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An Analysis on Applications of Machine Learning Tools, Techniques and Practices in Health Care System

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Abstract - Machine Learning (ML) helps to perform predictive analysis or pattern recognition on large data. In ML computers are trained to learn from, analyze and act on data without being explicitly programmed. Machine learning is the fastest growing field in computer science and health informatics is of greatest challenge in it. The goal of ML is to develop algorithms which can learn and improve over time and can be used for predictions. It offers a range of alerting and risk management decision support tools, targeted at improving patients' safety and healthcare quality. With the need to reduce healthcare costs and the movement towards personalized healthcare, the healthcare industry faces challenges in the core areas namely, electronic record management, data integration, and computer aided diagnoses and disease predictions. Machine learning offers a wide range of tools, techniques, and frameworks to address these challenges. This paper depicts the study on various machine learning prediction techniques and tools in practice. An analysis on the applications of machine learning prediction techniques in various domains are discussed here by highlighting on its prominence role in health care industry.

Keywords - Prediction, Predictive Analytics, Predictive Models, Machine Learning, Machine Learning Tools and Techniques, Health Care

I. INTRODUCTION

Machine Learning (ML) is a core, transformative way by which we're rethinking everything we're doing. Machine Learning techniques and its applications are in usage across all our daily practice, be it search, ads, YouTube or Play. Most industries working with large amounts of data have recognized the importance of machine learning technology. By gathering insights from these data, organizations are able to work more efficiently or gain an advantage over competitors. Innovative predictive models have been applied successfully with machine learning algorithms, tools and techniques in several domains. Information Technology is contributing in significant ways to enhance health care delivery and to improve the quality of human life. Medical or Health Informatics scientific field deals with storage, retrieval and optimal use of medical information, data and knowledge for problem solving and decision making. Technology in Health has an immense development over the years in information gathering, treatments, communications and research. Health Care informatics, a multi-disciplinary field has become synonymous with the technological advancements and data handling challenges by applying machine learning techniques.

II. PREDICTIVE ANALYTICS

Predictive Analytics is an advanced analytics used to make predictions about unknown future events. Predictive Analytics uses many techniques from data mining, statistics, modeling, machine learning and artificial intelligence to analyze current findings to make predictions about future. The predictor is the main entity in predictive analytics which is defined as a variable used for the measurement of future behavior. With the help of the predictors, upcoming probabilities are forecasted with highly reliable results. The approaches used to conduct predictive analytics can be classified into machine learning techniques and regression techniques. Machine learning techniques have become increasingly popular in conducting predictive analytics due to their outstanding performance in handling large scale datasets with uniform characteristics and noisy data. Observational studies show that machine learning is appropriate to build predictive models by extracting patterns from large datasets. These models are used in predictive data analytics applications including price prediction, risk assessment, predicting customer behavior, and document classification.

III. MACHINE LEARNING

Machine Learning: the classic definition is "A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P, if its performance at tasks in T, as measured by P, improves with experience E" [14]. Machine learning is a branch of artificial intelligence employs a variety of statistical, probabilistic and optimization techniques that allows computers to "learn" from past examples and to detect hard-to-discern patterns from large, noisy or complex data sets [16]. Using algorithms that iteratively learn from data, machine learning allows computers to find hidden insights without being explicitly programmed where to look.

A. Machine Learning's Strategic Role in Predictions

Enterprises are striving to find greater meaning in the substantial amounts of data they generate and save every day. Machine learning is providing the essential algorithms, applications, and frameworks to bring greater predictive accuracy and value to enterprises' data sets and contributing to diverse strategies succeeding. Machine learning techniques are designed to seek out opportunity to optimize decisions based on the predictive value of large-scale data sets. Machine learning is proving to be effective at handling predictive tasks including defining which behaviors have the highest tendency to drive preferred outcomes [9].

B. Steps to Apply Machine Learning to Data

The data associated with the problem is to be processed. Brett Lantz [3] illustrated the steps to be followed in learning process.

