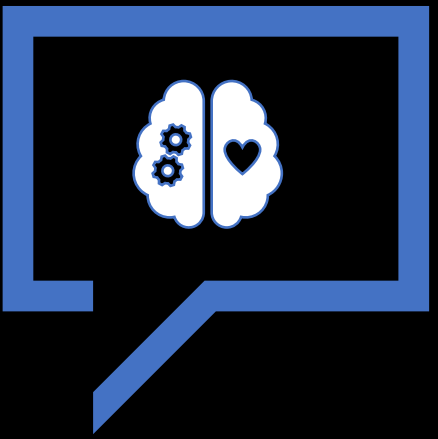
MAYO CLINIC



EXPANDING THE HORIZONS OF DELIRIUM PREDICTION

By Leveraging Artificial Intelligence

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Nurse Scientist, MICU Nurse Clinician
Mayo Clinic

November 21st, 2024
NIDUS Webinar

MY DISCLOSURES

National Institutes on Health, National Institute on Aging

- 1K23AG076662-01, Harnessing the Power of Technology to Transform Delirium Severity Measurement in the ICU.
- 1 L30 AG074162-01, Harnessing the Power of Patient Partnerships and Technology to Transform Delirium Prevention

American Thoracic Society

- RP-2021-91, Harnessing the Power of Technology to Transform Delirium Severity Measurement in the ICU

Mayo Clinic Internal

- Critical Care Research Committee, Development, testing, and refining of BrainSaver automated alert algorithm

Mayo Clinic Ventures - Disclosures

- DR24-925 – Automated Digital Marker for Delirium Severity: Lindroth, Herasevich, Nalaie, Pickering
- DR24-297 – Computer Vision Informed Acute Care: Pickering, Herasevich, Lindroth, Nalaie
- DR24-309 – Computer Vision Informed Care - Ambient Environment: Herasevich, Lindroth, Nalaie, Pickering

WHY AI?

