Stanford MEDICINE

Stanford | Center for Health Education

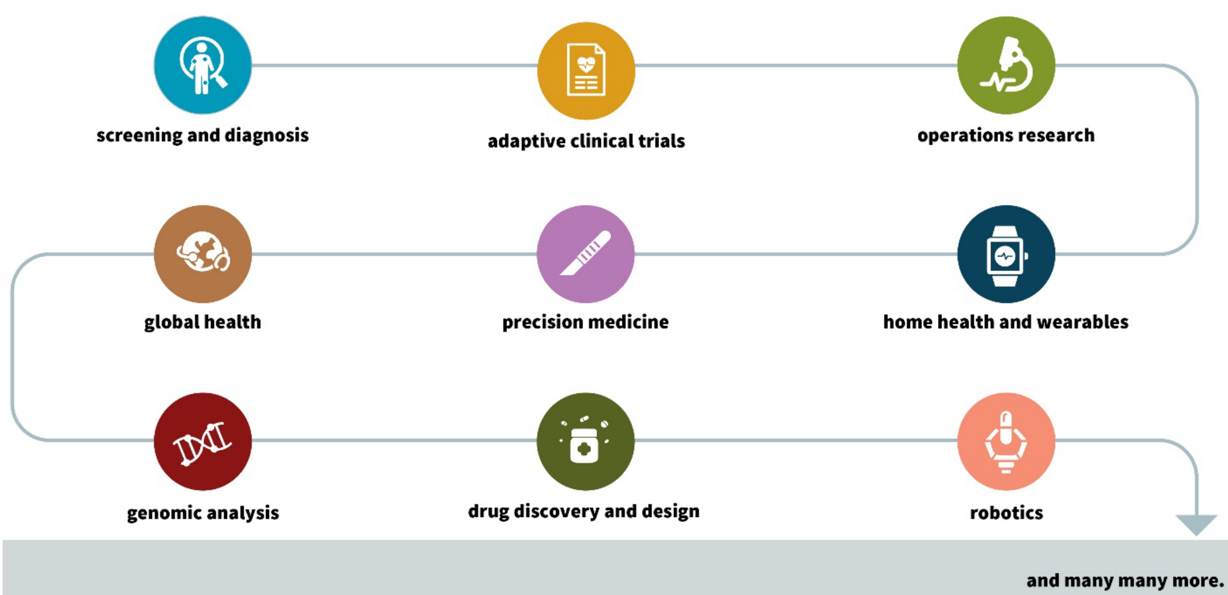
FUNDAMENTALS OF AI AND MACHINE LEARNING FOR HEALTHCARE

MODULE 1 - WHY MACHINE LEARNING IN HEALTHCARE?

LEARNING OBJECTIVES

- Recognize the importance of learning the fundamentals of clinical machine learning for and/all stakeholders in the healthcare ecosystem
- Overview of the origins of machine learning in healthcare
- Understand context and principles of common terms and definitions in machine learning
- Define important relationships between the fields of machine learning, biostatistics, and traditional computer programming
- Begin to recognize limitations to machine learning approach in healthcare
- Introduction to first principles for designing machine learning applications for healthcare

HISTORY OF MACHINE LEARNING IN HEALTHCARE



Examples of areas in which AI could have a large impact: Automated screening and diagnosis, adaptive clinical trials, operations research, global health, precision medicine, home health and wearables, genomic analysis, drug discovery and design, robotics.

Groups that will require a basic competency in both healthcare and machine learning concepts and principles: AI developers, tech companies, policy-makers and regulators, health care system leadership, pharmaceutical and device industry, frontline clinicians, ethicists, patients, patient caregivers.

In the late 1970s, Stanford became one of the first institutions to launch a program focused on applications of artificial intelligence research to biological and medical problems. It was called **SUMEX-AIM** (Stanford University Medical EXperimental computer for Artificial Intelligence in Medicine).

Projects that came out of the SUMEX-AIM project:

- AI applications to solve difficult diagnostic problems for infectious disease diagnosis
- Cancer drugs
- Diagnosis of diabetic retinopathy images
- AI Handbook Project

Progress plateaued because the ingredients required for high-performance AI algorithms did not yet exist.