1. Collecting data: Whether the data is written on paper, recorded in text files and spreadsheets, or stored in an SQL database, the data need to be gathered in an electronic format suitable for analysis. This data will serve as the learning material an algorithm uses to generate actionable information.

2. Exploring and preparing the data: The quality of any machine learning project is based largely on the quality of data it uses. This step in the machine learning process tends to require a great deal of human intervention. Statistic suggests that 80 percent of the effort in machine learning is devoted to data. Much of this time is spent learning more about the data and its nuances during a practice called data exploration.

3. Training a model on the data: The specific machine learning task will inform the selection of an appropriate algorithm, and the algorithm will represent the data in the form of a model.

4. Evaluating model performance: Because each machine learning model results in a biased solution to the learning problem, it is important to evaluate how well the algorithm learned from its experience. Depending on the type of model used, the accuracy of the model can be evaluated using a test dataset.

5. Improving model performance: If better performance is needed, it becomes necessary to utilize more advanced strategies to augment the performance of the model. Sometimes, it may be necessary to switch to a different type of model altogether.

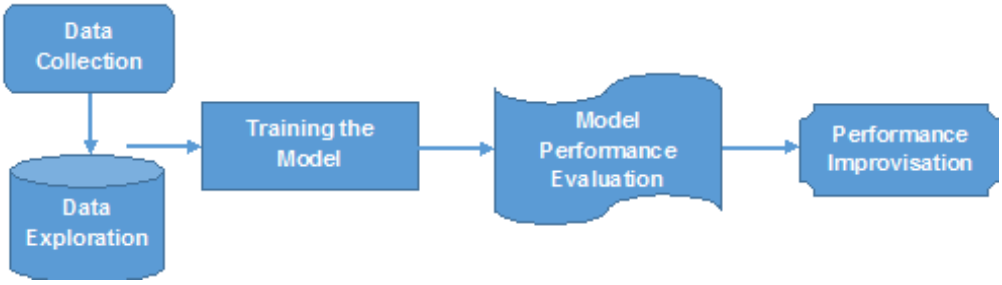

Fig. 1 Learning Process

After these steps have been completed, if the model appears to be performing satisfactorily, it can be deployed for its intended task. The model may be utilized to provide score data for predictions, for projections of financial data, to generate useful insight for marketing or research, or to automate tasks. The successes and failures of the deployed model might even provide additional data to train the next generation model.

Machine learning is closely related to computational statistics, a discipline which focuses in prediction through the use of computers. ML methods ties to mathematical optimization, which delivers methods, theory and application domains to the field.

IV. MACHINE LEARNING – TYPES

There are many algorithms available in Machine Learning and they are classified into four broad categories, depending on the nature of the learning.

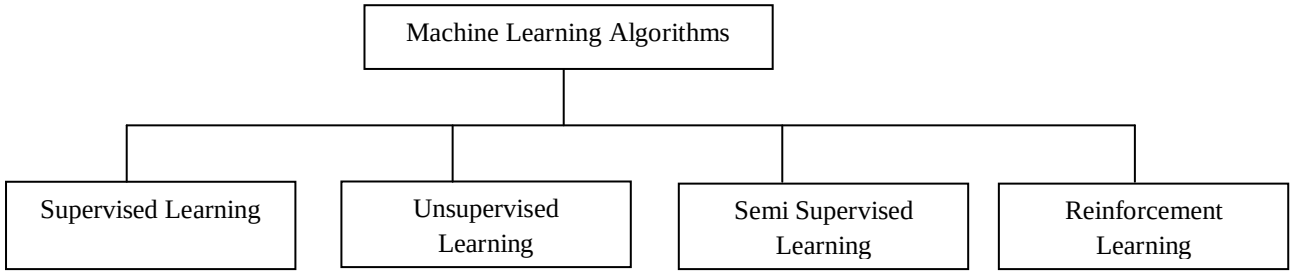

Fig. 2 Types of Machine Learning Algorithms

The process of choosing a machine learning algorithm involves matching the characteristics of the data to be learned to the biases of the available approaches. Machine learning algorithms can be divided into two main groups: supervised learners that are used to construct predictive models and unsupervised learners that are used to build descriptive models – but there are also other methods of machine learning. Here's an overview of the most popular types.

