UCDAVIS HEALTH | Department of Pathology and Laboratory Medicine

Supervised Machine Learning

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Disclosures

- Systems And Methods For Machine Learning-based Identification Of **Acute Kidney Injury** In Trauma Surgery And Burned Patients (Early Prediction Of Aki With Machine Learning): Co-inventors (Hooman H. Rashidi MD MS & Nam Tran PhD)
  - **University Of California Intellectual Property**

- Systems And Methods For Machine Learning-based Identification Of **Sepsis** (Early Prediction Of Sepsis With Machine Learning): Co-inventors (Hooman H. Rashidi MD MS & Nam Tran PhD)
  - **University Of California Intellectual Property**

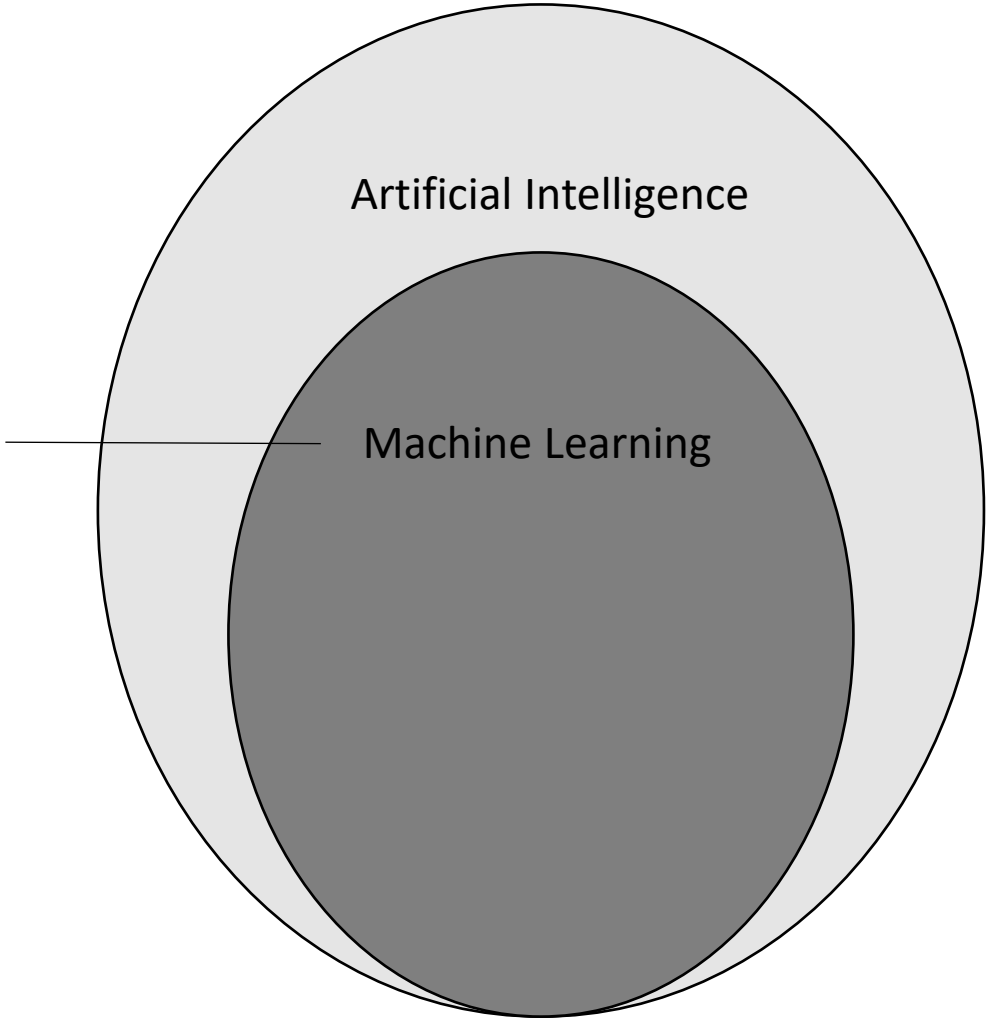
- Systems And Methods For Automated Machine Learning (**MILO**: Machine Intelligence Learning Optimizer)
  - **University Of California Intellectual Property (Patent Pending)**
    - **Co-inventors Of MILO**
    - **Hooman H. Rashidi MD MS**
    - **Samer Albahra MD**
    - **Nam Tran PhD**

Talk Outline

- Machine Learning (ML) overview
  - ML classification
- Supervised Machine Learning (ML)
  - CRISP-DM Study Design
  - Concept of Bias & Variance Trade Off
- Non-Image ML models:
  - Our AKI ML studies

What is Artificial Intelligence / Machine Learning?

"AI is the capability for machines to imitate intelligent human behavior, while ML is an application of AI that allows computer systems to automatically learn from experience without explicit programming. Paraphrasing Arthur Samuel and others, ML models are constructed by a set of data points and trained through mathematical and statistical approaches that ultimately enable prediction of new previously unseen data without being explicitly programmed to do so"

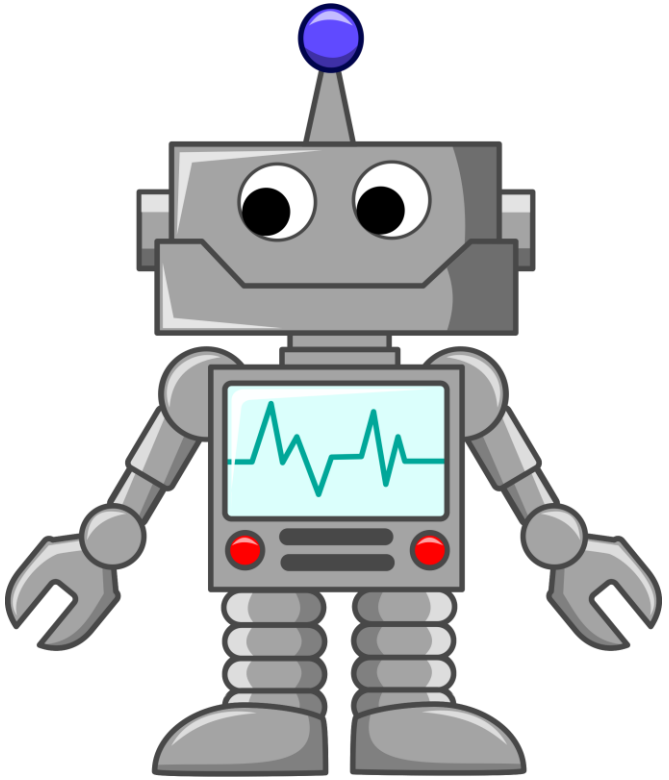


Rashidi HH, et al. Academic Pathology, 2019

Human Learning versus Machine Learning

Human learns through “experiences” and forms neuronal connections to help recall

Machine learns by experiences AKA “DATA” to build neuronal connections to be able to recall



Is there a difference in machine learning for medical applications?