Altered States on ICU

Visual hallucinations described by patients on intensive care

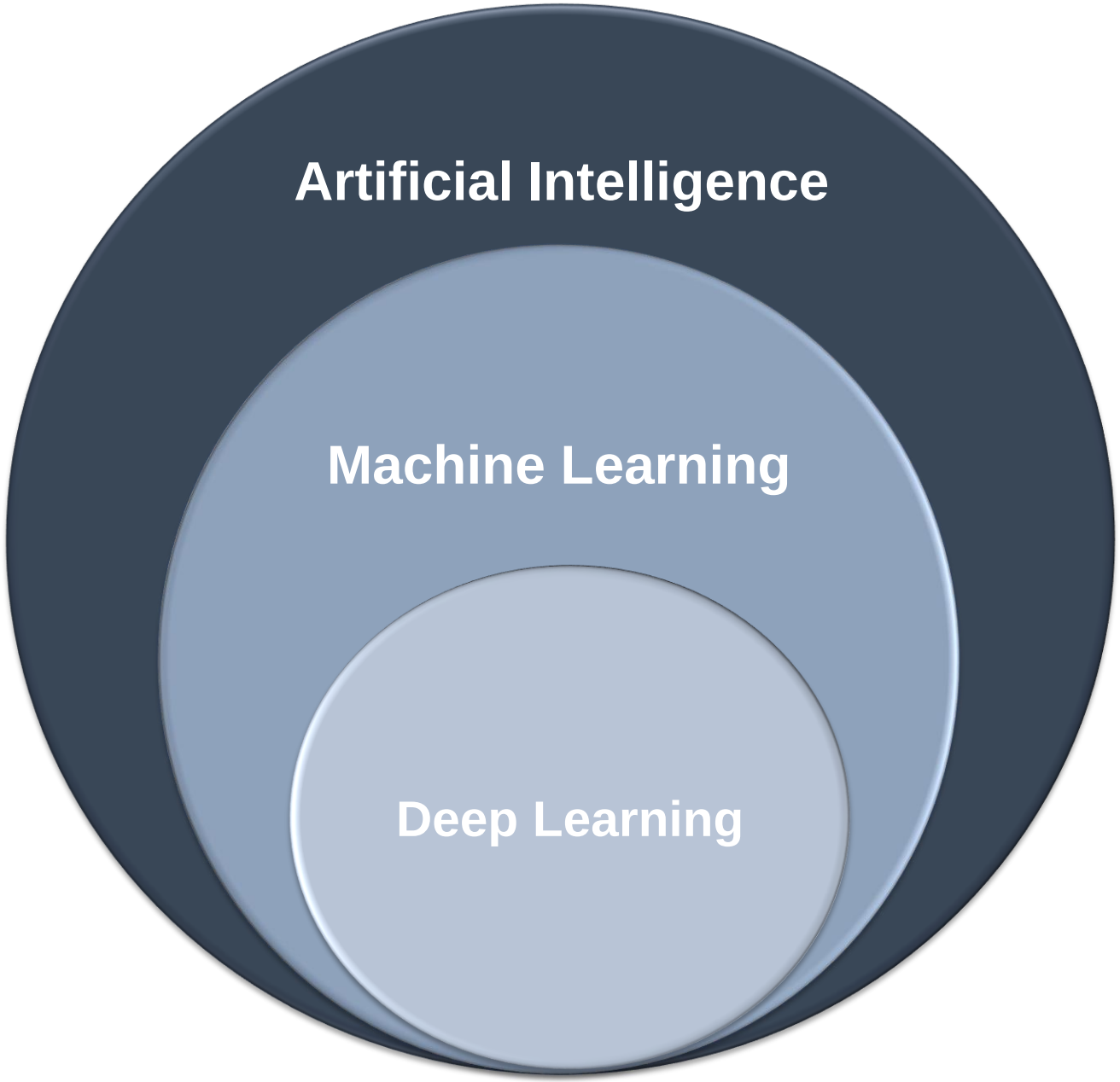
Martyn Stones and Janice Sharp

CURRENT DELIRIUM PREDICTION

Machine learning is…

- Fundamental process of AI
- Algorithm based
- Different types
  - Supervised, Unsupervised, Reinforcement

Premise	
Past	Future
X = Y	X = Y

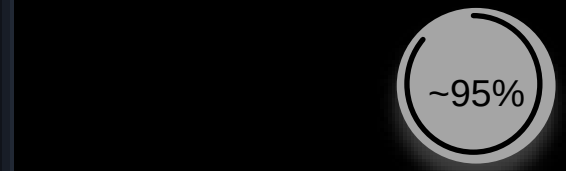


Machine Learning

Different Ways of Learning

Supervised

- Labeled data (we know the variables going in)
- Transparent, explainable
- Human-informed and guided
- Types/Examples:
  - Logistic & linear regression, decision-trees (random forest), support vector machine, neural networks, gradient descent. Etc.