A. Supervised Learning/Predictive models

A predictive model is used for tasks that involve for the prediction of one value using other values in the dataset. Because predictive models are given clear instruction on what they need to learn and how they are intended to learn it, the process of training a predictive model is known as supervised learning. The aim of supervised, machine learning is to build a model that makes predictions based on evidence in the presence of uncertainty. Specifically, a supervised learning algorithm (Fig. 3) takes a known set of input data and known responses to the data (output), and trains a model to generate reasonable predictions for the response to new data.

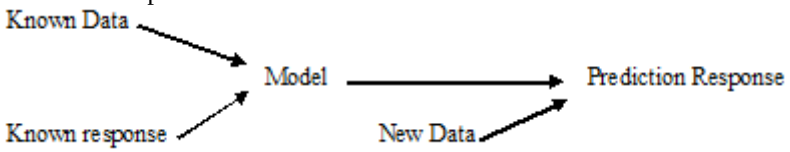

Fig. 3 Supervised Learning

B. Unsupervised Learning / Descriptive Models

A descriptive model is used for tasks that would benefit from the insight gained from summarizing data in new and interesting ways. As opposed to predictive models that predict a target of interest; in a descriptive model, no single feature is more important than any other. As there is no target to learn, the process of training a descriptive model is called unsupervised learning. The goal is to explore the data and find some structure within. Unsupervised learning works well on transactional data. Popular techniques include self-organizing maps, nearest-neighbor mapping, k-means clustering and singular value decomposition. These algorithms are also used to segment text topics, recommend items and identify data outliers.

The following table illustrates the list of machine learning algorithms that are extensively used.

Table I Supervised and Unsupervised Learning Algorithms

S. No.	Type of Learning	Model / Method	Extensively Used Algorithms
1	Supervised Learning	Decision Tree Technique	▪ Classification and Regression Tree (CART) ▪ Iterative Dichotomiser 3 (ID3) ▪ C4.5 and C5.0 ▪ Chi-squared Automatic Interaction Detection (CHAID) ▪ Decision Stump ▪ M5 ▪ Conditional Decision Trees
		Bayesian Methods	▪ Naive Bayes (NB) ▪ Gaussian Naive Bayes ▪ Multinomial Naive Bayes ▪ Averaged One-dependence Estimators (AODE) ▪ Bayesian Belief Network (BBN) ▪ Bayesian Network (BN)
		Artificial Neural Network	▪ Perceptron ▪ Back-Propagation ▪ Hopfield Network ▪ Radial Basis Function Network (RBFN)
		Instance Based Learning	▪ K - Nearest Neighbour (kNN) ▪ Learning Vector Quantization (LVQ) ▪ Self-Organizing Map (SOM) ▪ Locally Weighted Learning (LWL)
		Ensemble Methods	▪ Boosting ▪ Bootstrapped Aggregation (Bagging) ▪ AdaBoost ▪ Stacked Generalization (blending) ▪ Gradient Boosting Machines (GBM) ▪ Gradient Boosted Regression Trees (GBRT) ▪ Random Forest
2	Unsupervised Learning	Clustering Methods	▪ k-Means ▪ k-Medians ▪ Expectation Maximization (EM) ▪ Hierarchical Clustering
3	Supervised/ Unsupervised Learning	Regression Algorithms	▪ Ordinary Least Squares Regression (OLSR) ▪ Linear Regression ▪ Logistic Regression ▪ Stepwise Regression

			▪ Multivariate Adaptive Regression Splines (MARS) ▪ Locally Estimated Scatterplot Smoothing (LOESS)

C. Semi Supervised Learning

Is used for the same applications as supervised learning. But it uses both labeled and unlabeled data for training. This type of learning can be used with methods such as classification, regression and prediction. Semi supervised learning is useful when the cost associated with labeling is too high to allow for a fully labeled training process. Early examples of this include identifying a person's face on a web cam.