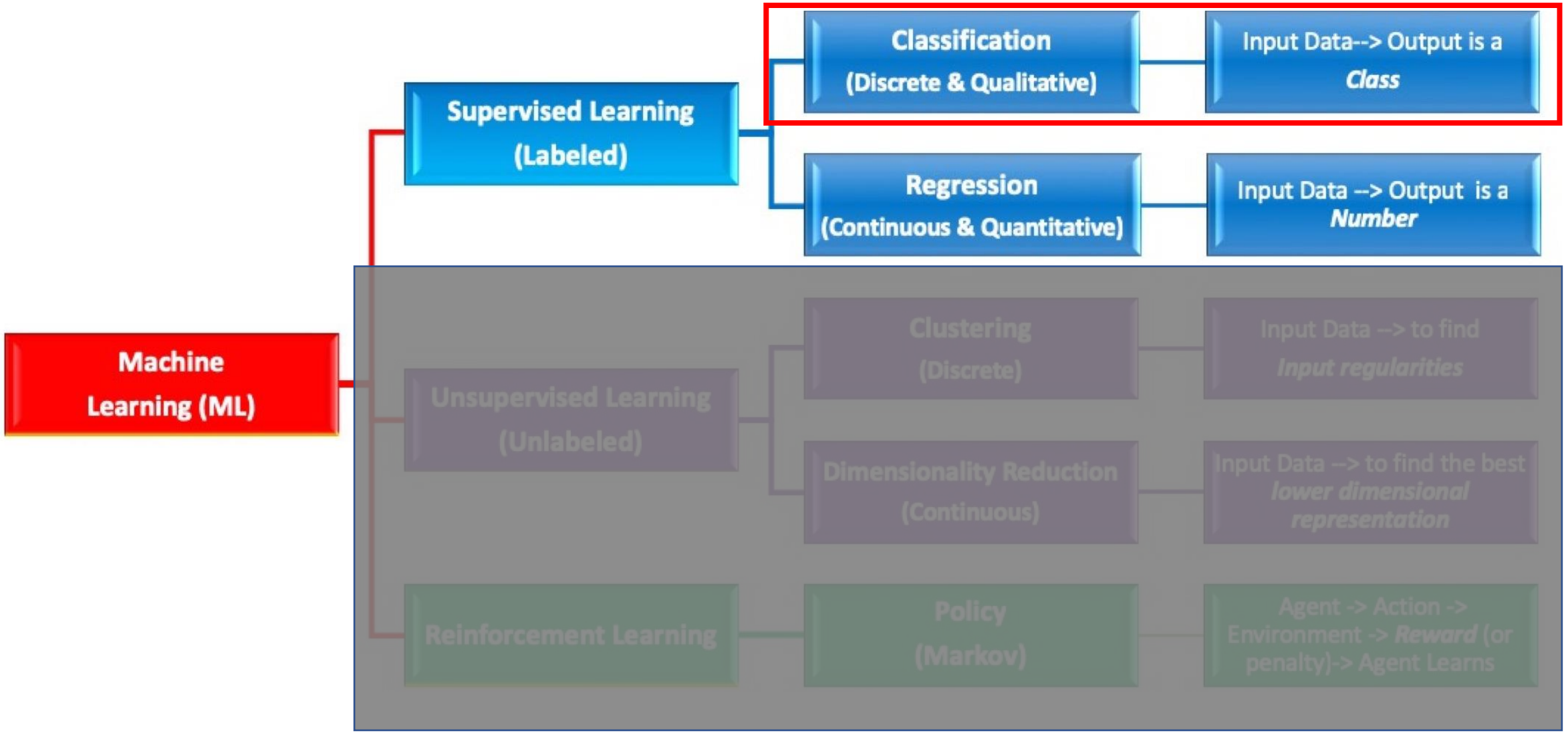
YES, Absolutely !

What is so different about our field (medicine) ?

- Practice of medicine is still a balance between art and science
  - most fields are experience driven
- Since the gold standard for how we practice is based on expertise that is experience driven, the data collected will have more variations
  - Ultimately increases the chance of interobserver variability
- Hence the data sets used in our fields are not as easily reproducible as in other fields that employ machine learning

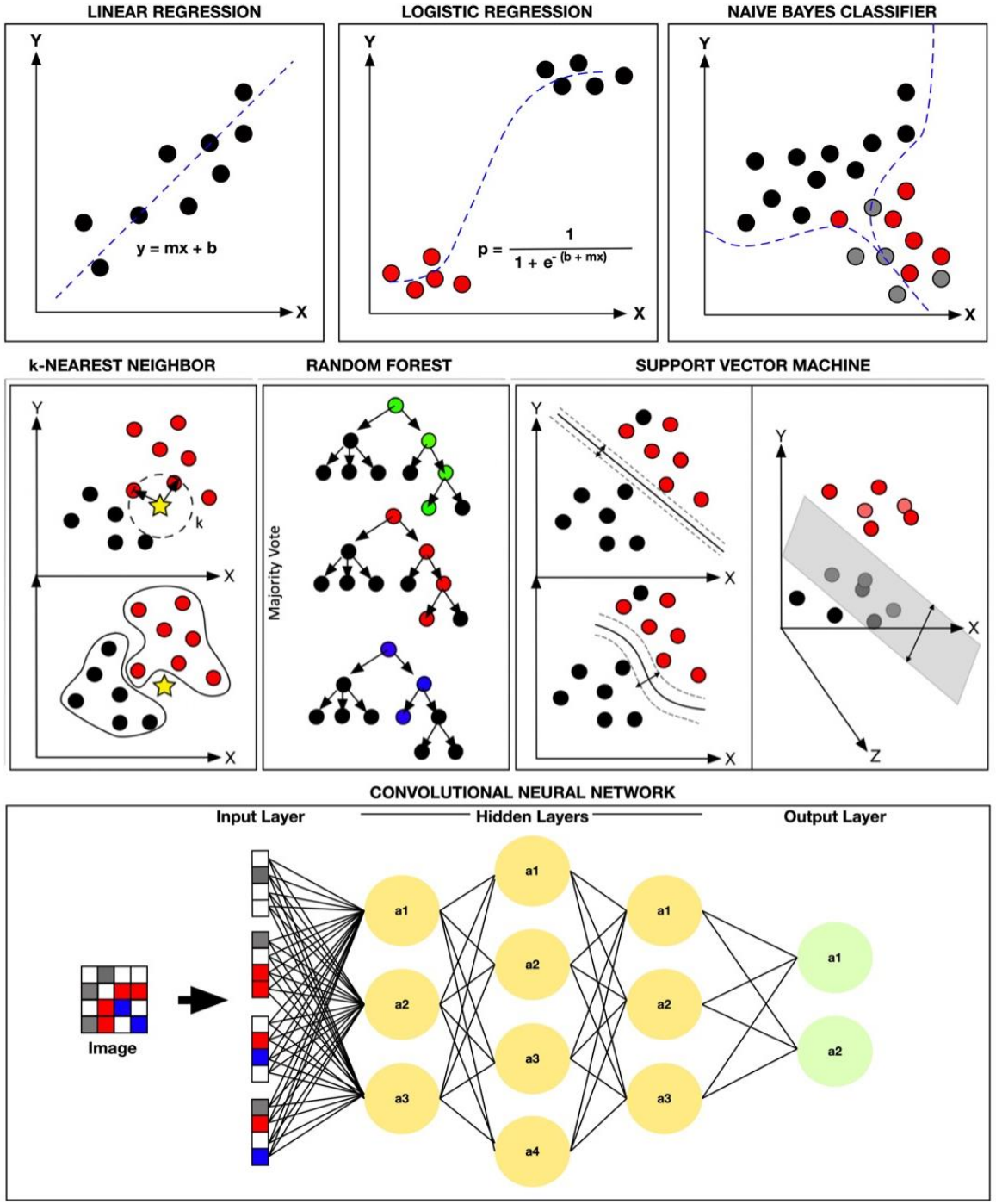
What ML approaches are used the most in medicine / pathology?