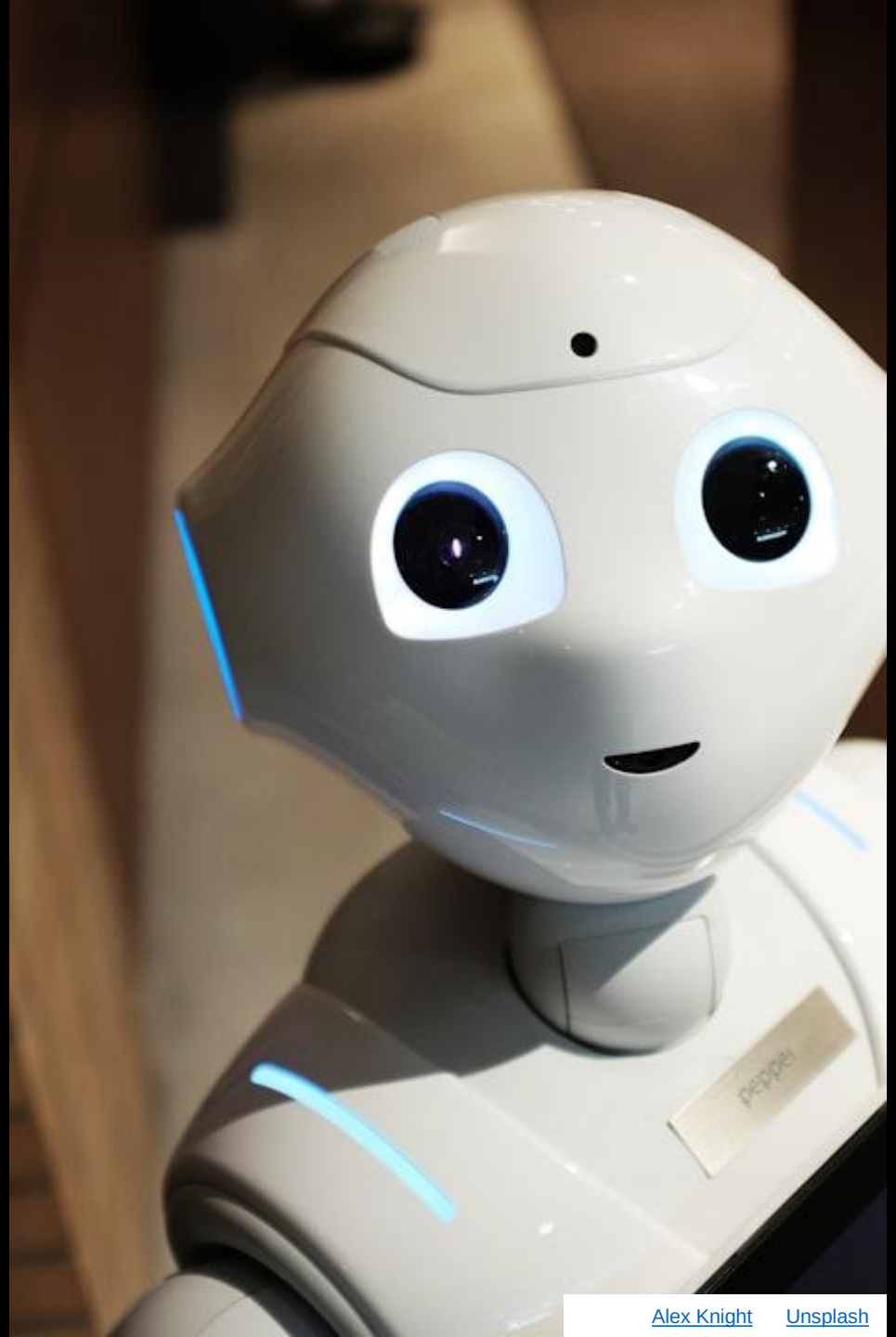


Existing Delirium Prediction Models

Unsupervised

- Unlabeled data (we do not know variables)
- Find hidden structures or patterns within data
- Considered “Black Box”
- Types/Examples:
  - Clustering, more advanced neural nets
  - Convolutional Neural Nets, Recurrent Neural nets, transformers. Etc.

Future Potential to Unlock Hidden Potential?



Alex Knight Unsplash

MACHINE LEARNING

Reinforcement Learning

- Decision-making
- Repeated trial & error, learns through rewards
- Learn series of actions (similar to Bayesian)
- Human-in-the-loop

Has been used to understand clinician decision-making (inverse)