D. Reinforcement Learning (RL)

In this type of learning, machine is trained to take specific decisions based on the business requirement with the objective to maximize the efficiency (performance). This continual learning process ensures less participation of human expertise and saves more time. Reinforcement Learning is often used for robotics, gaming and navigation. With reinforcement learning, the algorithm discovers through trial and error which actions yield the greatest rewards.

V. MACHINE LEARNING TOOLS

Machine learning provides a set of tools that use computers to transform data into actionable information. Tools are a big part of machine learning and choosing the right tool can be as important as working with the best algorithms. Machine learning tools make applied machine learning faster, easier. Good tools can automate each step in the applied machine learning process by shortening the time.

Three structured ways to think about machine learning tools:

- Platforms versus Libraries.
- Graphical User Interfaces versus Command-Line Interface versus Application Programming Interfaces.
- Local versus Remote.

Platforms – Used to complete machine learning project from beginning to end.

- Provide capabilities required at each step in a machine learning project.
- The interface may be graphical or command line.
- They provide a lose coupling of features.
- They are provided for general purpose use and exploration rather than speed, scalability or accuracy.

Library - Provides capabilities for completing part of a machine learning project.

- Provide a specific capability for one or more steps in a machine learning project.
- The interface is typically an application programming interface requiring programming.
- They are tailored for a specific use case, problem type or environment.

Graphical User Interfaces

- Allows less-technical users to work through machine learning.
- Focus on process and how to get the most from machine learning techniques.
- Structured process imposed on the user by the interface.
- Stronger focus on graphical presentations of information such as visualization.

Command-Line Interface

- Allows technical users who are not programmers to work through machine learning projects.
- Provides many small focused programs or program modes for specific sub-tasks of a machine learning project.
- Frames machine learning tasks in terms of the input required and output to be generated.
- Promotes reproducible results by recording or scripting commands and command line arguments.

Application Programming Interfaces

- To incorporate machine learning into our own software projects.
- To create our own machine learning tools.
- Gives the flexibility to use our own processes and automations on machine learning projects.
- Allows combining our own methods with those provided by the library as well as extending provided methods.

Local Tools – Can be downloaded, installed and run on local environment.

- Customized for in-memory data and algorithms.
- Control over run configuration and parameterization.
- Integrate into our own systems to meet our needs.

Remote Tools – Can be hosted on a server and called from local environment. These tools are often referred to as Machine Learning as a Service (MLaaS).

- Tailored for scale to be run on larger datasets.
- Run across multiple systems, multiple cores and shared memory.

- Fewer algorithms because of the modifications required for running at scale.
- Simpler interfaces providing less control over run configuration and algorithm parameterization.
- Integrated into our local environment via remote procedure calls.

Some of the Machine Learning tools are listed here with their features.

