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# Machine Learning in Medicine: A Primer

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**ABSTRACT**
Machine learning is the field that focuses on how computers learn from data. Today, machine learning is playing an integral role in the medical industry. This is due to its ability to process huge datasets beyond the scope of human capability, and then convert the data analyzed into clinical insights that aid physicians in providing care. Machine learning is a powerful, relatively easy to implement tool with numerous possibilities to enhance medical practice. The applications of machine learning in medicine are advancing medicine into a new realm. Therefore, educating the next generation of medical professionals with machine learning is essential. This paper provides a brief introduction to applying machine learning in medicine.

***KEYWORDS:*** *machine learning, computer algorithms, artificial intelligence, medicine, healthcare*

## INTRODUCTION

In today's information era, an organization should deduct meaningful information from their data obtained in order to be able to compete. Like other fields, medicine is going through data revolution. With the emergence big data, the explosion in data available for analysis is as evident in healthcare as anywhere else. Clinical medicine has always required doctors to handle enormous amounts of data. Diagnostic and imaging techniques generate such an incredible amount of data. Machine Learning techniques emerged as an objective tool to assist practitioners to diagnose certain conditions and make clinical decisions [1].

Most computer-based algorithms in medicine are "expert systems." Expert systems work the way an ideal medical student would: they take general medical principles and apply them to patients. Machine learning handles problems as a doctor progressing through residency might: by learning rules from data. It is a branch in computer science that employs knowledge from artificial intelligence, optimization, and statistics to develop algorithms. It focuses on how computers learn from data. Such an algorithmic method allows data to speak for themselves.

Although machine learning (ML) is widely used in other industries, such as retail and banking, it is not routine in medicine because of the complexity and limited availability of data. In medicine, the bottom line is to use machine learning to augment patient care, save more lives, improve more care, while saving money at the same time. ML can automate the manual processes carried out by practitioners, which are usually time-consuming and subjective. Thus, using ML can save time for practitioners and provide unbiased, repeatable results.

## MACHINE LEARNING

*Machine learning (ML) is the discipline that gives computers the ability to learn without being explicitly programmed.* The term "machine learning" (ML) was initially coined in 1959 by Arthur Samuel, a computer scientist. Machine learning (or statistical learning) is part of artificial intelligence. As illustrated in Figure 1, ML may also be regarded as a sub-disciplines of data science [2]. It assists computers in estimating future events and modelling based on experiences gained from previous information. Machine learning (ML) focuses on how computers "learn" from data. It allows computers to learn from past examples and to detect hard-to-discern patterns from large data sets. An example of how a machine learner is trained is shown in Figure 2 [3]. It describes a class of algorithms which learn model parameters from a set of training data with the purpose of accurately predicting outcomes for previously unseen data. ML is a marriage between statistics and computer science [4,5].

There are two types of learning: supervised learning and unsupervised learning. Supervised learning focuses on classification and prediction. It involves building a statistical model for predicting or estimating an outcome based on one or more inputs. It is often used to estimate risk. Supervised ML is where algorithms are given training data. Learning from data is used when there is no theoretical or prior knowledge solution, but data is available to construct an empirical solution. Supervised ML is increasingly being used in medicine such as in cardiac electrophysiology. In unsupervised learning, we are interested in finding naturally occurring patterns within the data. Unlike supervised learning, there is no predicted outcome. Unsupervised learning looks for internal structure in the data [6]. Unsupervised learning algorithms are common in neural network models. A common application of such a process is to explore interrelationships between genetics, biochemistry, histology, and disease states.

The most commonly used ML algorithms include neural networks, support vector machines, and decision trees. Other ML techniques include classification, regression, and clustering. There are some software packages that do some form of machine learning [7].

There is significant interest in the use of ML in medicine. ML techniques can 'learn' from the vast amount of medical data and assist clinical decision making. They are often suitable for detecting complex patterns in large and noisy data sets. For a ML system to be useful in solving medical diagnostic tasks, the following features are desired: good performance, the ability to appropriately deal with missing data, the transparency of diagnostic knowledge, the ability to explain decisions, and the ability of the algorithm to reduce the

number of tests necessary to obtain reliable diagnosis [8]. However, success in using ML is not always guaranteed. Like any technique, an appreciation of the limitations of ML algorithms is crucial.

**APPLICATIONS OF ML IN MEDICINE**

Machine learning techniques have been currently applied in the analysis of data in various fields including medicine, finance, business, education, advertising, cyber security, and energy applications. They were first applied to medicine with the use of electronic health records. They emerged in the medical sciences as clinical decision-support techniques to improve sensitivity, disease detection, and monitoring. There are almost limitless opportunities for machine learning in medicine. We can consider some popular areas in medicine that have benefited or might benefit from machine learning approaches. Both supervised and unsupervised can be applied to clinical data sets for the purpose of developing robust risk models and redefining patient classes. Few applications of machine learning include [9, 10]:

- **Oncology:** Almost all works in this field apply machine learning techniques, which perform deep statistical analysis of a set of clinical cases supported by gene expression data. Researchers are using deep learning to train algorithms to recognize cancerous tissue at a level comparable to trained physicians. Google has developed a machine learning algorithm to help identify cancerous tumors on mammograms. Stanford is using a deep learning algorithm to identify skin cancer. Lately machine learning has been applied to cancer prognosis and prediction [3].
- **Pathology:** Pathology is the medical specialty that is concerned with the diagnosis of disease. Machine vision and other machine learning technologies can enhance the efforts traditionally left only to pathologists with microscopes.
- **Genomic Medicine:** One of the goals of genomic medicine is to determine how variations in the DNA of individuals can affect the risk of different diseases. Machine learning can help to model the relationship between DNA and the quantities of key molecules in the cell [11].
- **Predicting Chronic Disease:** Machine learning can help hospital systems identify patients with chronic disease, predict the likelihood that patients will develop chronic disease, and present patient-specific prevention interventions. For example, ML approaches have significant potential in prediction of acute exacerbations in asthma patients [12].
- **Personalized Medicine:** This is individualization, recognition of the micro-variables within a patient that may cause them to be different from their peers. ML for personalized medicine is a growing area. It involves the ability to draw on large data sets and predictive models allows for clinicians to more confidently diagnose, predict and treat their patients.
- **Reduce Readmissions:** Machine learning can reduce readmissions. Clinicians can receive daily guidance as to which patients are most likely to be readmitted and how they might be able to reduce that risk.

These advances would have been unimaginable without machine learning. Other areas include surgery, radiology, emergency medicine, traditional medicine, mental health, psychiatry, ophthalmology, and optometry. ML provides methods, techniques, and tools that can help solve diagnostic and prognostic problems in various medical domains. Machine learning techniques have been successfully applied to different branches of medicine as a tool to help diagnose diseases. ML algorithms have immense potential to enhance diagnostic and intervention research in smoking, depression, asthma, and chronic obstructive pulmonary disease (COPD). ML is also being used for data analysis and interpretation of continuous data used in the Intensive Care Unit [13]. With time, the healthcare environment will become more and more reliant on computer technology and ML capabilities will reach into all aspects of medicine.

**BENEFITS AND CHALLENGES**

Machine accuracy will soon exceed that of humans. Machine learning can be trained to look at images, identify abnormalities, and point to areas that need attention. It can be helpful in alerting a physician or a patient's family when things begin to go wrong. It can lead to more accurate diagnostic algorithms and individualize patient treatment. It has the potential to positively change the role of physicians in patient care.

While ML has the potential to significantly help medical practice, some negative consequences that may arise from using ML decision support in medicine. Critical voices have emerged warning of potential problems surrounding the use of ML [14]. Ethical and regulatory concerns about health data have expressed for long. ML algorithms use data that are subject to privacy protections, requiring that their developers pay close attention to ethical and regulatory restrictions. Data used to train algorithms should have the necessary use authorizations, but determining which data uses are permitted for a given purpose is not an easy [15]. People are understandably hesitant when they learn that healthcare professionals are being replaced by algorithms. Machine learning algorithms often require thousands of observations to reach acceptable performance levels. How doctors handle these challenges will create winners and losers in medicine.

**CONCLUSION**

Machine learning should no longer be regarded as a futuristic concept but a real-world tool that can be deployed today. Machine learning is critical for anyone practicing medicine in the 21st century. Today, ML techniques are suited for analyzing medical data and serving as tools for medical diagnosis in a variety of medical domains. They will become indispensable tools for clinicians who truly seek to understand their patients.

If technology is to improve medicine in the future, the data provided to doctors needs to be enhanced by the power of analytics and machine learning. This will help them make better decisions about patient diagnoses and treatment option. Machine learning represents the next wave in advancing modern medicine. The next generation of medical professionals should be equipped with the right ML techniques that will enable them to become part of this emerging revolutionary technology [16]. For more information on ML, see the book in [17] and other books available at Amazon.com

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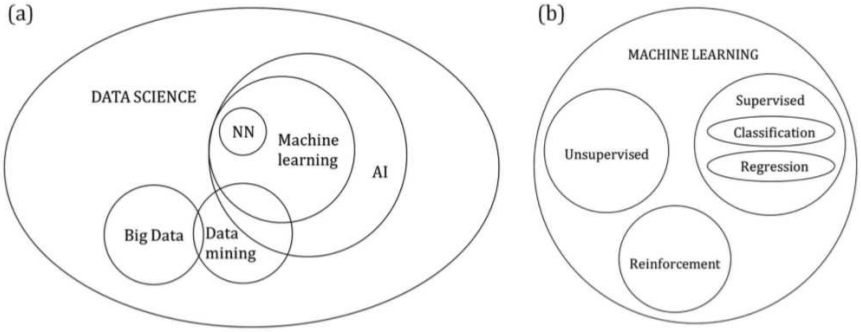


Figure 1 (a) Data science, (b) Machine learning [2].

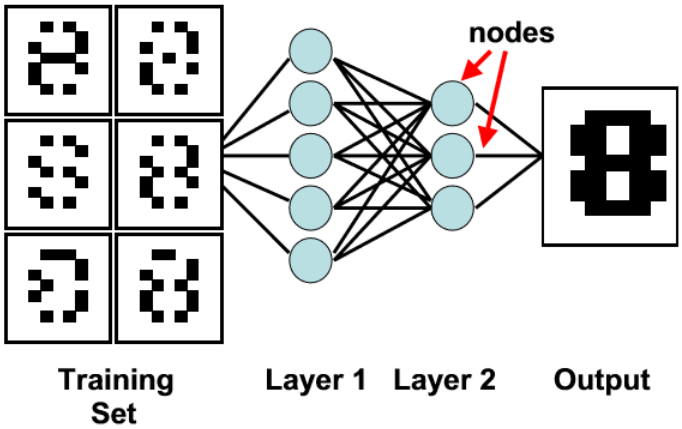


Figure 2 an example of how a machine learner is trained [3].