- Supervised Machine Learning



Rashidi, HH et al. Academic Pathology, 2019

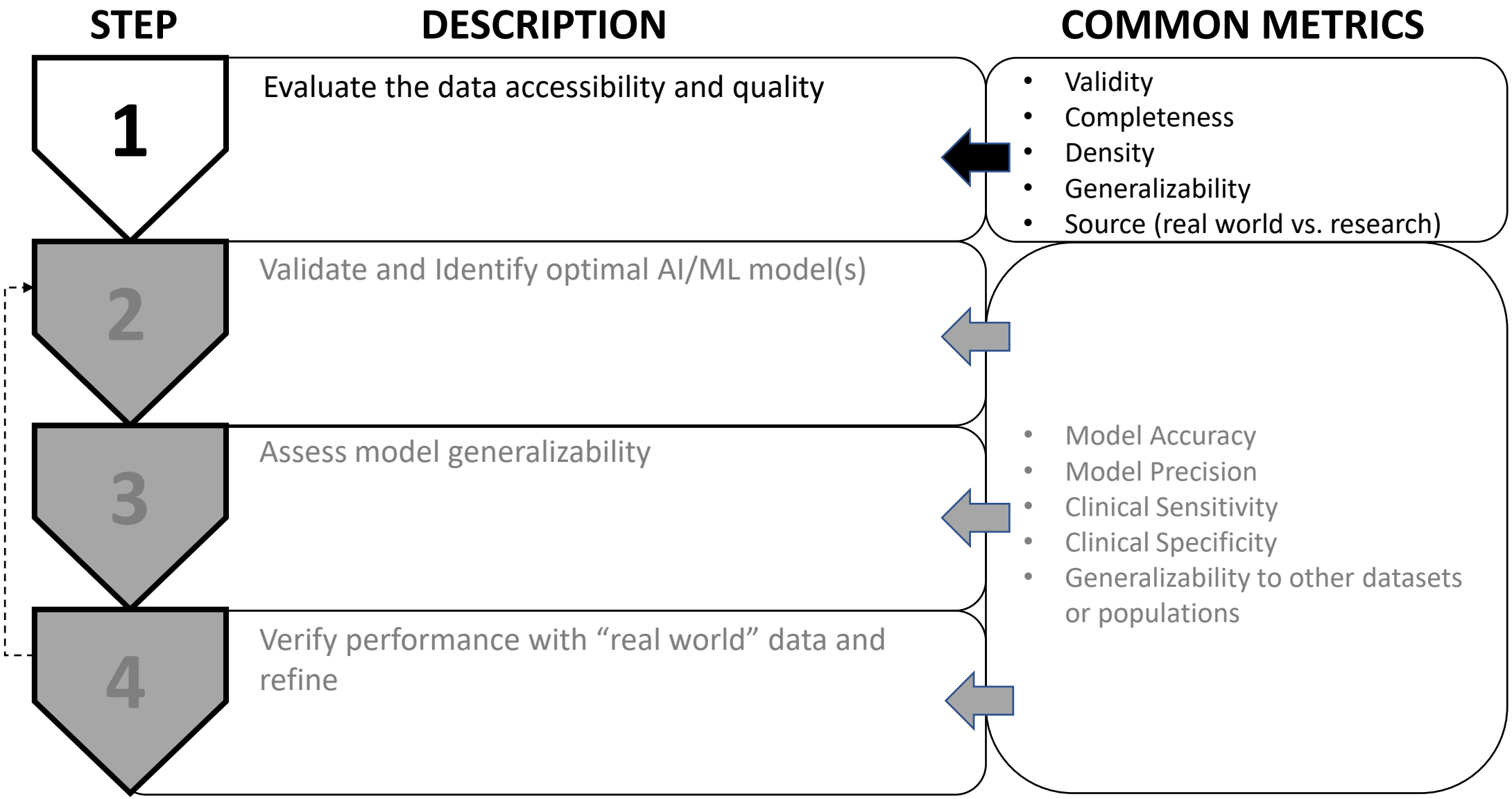
Examples of Supervised Machine Learning



Rashidi, HH et al.
Academic Pathology, 2019

AI/ML in Healthcare?

Where to start with AI/ML in Healthcare?



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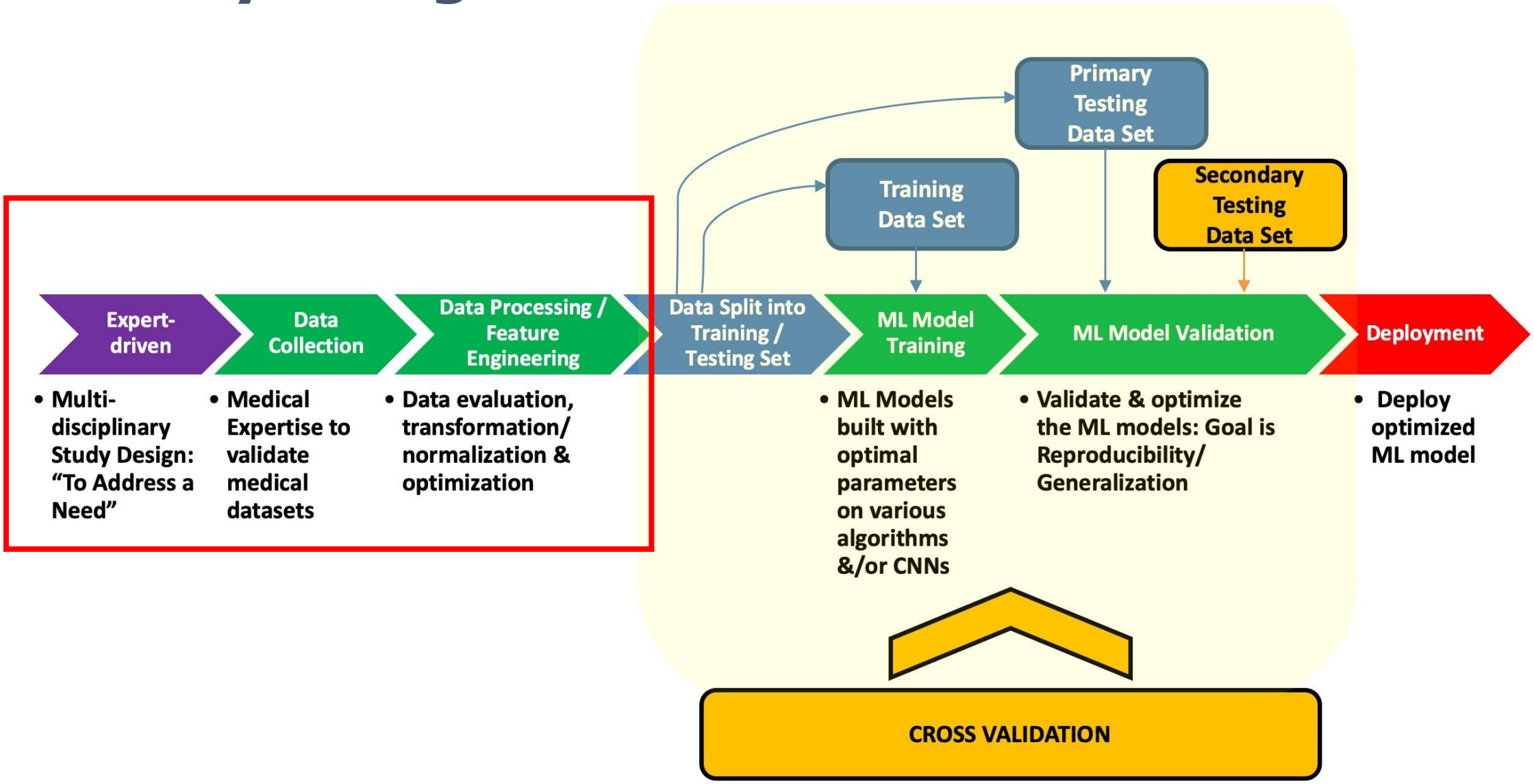
ML Study Design: CRISP-DM-Based



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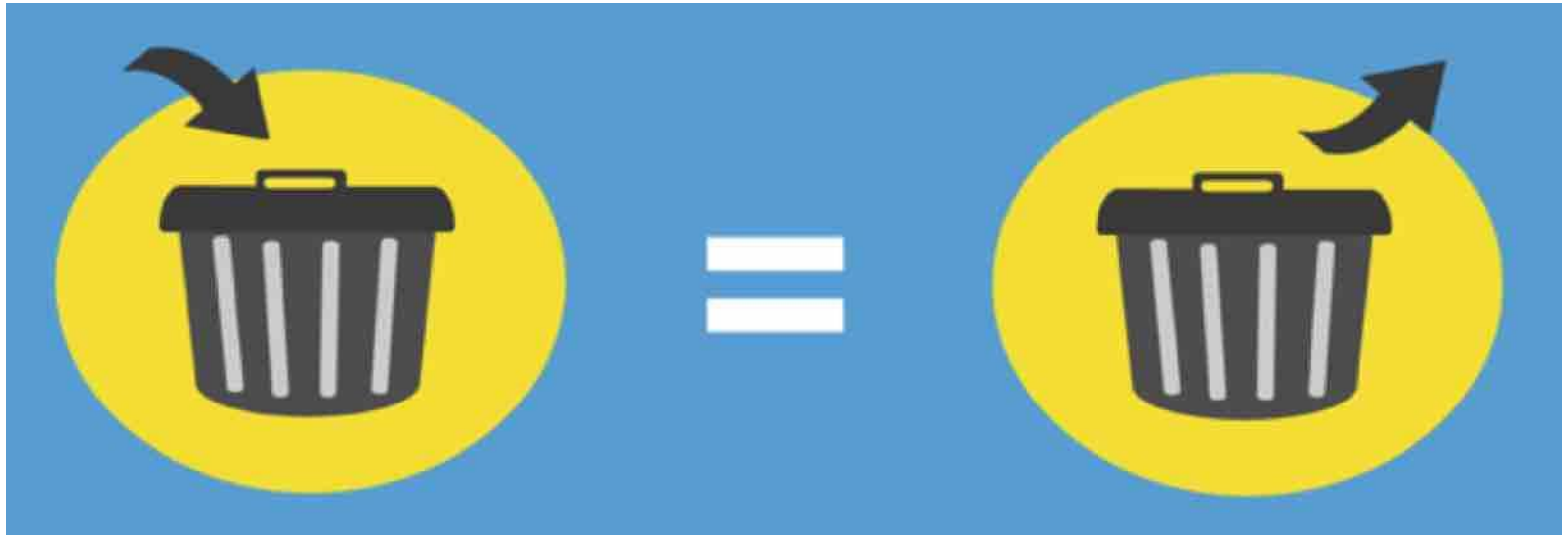
AI/ML in healthcare: Big Promises, but….