Need to Explore how to apply in delirium prediction

DATA TYPES

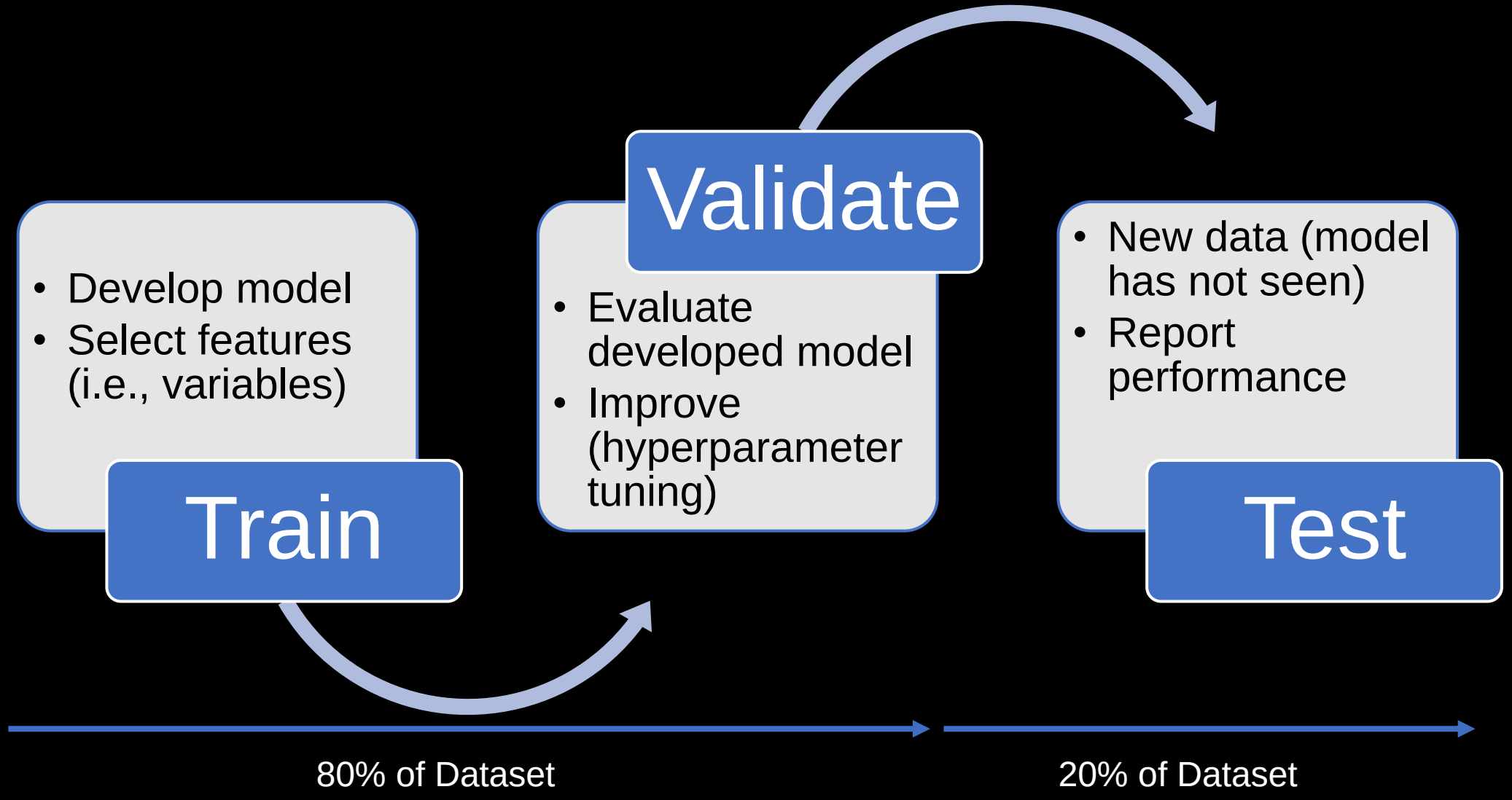
Structured

Defined, searchable
EHR flowsheet data
Relational Database/Datamart

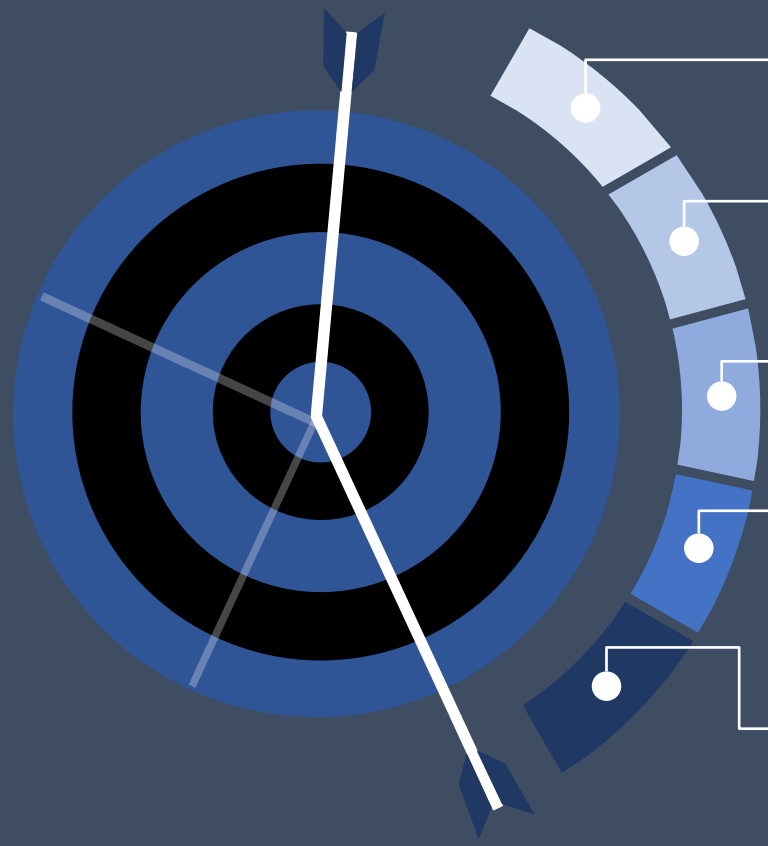
Unstructured

Data types vary
Text, images, waveform
Data Lakes

MODEL DEVELOPMENT & TESTING



Evaluating Performance of ML Models



1. **AUROC = Performance of Model**
   Plots True Positives against False Positives
2. **Accuracy = How often is model right?**
   (TP + TN)/Total Predictions
3. **Precision = Ability identify True Positives**
   TP/(TP + FP)
4. **Recall = Identification of ALL True Positives**
   TP/(TP + FN)
5. **F1 Score = Balance b/w Recall & Precision**
   2*Recall*Precision/Recall+Precision

Confusion Matrix	Positive	Negative
Positive	True Positive (TP)	False Positive (FP)
Negative	False Negative (FN)	True Negative (TN)

How is Supervised ML different from regular Logistic Regression?

