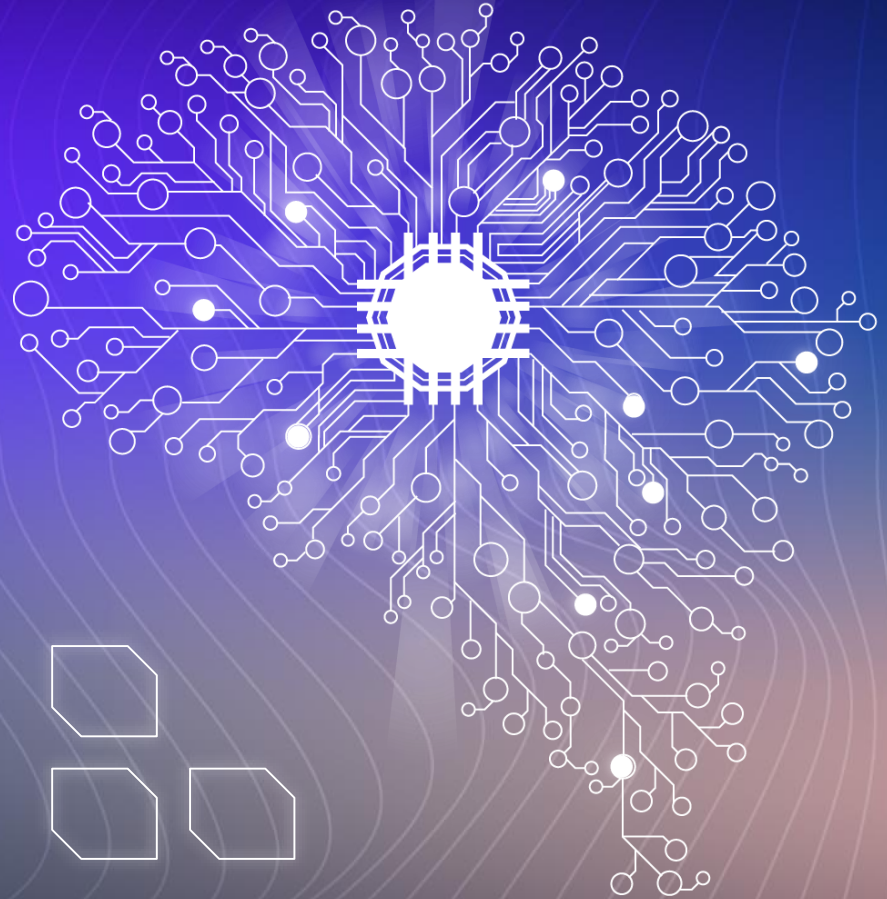
AiCure technology uses a smartphone's webcam to independently confirm that patients are taking their medications

AiCure has been used to assess dosing compliance in a phase 2 clinical trial for ABT-126 in patients with schizophrenia



ChatBots

Allows for quick access to clinical information, and can build upon previous inquiries. Can help users start with general information and research further if needed.



ChatGPT (GPT4)

• • • • •

- Provide conversation to patients
- Medical information requests
- Solving clinical cases?



GPT4 Example



Cooper
@peakcooper

#GPT4 saved my dog's life.

After my dog got diagnosed with a tick-borne disease, the vet started her on the proper treatment, and despite a serious anemia, her condition seemed to be improving relatively well.

After a few days however, things took a turn for the worse 1/

1

E

On the day of 20th:

My dog had a very high fever of 41.5C. We took him to the vet immediately, where blood work was done which indicated anemia, the veterinarian determined canine babesiosis as the diagnosis.

These are the blood work results from that day:

WBC - $4.1 \times 10^9/L$
Lymph# - $1.0 \times 10^9/L$
Mon# - $0.1 \times 10^9/L$
Gran# - $3.0 \times 10^9/L$
Lymph% - 23.7%
Mon% - 3.1%
Gran% - 73.2%

RBC - $4.66 \times 10^{12}/L$
HGB - 109 g/L
HCT - 33.1%
MCV - 71.1 fL
MCH - 23.3 pg
MCHC - 329 g/L
RDW - 11.2%

PLT - $28 \times 10^9/L$
MPV - 7.9 fL
PDW - 17.6
PCT - 0.022%

The veterinarian administered the antidote for babesiosis. After the antidote, the fever went away on the second day.

The following 3 days, the dog received antibiotics treatment through pills at home.

The dog showed general signs of improvement, but on the 24th, I noticed his gums were very pale so we went back to the veterinarian.

The veterinarian administered the antidote for babesiosis. After the antidote, the fever went away on the second day.

The following 3 days, the dog received antibiotics treatment through pills at home.

The dog showed general signs of improvement, but on the 24th, I noticed his gums were very pale so we went back to the veterinarian.