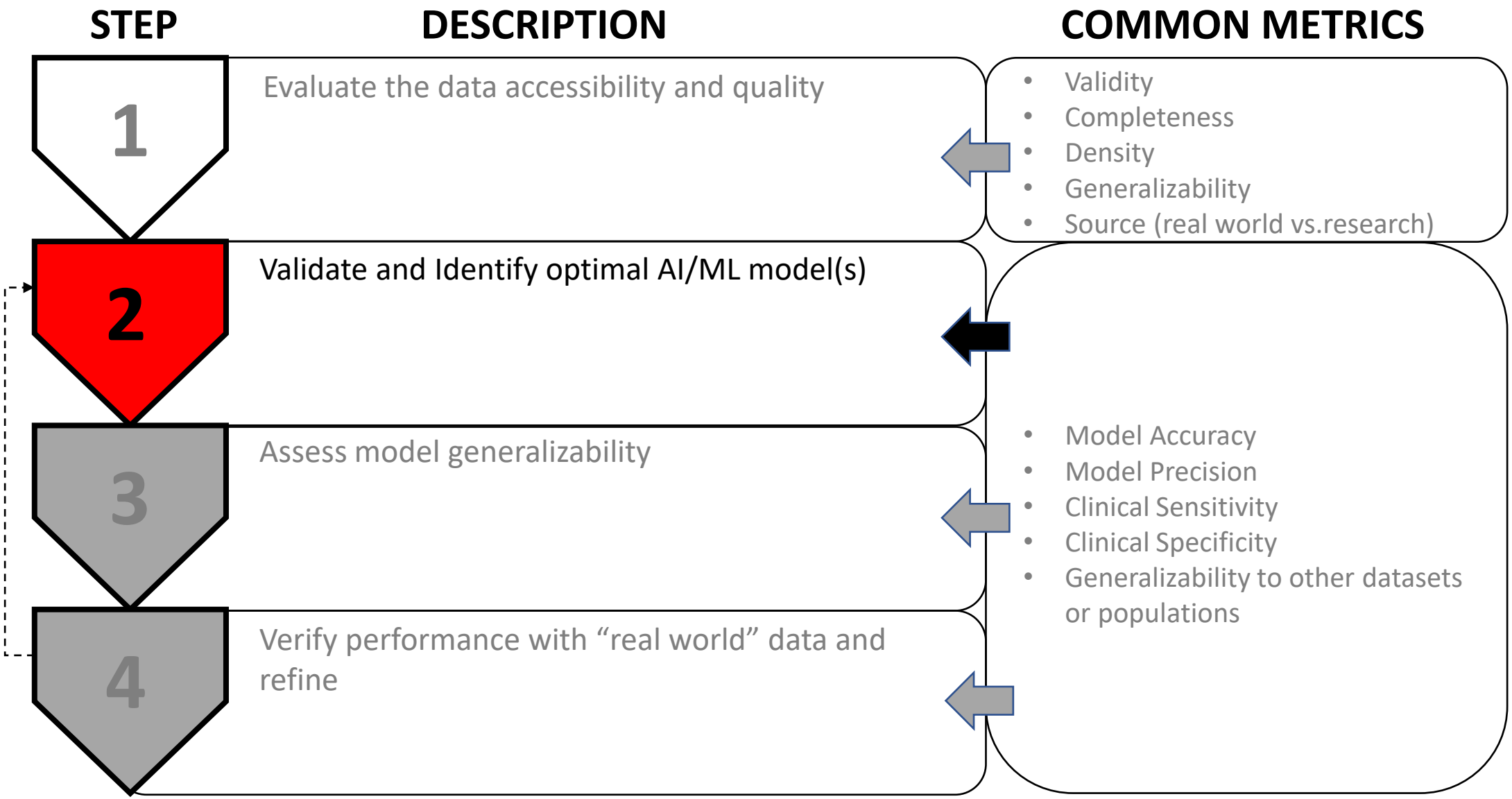


Junk in Junk out

Artificial intelligence / machine learning will only be as good as the data you provide it.

- We can’t know what we don’t know.
- How do we convert dirty data (”dirta”) to data and ultimately convert data to actionable knowledge?

Where to start with AI/ML in Healthcare?



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What do most of these ML models share in common?

- Training step
- Testing step(s)

What do all of these Supervised ML algorithms share in common?

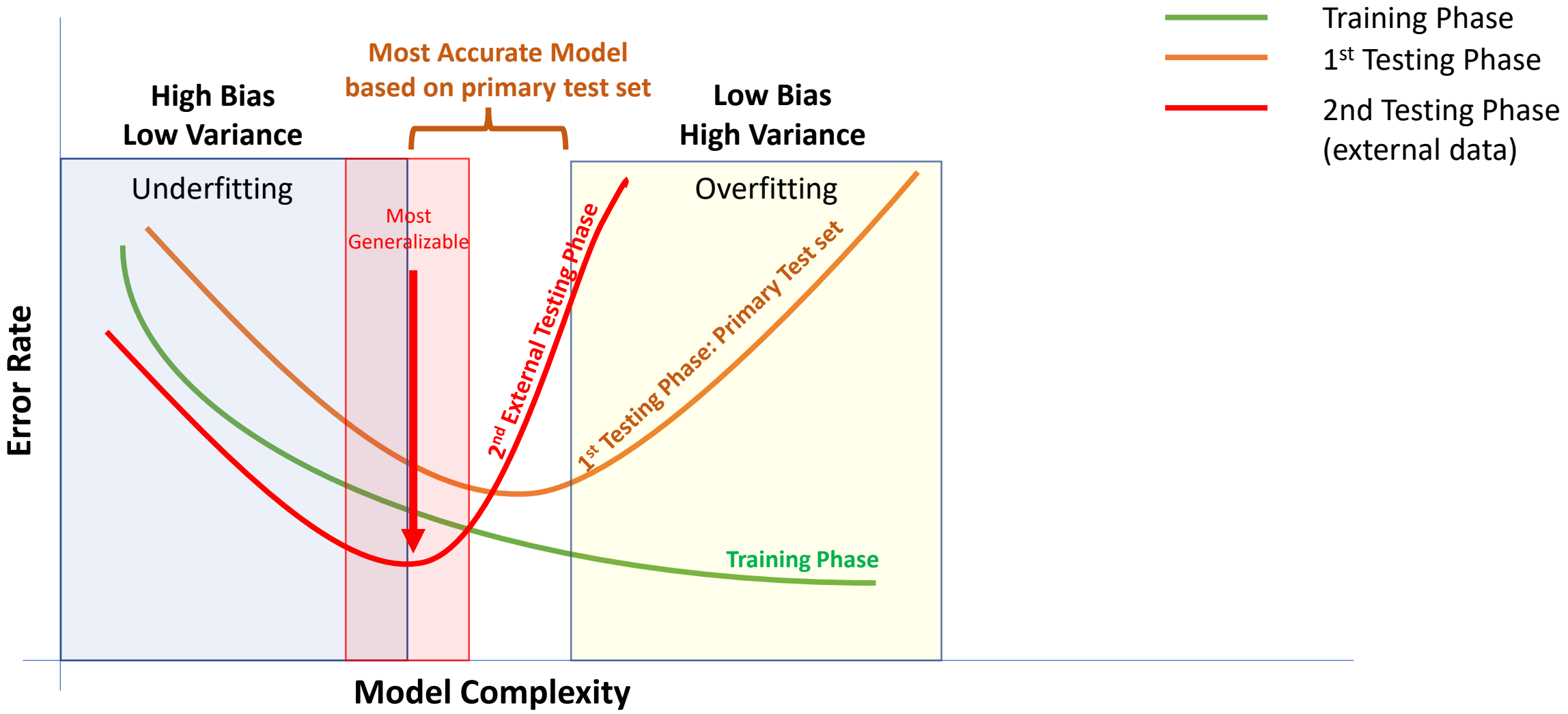
- The concept of Bias-Variance Tradeoff

The concept of Bias-Variance Tradeoff

- To make the best ML model
  - Must select the most appropriate ML algorithm
  - Must optimize the balance between Bias & Variance

- What is the Bias-Variance Tradeoff?