The two recent ingredients that have led to newfound success in AI in medicine:

- The availability of and access to large volumes of digital healthcare data

- The development of graphical processing units (GPUs), which enable massive parallel computation

We interact with AI algorithms daily in email spam-filters, retail and e-commerce, government, finance, transportation, manufacturing, autonomous driving.

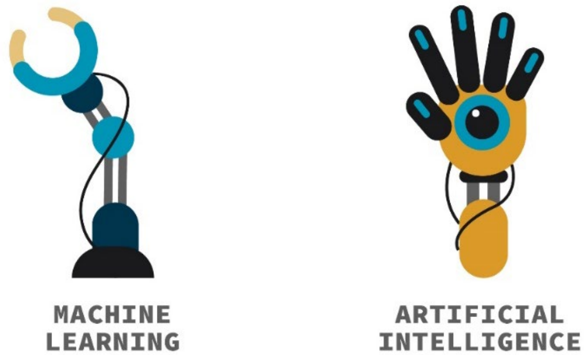
Unresolved concerns about AI in healthcare:

- Workforce displacement
- Skill atrophy
- Algorithmic and user bias
- Patient privacy
- Medical-legal responsibility
- Oversight and regulation

Early use cases of machine learning in healthcare:

- Enhancing and optimizing care delivery
- Improving information management
- Cognitive support for clinical care and prediction
- Early detection
- Risk assessment for individuals

THE MAGIC OF MACHINE LEARNING AND THE DIFFERENT APPROACHES TO SOLVING PROBLEMS



The terms "AI" and "machine learning" are often used interchangeably.

- The term "**machine learning**" is often used by scientists or data-science practitioners
- The term "**AI**" is often used for marketing purposes or for communicating to the public

In most cases, "**machine learning**" is likely more appropriate.

The modern terms of machine learning and artificial intelligence were coined in the 1950s and '60s: The theory that machines could be made to simulate learning or any other feature of intelligence.

Artificial intelligence refers broadly to the development of machine capabilities.

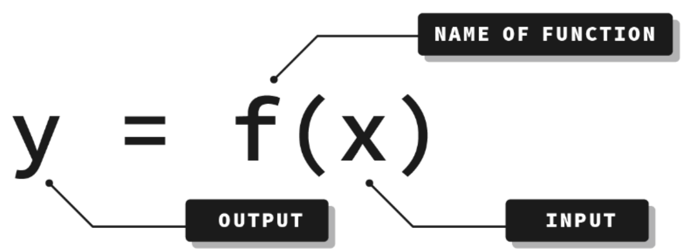
Machine learning: A family of statistical and mathematical modeling techniques that uses a variety of approaches to automatically learn and improve the prediction of a target state, without explicit programming

	Statistics	Machine Learning
Background	Statistics and data science	Computer science and engineering
Approach	Hypothesis-drive model development	Creating system that learn from data
Goal	Inferences; Relationships between variables	Optimization; Prediction accuracy
Assumptions	Some knowledge about population usually required	None

Data complexity	Usually applied to low-dimensional data	Usually applied high dimensional data; ML learns from data
Definition of Success	Discoveries that can be applied for new predictions	Resulting model produces accurate predictions without predefined characteristics

Computer Programming vs. Machine Learning

- All computer interactions consist of an input, a function, and an output



- Computer programming
    - The computer programmer knows what the input and output looks like
    - The computer programmer writes a function that processes an input and produces an output
    - The programming and potential decisions are part of a manual effort to deliberately encode the steps or knowledge needed to provide automated output
    - Often called "rules-based systems"
- Machine learning
    - The function that maps inputs to outputs can sometimes too complex to code manually
    - In machine learning, the computer learns the function that maps inputs to outputs
    - Instead of relying on a computer programmer to come up with the rules of the function, we instead leverage existing input-output pairs to enable function learning. This is called "training" the statistical model

Project Success:

- With biostatistics, success is chiefly learning new insights about the problem based on statistical assumptions, and building models based on those insights
- With Machine Learning, success is chiefly defined as creating the most accurate and reproducible model for the given task

Methodology in Machine Learning vs. Traditional computer programming:

- Machine Learning: Function learning based on the data
- Traditional computer programming: Function writing using manually coded rules

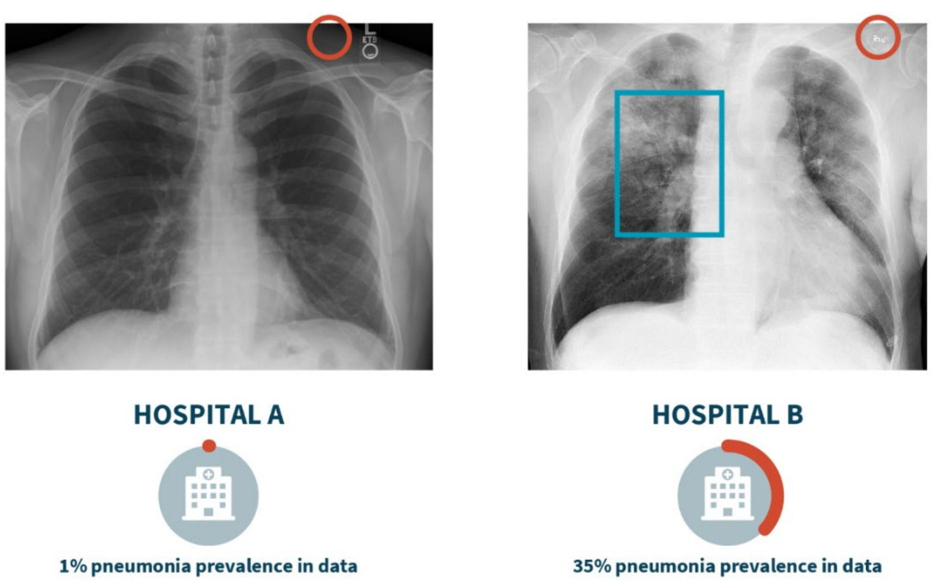
Machine learning relies heavily on pattern recognition and the theory that computers can learn useful relationships in data towards an output without being explicitly programmed.

“Learning” in machine learning is the reference of the desire to create a model that can learn like a human, through experience, and achieve an objective with little to no external (human) assistance.

Machine learning is often anthropomorphized– however, the algorithms behind the scenes use mathematical formulations to represent models and strive to learn parameters in these formulations, by tracking them back from a dataset of observations.

Machine learning has its weaknesses:

- Bias
    - Tank Example: Learning the background and the weather, not the object



- A machine learning model trained to identify pneumonia in Chest X-rays may rely on artifacts in the images in order to determine which hospital the X-rays came from. If one hospital sees much higher prevalence than another, the model may "cheat" and predict pneumonia cases with reasonable accuracy, despite not learning anything about pneumonia at all

- Data Formatting
    - Hospitals have been collecting data for years; however, it may not be usable
    - Medical data is often generated in a discontinuous timeline
    - Medical shelf-life

It is critically important to begin with an informed question. This may be from the medical literature or pressing clinical question, but you have to start with a question that include the detailed analysis of the output of your future model and the available actions. Especially in medicine, machine learning is best understood as a means to an end that has consequences.

CITATIONS AND ADDITIONAL READINGS

Liu, Y., Chen, P. H. C., Krause, J., & Peng, L. (2019). How to read articles that use machine learning: users' guides to the medical literature. *Jama*, *322*(18), 1806-1816. https://jamanetwork.com/journals/jama/fullarticle/2754798

Matheny, M. E., Whicher, D., & Israni, S. T. (2020). Artificial Intelligence in health Care: A report from the National Academy of Medicine. *Jama*, *323*(6), 509-510. https://jamanetwork.com/journals/jama/fullarticle/2757958

Office, U. (2020, January 21). Artificial Intelligence in Health Care: Benefits and Challenges of Machine Learning in Drug Development [Reissued with revisions on Jan. 31, 2020.]. https://www.gao.gov/products/GAO-20-215SP

Schwartz, W. B. (1970). Medicine and the computer: the promise and problems of change. In *Use and Impact of Computers in Clinical Medicine* (pp. 321-335). Springer, New York, NY. https://www.nejm.org/doi/full/10.1056/NEJM197012032832305