Terminology

Variables
vs
Features/Labels

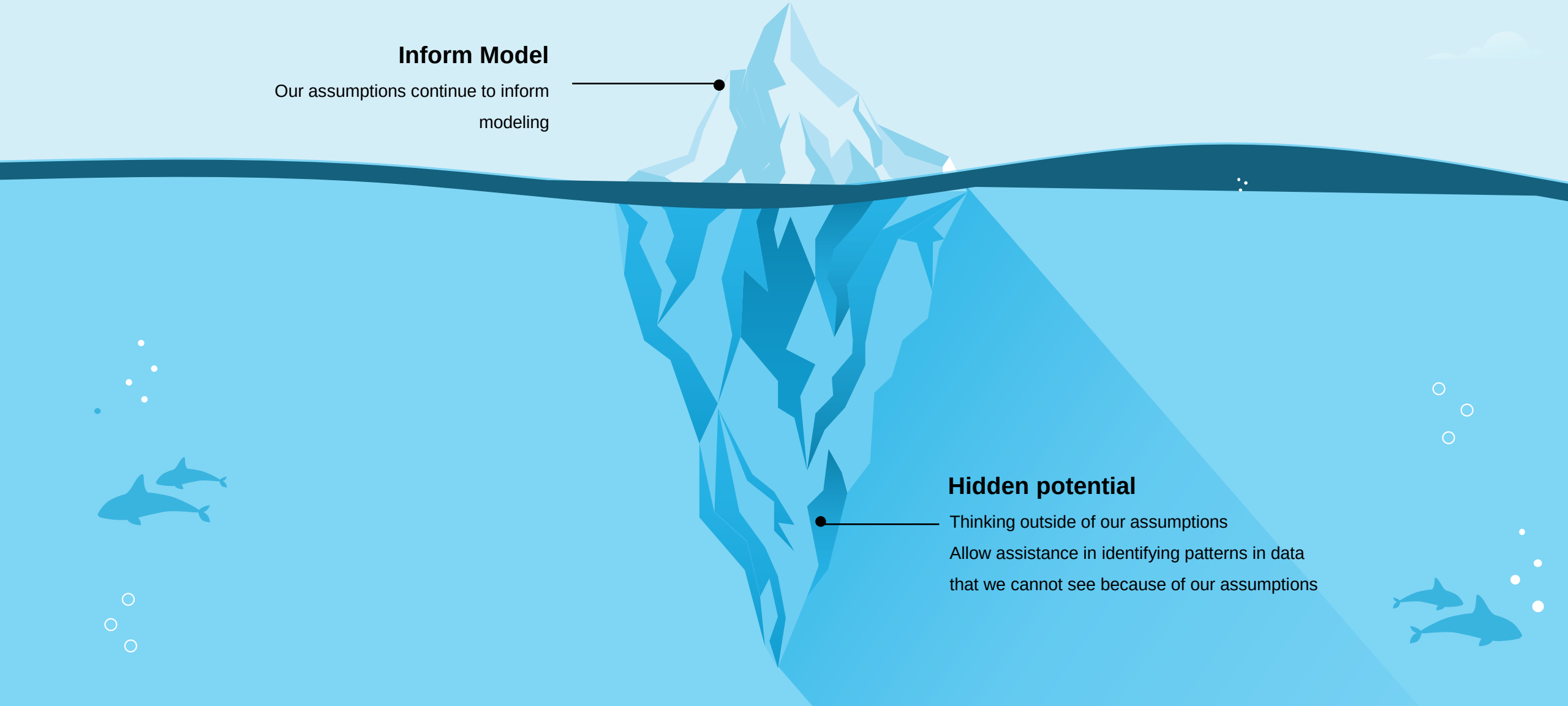
Intent

Examining relationships
vs
Finding the best performing model

Problem Being Solved

Practice or Research?
Exploratory, hypothesis generating?

WHAT IS THE SAME?