MODEL OPTIMIZATION: BIAS-VARIANCE TRADE-OFF



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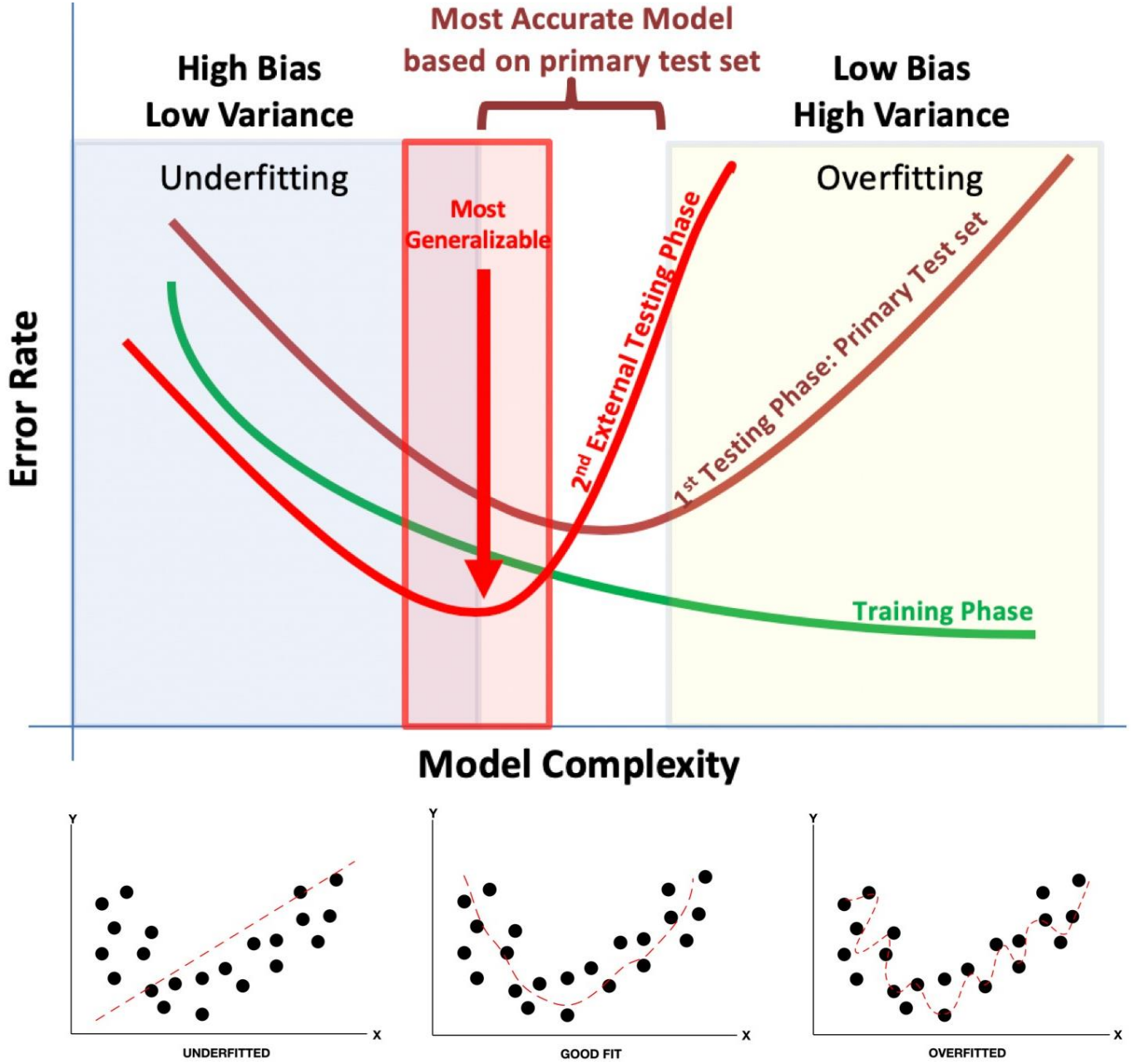

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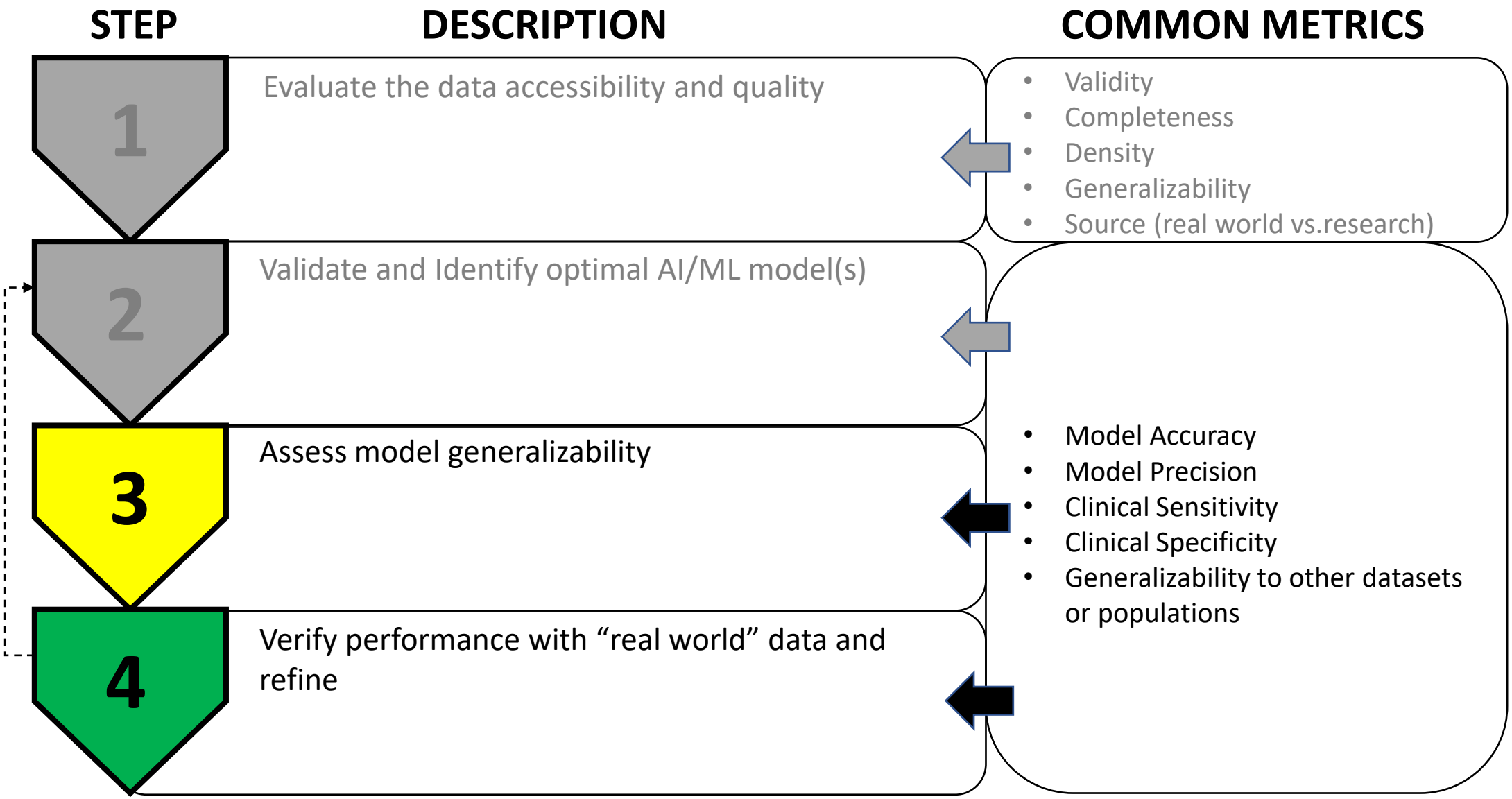
Model Performance is a Balancing Act

- How a model performs during training may not represent the “real world”.
- There is a relationship between error rate vs. data fitting.
- Balance between variance vs. bias vs. error rate is unique for each type of data (one size does not fit all).