A test was done that ruled out other common tick-borne diseases, and another set of blood work was done, and these are the results:

WBC - $19.2 \times 10^9/L$
Lymph# - $5.1 \times 10^9/L$
Mon# - $0.7 \times 10^9/L$
Gran# - $13.4 \times 10^9/L$
Lymph% - 26.6%
Mon% - 3.4%
Gran% - 70.0%

RBC - $2.83 \times 10^{12}/L$
HGB - 69 g/L
HCT - 21.9%
MCV - 77.6 fL
MCH - 24.3 pg
MCHC - 315 g/L
RDW - 14.5%

PLT - $232 \times 10^9/L$
MPV - 10.6 fL
PDW - 16.9
PCT - 0.245%

Considering all the above, what is happening?

GPT4 Example



Cooper
@peakcooper

#GPT4 saved my dog's life.

After my dog got diagnosed with a tick-borne disease, the vet started her on the proper treatment, and despite a serious anemia, her condition seemed to be improving relatively well.

After a few days however, things took a turn for the worse 1/



I'm not a veterinarian, but I can try to help you understand the blood work results and what might be happening with your dog.

First, it's important to note that the blood work results have significantly changed between the two tests.

In the first test, the most noticeable abnormalities were:

1. Anemia (low RBC, HGB, and HCT values)
2. Low platelet count (PLT)

These findings, along with the high fever, are consistent with a diagnosis of canine babesiosis, a tick-borne disease that affects red blood cells and can cause anemia and other symptoms.

After treatment with the antidote and antibiotics, the second set of blood work results showed:

1. An increase in WBC, which could be due to the body's immune response to infection.
2. A further decrease in RBC, HGB, and HCT, indicating that the anemia has worsened.
3. A significant increase in platelet count (PLT), which could be a response to the anemia or inflammation.

The pale gums you observed are likely a result of the worsening anemia. The fact that the anemia has worsened after treatment could indicate that the initial treatment was not entirely effective, or that there might be another underlying issue contributing to the anemia.

2

What are other possible underlying issues in this scenario?



I'm not a veterinarian, but I can provide some general information about possible underlying issues that might contribute to anemia in dogs. It's important to consult with your veterinarian to get a proper diagnosis and treatment recommendations for your dog's specific situation.

Some possible underlying issues that could contribute to anemia in dogs include:

1. Hemolysis: The destruction of red blood cells due to various reasons, such as immune-mediated hemolytic anemia (IMHA), toxins, or other infections besides babesiosis.
2. Blood loss: Internal or external bleeding, which can be caused by trauma, surgery, or gastrointestinal issues like ulcers or parasites.



Cooper
@peakcooper · Mar 25

When we reached the second vet, I asked if it's possible it might be IMHA.

The vet agreed that it's a possible diagnosis. They drew blood, where they noticed visible agglutination.

After numerous other tests, the diagnosis was confirmed. GPT4 was right. 7/



Cooper
@peakcooper · Mar 25

We started the dog on the proper treatment, and she's made almost a full recovery now.

Note that both of these diseases are very common. Babesiosis is the #1 tick-borne disease, and IMHA is a common complication of it, especially for this breed. 8/

Assessment Question 4

- Which application of AI in healthcare has been used in clinical trials?
 - A. Clinical trial matching
 - B. Precision dosing
 - C. Medication adherence
 - D. A and C
 - E. All of the above

Assessment Question 4

- Which application of AI in healthcare has been used in clinical trials?
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 - E. **All of the above**

Examples

AI Product	Service	Cost
Transpara	Breast cancer screening	Unavailable
Mia	Breast cancer screening	Unavailable
Curate.AI	Drug dosing	Unavailable
Dosis	Drug dosing	Unavailable
Mendel	Clinical trial matching	\$99 for 3 months
Deep 6 AI	Clinical trial matching	Unavailable
AiCure	Medication adherence	\$750 per clinic per month



05

Current Challenges & Future Directions

Current Challenges

Data Privacy and Security

- Requires large amounts of patient data

Bias

- If data is trained on unrepresentative patient populations

Lack of transparency

- Difficult to discern how the system arrived at its conclusion

Regulation and Governance

- Lack of clear regulations for the use of AI in healthcare

Lack of understanding

- Technical concept that many clinicians may not understand

SWOT analysis

.....

Strengths

Powerful tools that can help realize interventions beyond the clinician alone

S

W

Weaknesses

Biased data can lead to biased recommendations
Cost/barriers to implementation

Opportunities

Save time on both routine and complex clinical tasks and processes

O

T

Threats

Data privacy and potential to replace jobs

Future Directions

Administrative

Streamlining routine administrative tasks such as processing insurance claims

- Reduce Costs
- Improve efficiency

Office Tasks

Achieving insights and streamlining tasks in all Microsoft applications

- Automatic meeting notes
- Streamline Outlook

Education



Personalized AI tutors to tailor content based on the learner's interests, goals, and needs

- Adapting to tools like ChatGPT
- Individual-based learning





Conclusion

- AI is advancing at a fast rate affecting many different industries including therapeutic areas within healthcare
 - AI can drastically save time on routine and even complex tasks allowing optimized work in other areas
 - Augmented intelligence will play an indispensable role to clinicians in the future of healthcare delivery
- 
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Thanks!

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