Inform Model

Our assumptions continue to inform modeling

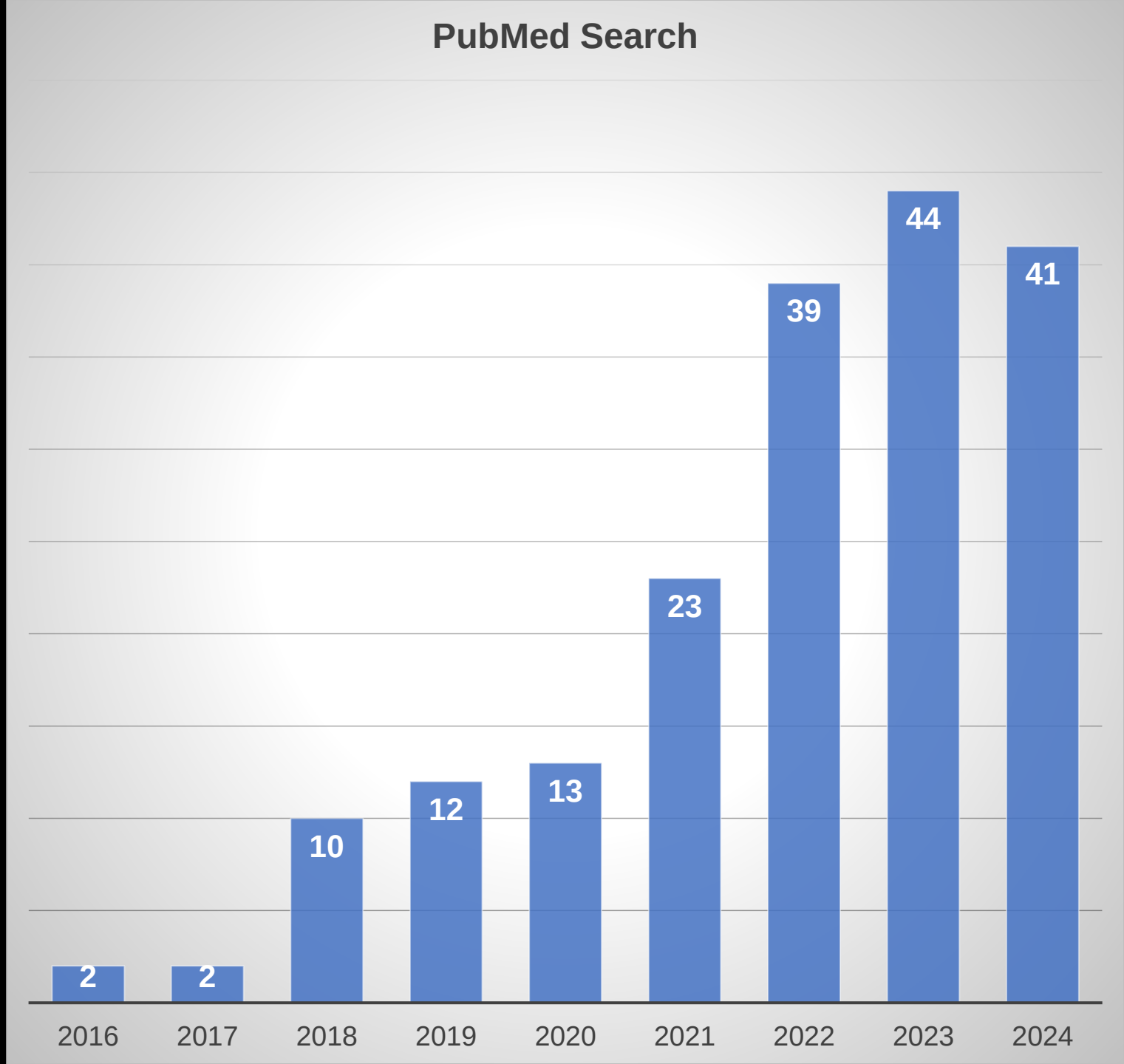
Hidden potential

Thinking outside of our assumptions

Allow assistance in identifying patterns in data that we cannot see because of our assumptions

WHERE ARE WE NOW?

- Search terms “Delirium” AND “Machine Learning”
- 3 systematic reviews
  - Postoperative (PMID 39395856):
    - Random forest most frequently used
    - Pooled AUC 0.792
    - Ensemble models perform better (AUC 0.805)
  - All Adult Settings (PMID 35922015) :
    - Pooled performance AUROC: 0.89
  - All Settings (PMID 34373042)
    - Random forest
    - AUROC 0.79-0.91



How could AI improve delirium prediction?

01 Reduce Noise in Data

02 Dynamic Modeling

Incorporate realtime information, adapt to changing circumstances

03 Incorporate various data types

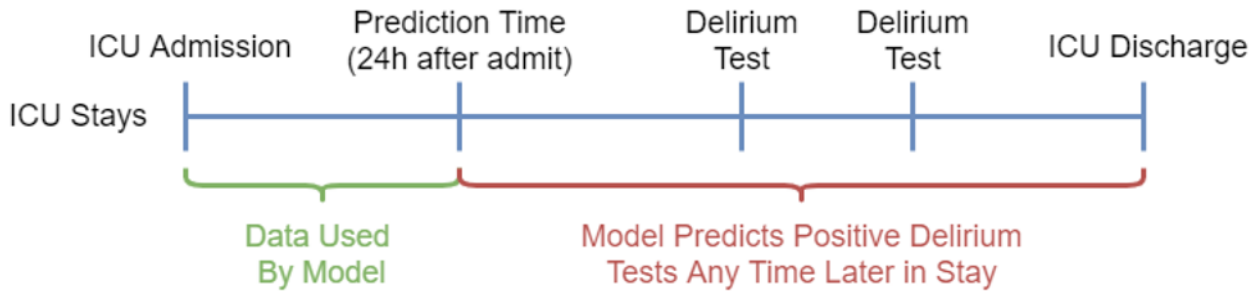
Structured, unstructured, wearables, environmental, genetic, lifestyle, ambient sensing, etc.