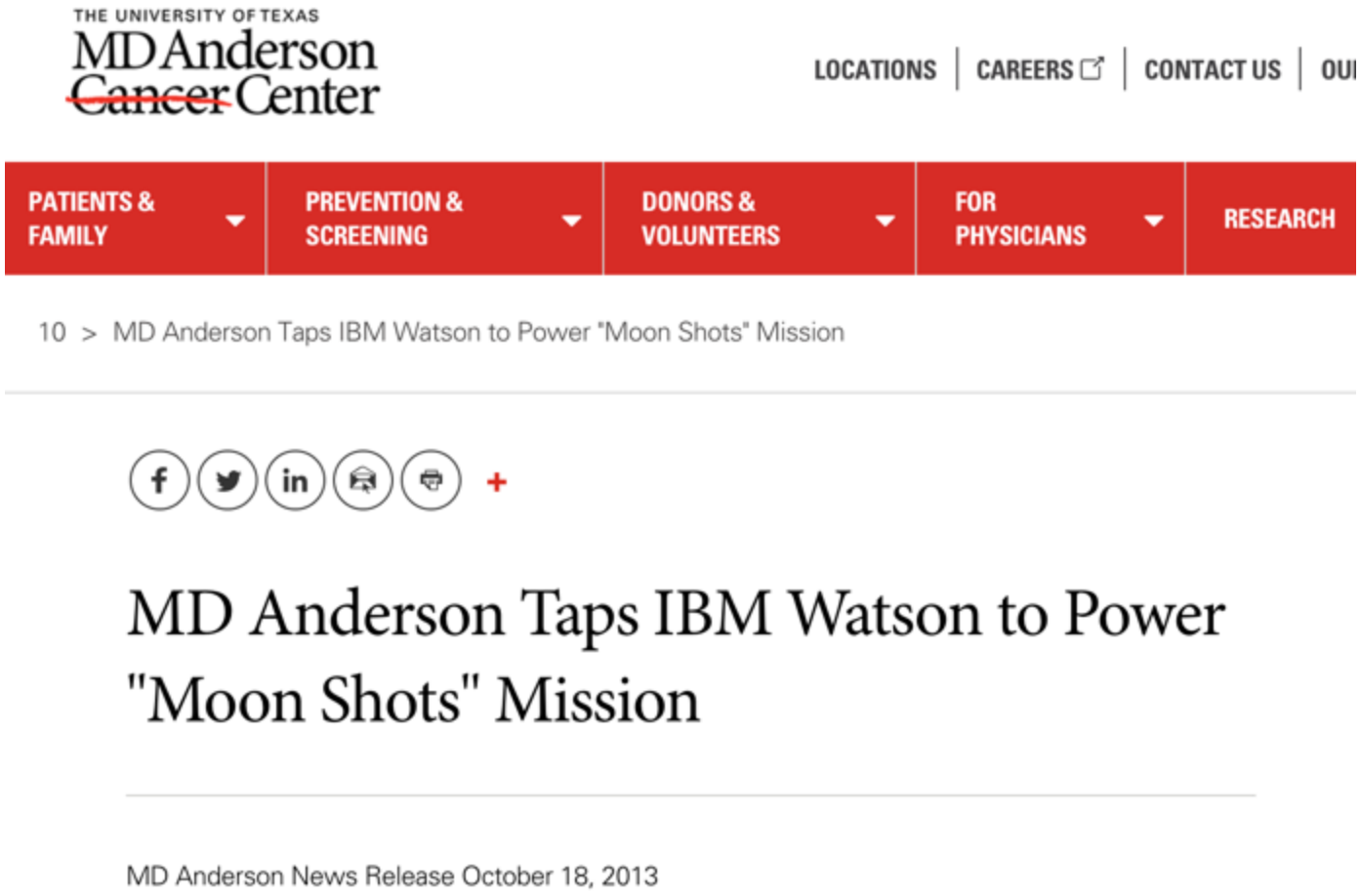
Where to start with AI/ML in Healthcare?



ML Model assessment

- Accuracy
- Precision
- ROC-AUC
- Sensitivity
- Specificity
- F1
- Brier Score, etc.

The "real world" can be a tough place!



- MD Anderson partners with IBM Watson to use "Oncology Expert Advisor" for targeting cancer therapy.

- *"A new era of computing has emerged, in which cognitive systems "understand" the context within users' questions, uncover answers from Big Data, and improve in performance by continuously learning from experiences"*

The “real world” can be a tough place!

EDITOR'S PICK | 212,548 views | Feb 19, 2017, 03:48pm

MD Anderson Benches IBM Watson In Setback For Artificial Intelligence In Medicine

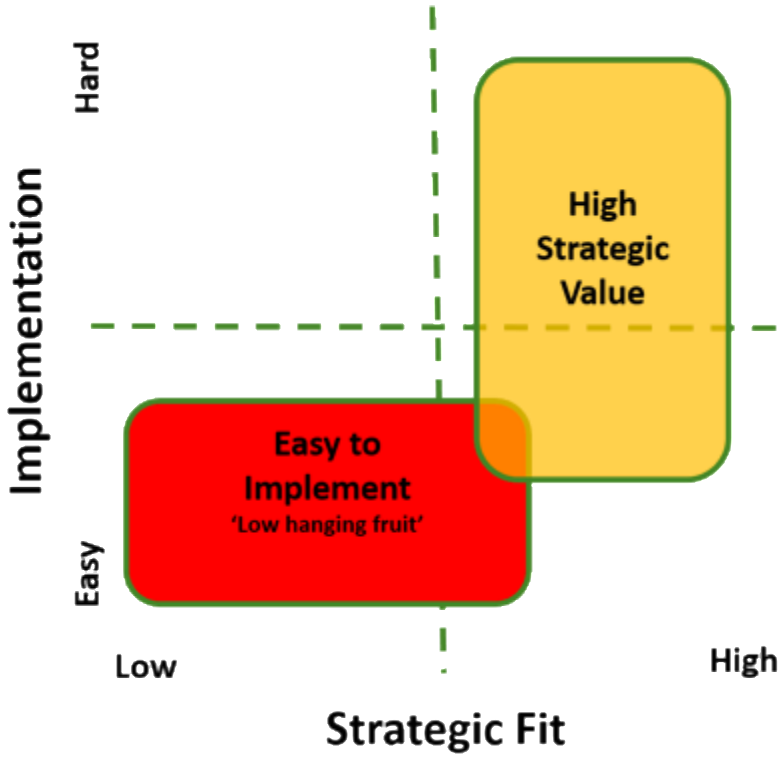
Matthew Herper Forbes Staff
Pharma & Healthcare
I covered science and medicine, and believe this is biology's century.

