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The Path Forward for AI in Healthcare: Bridging Technology and Nursing Gaps

Artificial intelligence (AI) is a broad term that captures a wide variety of theoretical questions and practical applications of computer systems. A subset of AI, particularly in healthcare settings, seeks to learn patterns from data and then use those patterns to make predictions or inform human experts. This handout gives definitions and examples to explain some common terminology.

Suppose we want to create an automated system that predicts whether a patient in the ICU is at risk of septic shock.[1] With access to thousands or millions of patient records, such a system might be able to learn patterns that reliably predict septic shock before human-interpretable symptoms present. This system could benefit from recent advances **machine learning** research; while simple models such as a linear regression have benefits, **neural networks** can learn more complicated patterns.

Machine learning (ML) is the study of computational methods that use data to discover or predict patterns. A conventional method like linear regression can be considered an ML method because it learns its **parameters** from data. However, a linear regression model can only learn linear patterns between the inputs and the outputs. Decision trees, random forests, and **neural networks** are all machine learning methods that are better suited to learning complicated nonlinear patterns that might help detect sepsis.

The word **model** can be used in multiple ways in an ML context. As a verb, it can just mean "discover patterns using ML"; e.g., one could say, "we are going to use a neural network to *model* this data." As a noun, it can refer to a specific ML implementation in use. For example, one could say, "our neural network *model* can accurately predict sepsis."

A machine learning **dataset** can be any collection of data, but often it is characterized by specific inputs and outputs that are paired together. A simple linear regression that predicts `y = m x + b` would learn from a dataset of `(x, y)` pairs. A dataset for predicting septic shock would require collecting, cleaning, and formatting patient records.

Parameters are the numbers inside a model that are updated while it learns. In a simple linear regression `y = m x + b`, the slope `m` and the intercept `b` are the only two parameters. **Training** or **fitting** a model refers to finding good parameter values that capture patterns in a dataset. An **algorithm** typically refers to the step-by-step process that allows a model to learn its parameters from data. Sometimes, the word algorithm is used interchangeably with "model."

Neural networks are a class of machine learning methods that can range in complexity from hundreds to billions of parameters. While such models are powerful, they often require far more data than simpler models. The neural network model behind ChatGPT,[2] has 175 billion parameters and was trained on a dataset of text containing roughly 400 billion words. **Deep learning** generally refers to any machine learning that uses neural networks. "Deeper" neural networks are those with more parameters.

Structured data can be collected and represented in a simple structure (e.g., a table or a spreadsheet). A patient's age would be considered a structured variable, because every patient has an age represented by a single number. This structure can make it easy to include in a model; for example, a linear model for sepsis might show that older patients have higher risk.

Unstructured data refers to data sources such as free text notes or clinical images. While neural networks can successfully learn patterns from unstructured data, many simpler models cannot. We can easily compare patients via structured variables – e.g., whether one patient is older than another. It is much harder for a computational model to compare two patients based on unstructured variables – e.g., which patient has a "worse" X-ray might be complex.

Natural language processing is the application of machine learning to natural language, often with insights drawn from linguistics. Examples include automatic translation systems, speech recognition systems, and ChatGPT.

Image recognition or **computer vision** is the application of machine learning to images and videos. Such methods have been used in cardiac imaging, for example to automatically predict coronary artery disease from X-rays or CT scans.[3]

A model for predicting septic shock is an example of **supervised learning** because it learns from both inputs (data from each patient) and outputs (whether each patient had septic shock). The model is trained to predict outputs from inputs, and we can evaluate whether it correctly predicts sepsis for new patients. ML models can **overfit**, or simply memorize the training data, rather than learn general patterns that can accurately predict future labels.

An **unsupervised learning** approach learns general patterns from inputs alone. For example, researchers trained an unsupervised model on data from patients diagnosed with sepsis; the model learned to differentiate four unique clinical phenotypes with different symptoms and mortality rates.[4]

A major barrier to using ML in clinical care is that ML models are often uninterpretable – unlike a human expert, they typically cannot justify their predictions with a rationale. **Augmented intelligence** focuses on using ML to supplement human decision-making, rather than replace it altogether.[5]

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