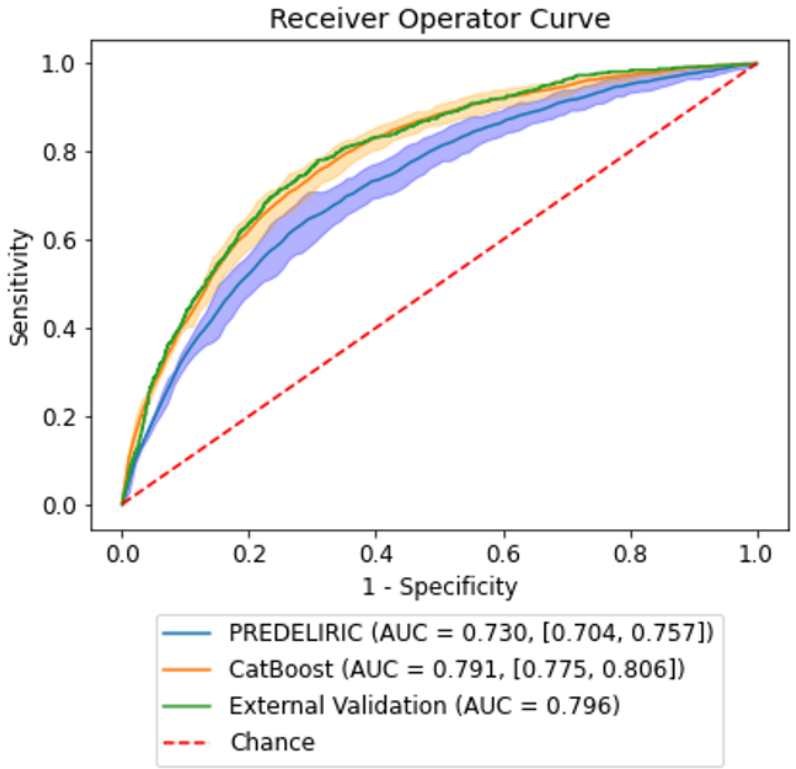
04 Improve Screening for Studies

More precise, efficient, and dynamic screening for eligibility

05 **What else?**

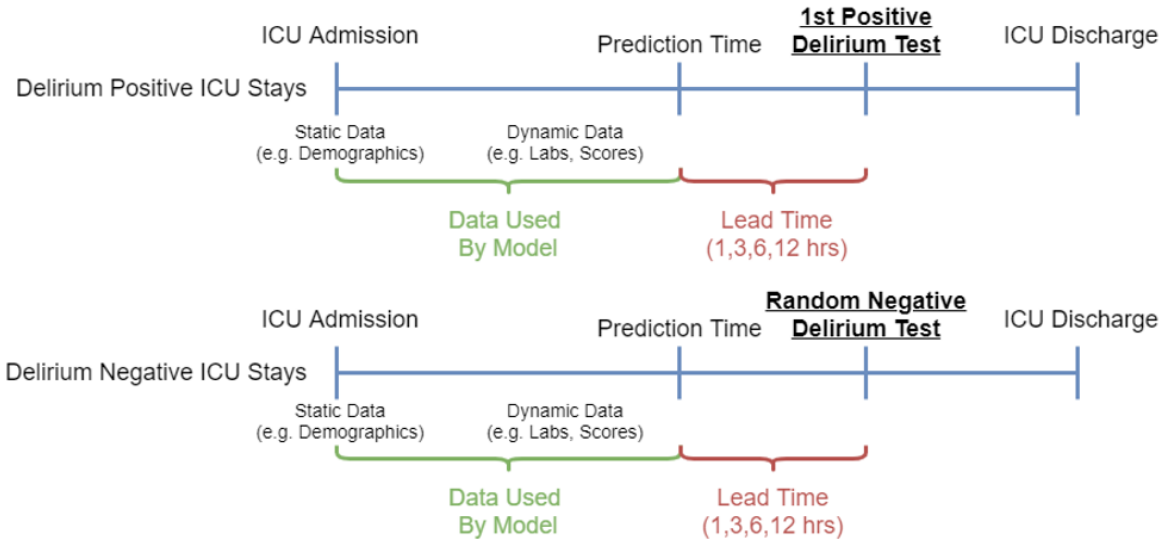
Passive digital markers, detection, prognosis, ???

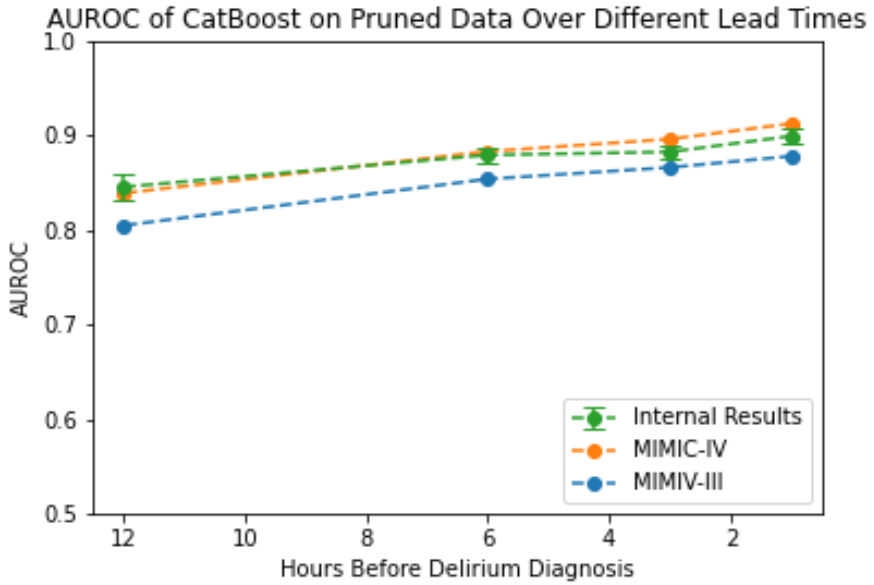




Previous Work: Static Models

Kirby D. Gong, Ryan Lu, Teya S. Bergamaschi, Akaash Sanyal, Joanna Guo, Han B. Kim, Hieu T. Nguyen, Joseph L. Greenstein, Raimond L. Winslow, Robert D. Stevens; Predicting Intensive Care Delirium with Machine Learning: Model Development and External Validation. *Anesthesiology*2023; 138:299–311
doi: https://doi.org/10.1097/ALN.0000000000004478