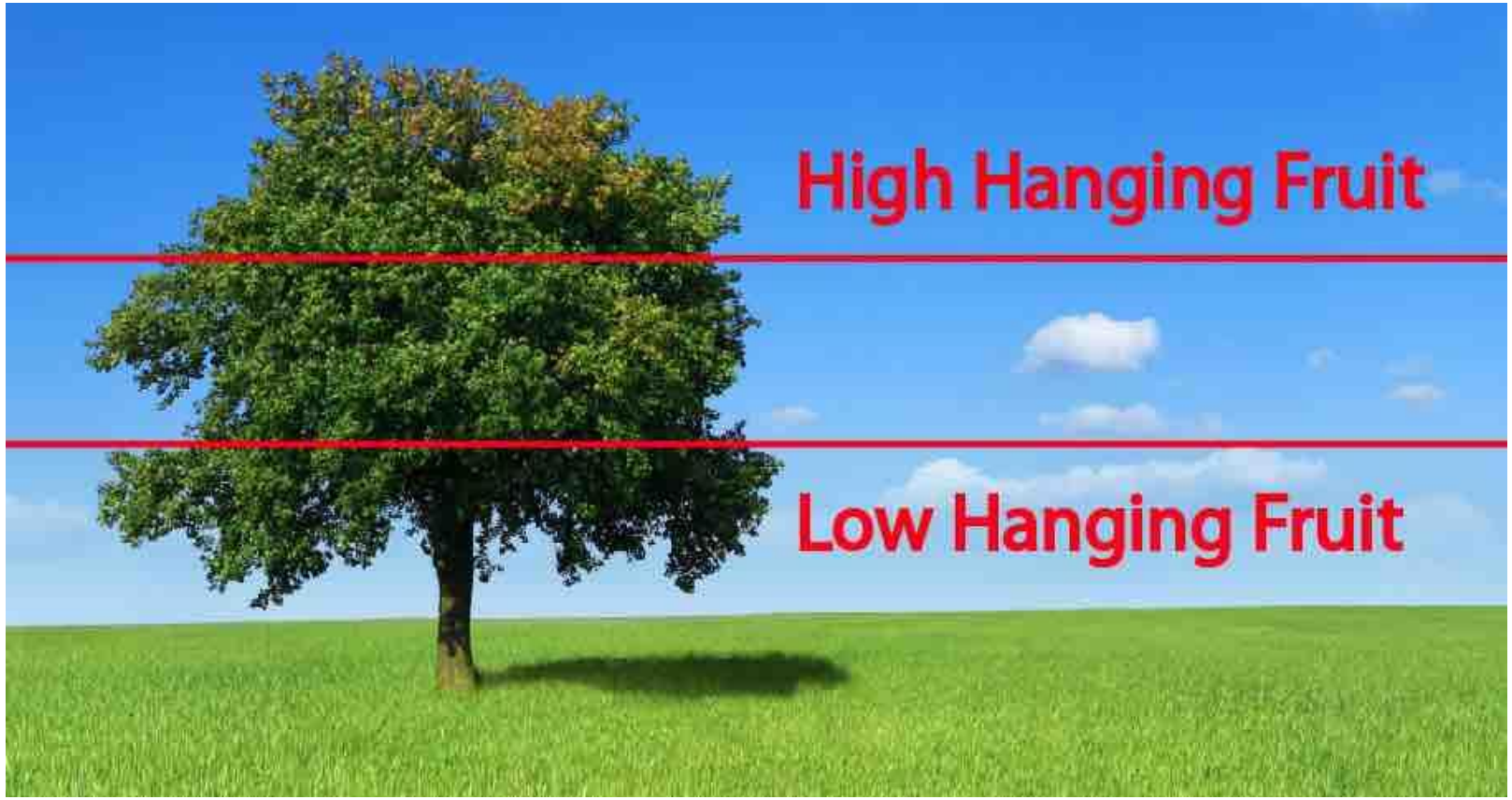
$62 million wasted without achieving goals

“Treating cancer is more complex than winning a trivia game, and the “vast universe of medical knowledge” may not be as significant as purveyors of artificial intelligence make it out to be…”

https://www.healthnewsreview.org/2017/02/md-anderson-cancer-centers-ibm-watson-project-fails-journalism-related/

Realistic Opportunities for Healthcare AI/ML?





AI/ML Enhanced Detection of Burn Related AKI: A Proof of Concept

Tran NK, Sen S, Palmieri TL, Lima K, Falwell S, Wajda J, Rashidi H. *Burns* 2019

- Goal: To build Models that predict Acute kidney Injury (AKI)

Current Standard for AKI diagnosis

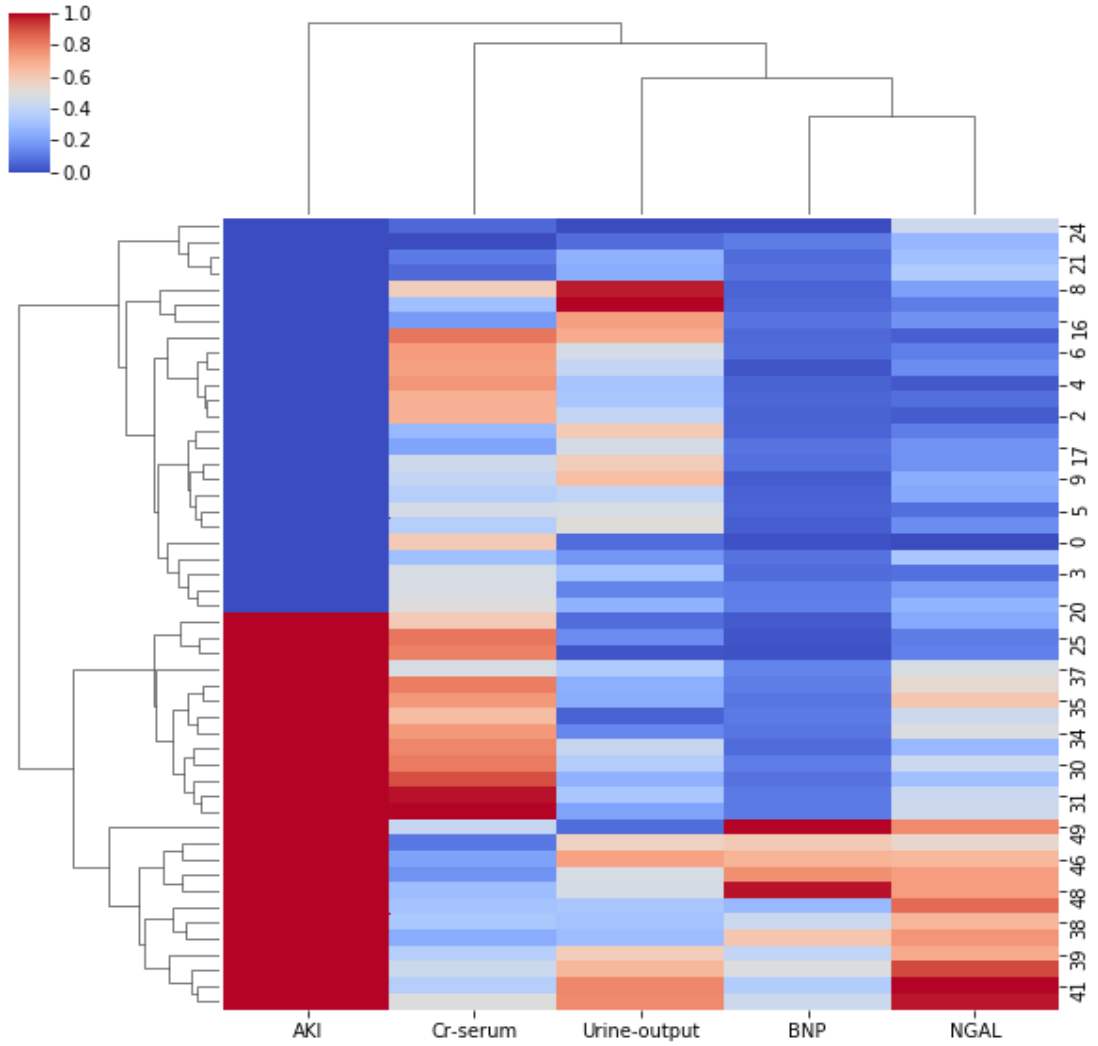
- Kidney Disease and Improving Global Outcome (KDIGO)
- Based on Serial Creatinine (Cr) and Urine Outputs (UOP)
- Takes days (since it’s on serial Cr and UOP measurements)
- Sensitivity in 50s

Here comes NGAL to the rescue

- **NGAL (Neutrophil Gelatinase Associated Lipocalin)**
- **Used in Europe**
- **Reportedly in the process of being FDA cleared in US**