Previous Work: Dynamic Models

Kirby D. Gong, Ryan Lu, Teya S. Bergamaschi, Akaash Sanyal, Joanna Guo, Han B. Kim, Hieu T. Nguyen, Joseph L. Greenstein, Raimond L. Winslow, Robert D. Stevens; Predicting Intensive Care Delirium with Machine Learning: Model Development and External Validation. *Anesthesiology*2023; 138:299–311
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WHAT COULD WE DO?

- Are we predicting the risk of delirium? Low, medium, high risk?
- Are we predicting the presence of delirium? Diagnostic focused
- Are we predicting the prognosis? The likely course and outcomes for this individual?
- Are we predicting treatment response?
- Are we predicting disease progression?

Mohamed Khalifa, Mona Albadawy,
Artificial Intelligence for Clinical Prediction: Exploring Key Domains and Essential Functions,
Computer Methods and Programs in Biomedicine Update,
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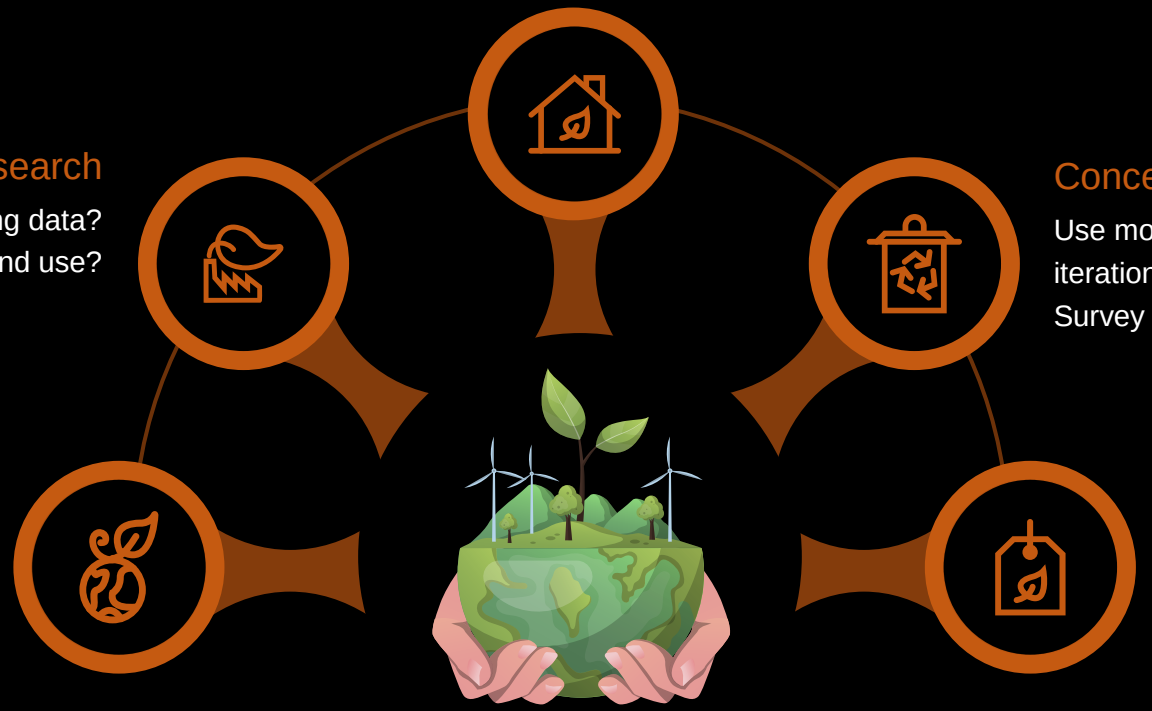
ISSN 2666-9900,
https://doi.org/10.1016/j.cmpbup.2024.100148.
(https://www.sciencedirect.com/science/article/pii/S2666990024000156)

Considerations for the Lifecycle of an Algorithm

Skills

Team Science

Be the Symphony Director



Research

What bias or unfairness might be in the training data?
How will this influence the algorithm and use?

Concern

Use models or frameworks that support rapid iterations, like Agile Science
Survey for unintended consequences

Participation

Codesign with diverse stakeholder team
Ethical considerations
Deeply understand the problem or question

Knowledge

Know the end-goal for the algorithm.
Think about deployment and the lifecycle of that algorithm

QUESTIONS AT THE END ☺

Thanks for listening!

Please email me with questions or if you want to chat!

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