AI/ML Enhanced Detection of Burn Related AKI: A Proof of Concept

Tran NK, Sen S, Palmieri TL, Lima K, Falwell S, Wajda J, Rashidi H. *Burns* 2019



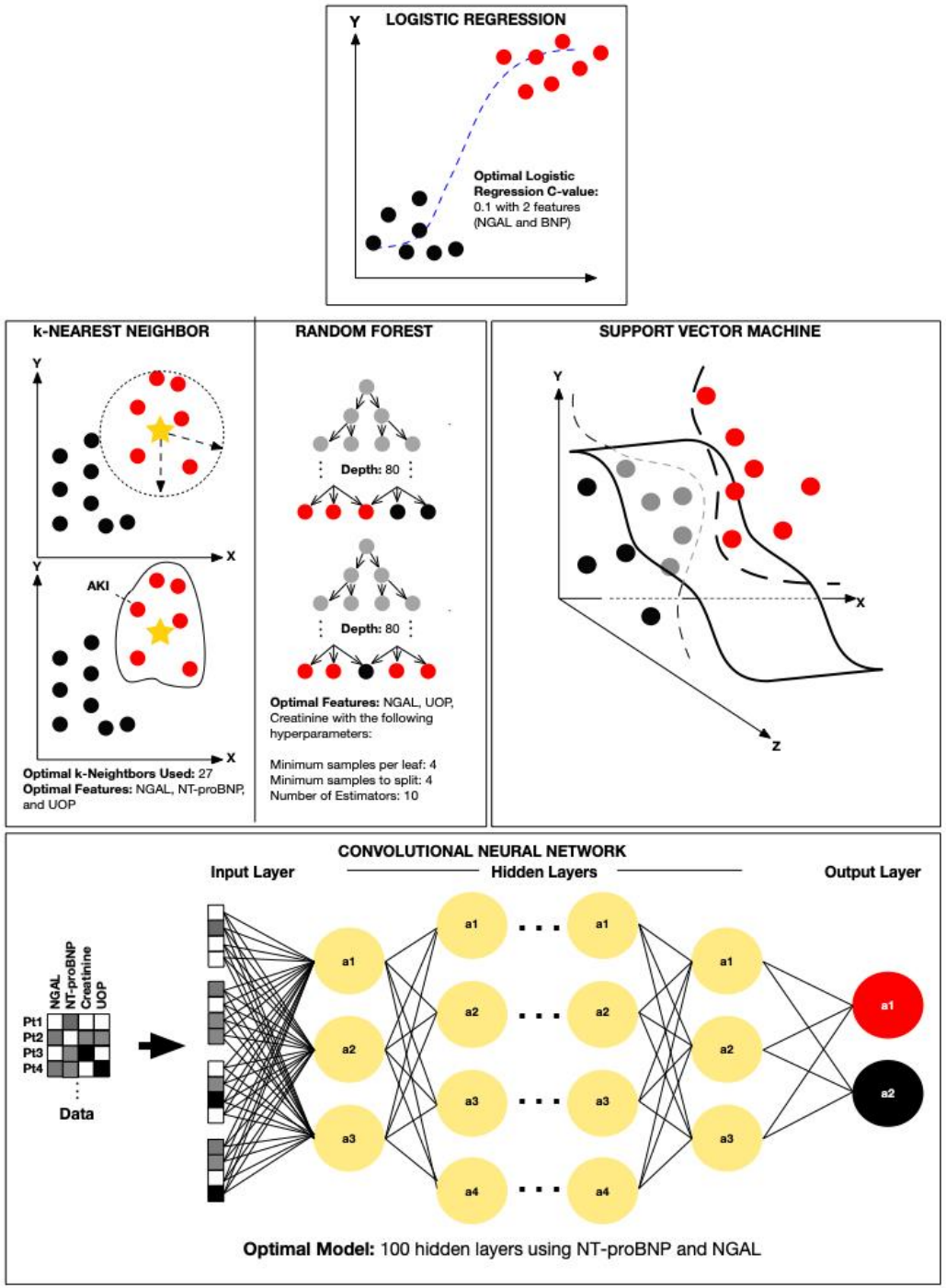
The ”Burns” population proof of concept

- Showed that ML (specifically a K-NN model) can enhance NGAL’s performance for
  - By combining it with other markers
    - BNP
    - Cr
    - UOP
- Sensitivity and accuracy in low 90s

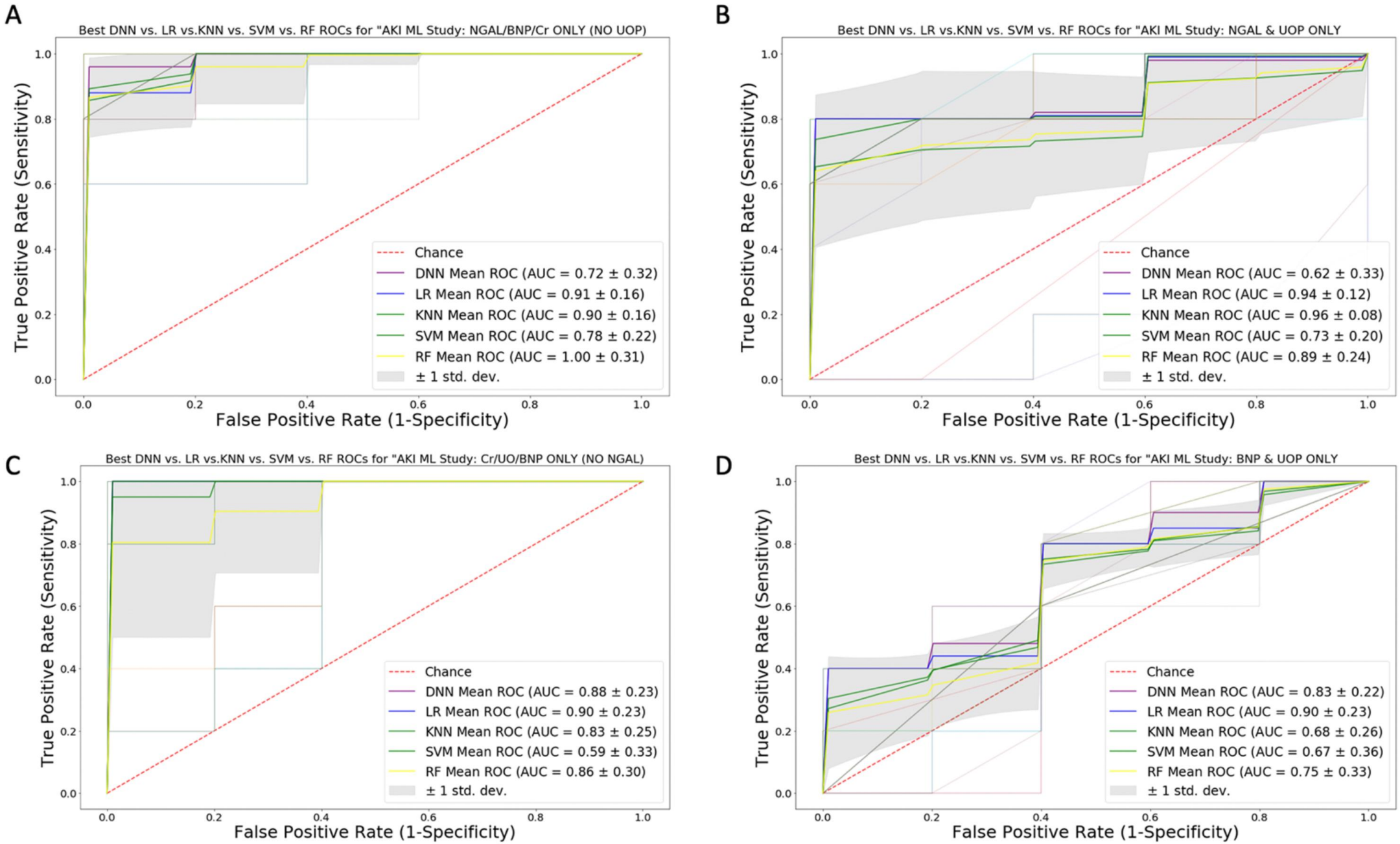
Our Follow up AKI ML study

- Can the Burns-derived AKI ML model predict AKI in Non-Burn Trauma patient population

Early Recognition of Burn- and trauma-Related Acute Kidney injury: A pilot comparison of Machine Learning techniques. Hooman H. Rashidi*, Soman Sen, Tina L. Palmieri, Thomas Blackmon, Jeffery Wajda & Nam K. Tran*. Nature Scientific Reports Jan 2020



Rashidi H. et. al.
Nature's Scientific Reports, 2020



Rashidi H. et. al. Nature's Scientific Reports, 2020

In summary

- The AKI ML models trained on the Burn Population were able to predict AKI in Non-Burn trauma and Burn patient populations
- ML enhances the predictive capability of NGAL and NGAL combined with other markers (esp. Cr and BNP)
- Most importantly:
  - **The AI/ML algorithm helped predict AKI 61.8 (32.5) hours faster than the KDIGO criteria for burn and non-burned trauma patients**

Rashidi H. et. al. Nature's Scientific Reports, 2020

Special Thanks to our Studies Collaborators

Our AKI & Sepsis ML Team

- Nam Tran
- Tina Palmieri
- Soman Sen
- Samer Albahra
- Jeff Wajda
- Hooman Rashidi

Collaborators for our other validation studies

- Joe Galante & Shawn Tejiram: MTP
- Imran Khan : TB
- Kuang yu Jen: DGF (transplant)
- Thomas Smith & William Wung (Cath results: Cardiology)
- Erin Griffin, Sharad Jain & Kristin Olson (USMLE step 1 studies)

Thank you for your attention