Table II Machine Learning Tools Category

Category	**Tools**	**Features**
Platforms Vs. Libraries	WEKA - Waikato Environment for Knowledge Analysis.	● A modern platform for applied machine learning. ● Allows completing machine learning projects without programming. ● Contains tools for data pre-processing, classification, regression, clustering, association rules, and visualization.
	R	➢ One of the most powerful and most popular platforms for statistical programming and applied machine learning. ➢ It is a variant of Lisp ➢ Can parse and execute R scripts (programs) that are typed in directly or loaded from a file with an .R extension. ➢ Can create graphics to be displayed on the screen or saved to file, also prepare models that can be queried and updated.
	Scikit-learn	● A Python module for machine learning built on top of SciPy. ● Used for math and science work. ● The resulting libraries can be used either for interactive "workbench" applications or be embedded into other software and reused.
	Accord	○ The Accord.NET Framework provides machine learning, mathematics, statistics, computer vision, computer audition, and several scientific computing related methods and techniques to .NET.
	JSAT	○ Includes libraries that provide a more conventional range of machine learning functions, from neural networks to decision-tree systems.
		❖ Java Statistical Analysis Tool, a Java library for Machine Learning.
GUI Vs. CLI Vs. API	Orange	● An appropriate tool for quick comparisons across estimation techniques. ● A slick desktop app where data can be processed through a number of steps and estimation techniques. ● Uses a widget and connector construction on the GUI to move from raw data to finished model.
	Waffles	➢ Waffles apps are thin wrappers around functionality in a well-documented C++ class library. ➢ Script-friendly, and are designed to be used with automated processes. ➢ Will not depend on any platform or virtual machine. ➢ Waffles algorithms can automatically tune their own parameters.
	Deeplearning4j	❖ The first commercial-grade, open-source, distributed deep-learning library written for Java and Scala. ❖ Integrated with Hadoop and Spark. ❖ DL4J is designed to be used in business environments on distributed GPUs and CPUs.
Local Vs. Remote	Shogun	● Implemented in C++ and interfaces to Matlab(tm), R, Octave, Java, C#, Ruby, Lua and Python. ● Designed for unified large-scale learning for a broad range of feature types and learning settings, like classification, regression, or explorative data analysis. ✓ Google's Go language has started to enjoy wider use, due to a growing collection of libraries.

	GoLearn	✓ GoLearn is a 'batteries included' machine learning library for Go. ✓ Created to address the lack of an all-in-one machine learning library for Go.
	Google Prediction API	● Provides pattern-matching and machine learning capabilities. ● After learning from training data, Prediction API can predict a numeric value or choose a category that describes a new piece of data. ● Applications can be created to perform tasks such as predicting what movies or products a user might like, categorizing emails as spam or non-spam, assessing whether posted comments have positive or negative sentiment, or guessing how much a user might spend on a given day.
	AWS	Amazon Machine Learning provides visualization tools and wizards that guide through the process of creating machine learning (ML) models without having to learn complex ML algorithms and technology.
	Microsoft Azure	✓ A fully managed cloud service that enables to easily build, deploy and share predictive analytics solutions.

There are tools that can be used to set-up our own remote solution and integrate into our environment as a service. Examples include:

Mahout – The Mahout framework has long been tied to Hadoop, but many of the algorithms under its umbrella can also run outside Hadoop. They're useful for stand-alone applications that might eventually be migrated into Hadoop or for Hadoop projects that could be spun off into their own stand-alone applications. It provides a simple and extensible programming environment and framework for building scalable algorithms.

- *MLlib* - Apache's own machine learning library for Spark and Hadoop, MLlib boasts a gamut of common algorithms and useful data types, designed to run at speed and scale.
- *PredictionIO* - An open source Machine Learning Server built on top of state-of-the-art open source stack for developers and data scientists. It is used to create predictive engines for any kind of machine learning task.

Applying popular machine learning algorithms to large amounts of data raised new challenges for ML practitioners. Traditional ML libraries does not support well processing of huge data sets, so that new approaches are needed based on parallelization of time-consuming tasks using modern parallel computing frameworks [7].

VI. APPLICATIONS OF MACHINE LEARNING IN DIVERSE FIELDS

Machine learning played great role in recent years as significant development happened in various fields using it. ML lets machines make decision from enormous data. Companies such as Google, Amazon, Accenture, Toyota, Hitachi, Tesla, Johnson & Johnson have embraced machine learning at massive scale and improved their products & services. Start-up companies also developed innovative applications using machine learning. Amazon launched machine learning platform in 2015 and showed more helpful reviews to customers, Google used the ML to translate text in 27 languages. Tesla adopted ML in Auto pilot technology [20]. Machine learning is being used in a wide range of application domains and few foretastes are listed here.

- ***Financial services***

Banks and other businesses in the financial industry use machine learning technology for two key purposes: to identify important insights in data, and prevent fraud. The insights can identify investment opportunities, or help investors know when to trade. A team of researchers in the Machine Learning Technologies group at IBM Research - Haifa are taking fraud prevention and detection to a new level with the IBM Detecting Fraud in Financial Transactions solution. Rather than singling out specific types of transactions, the suggested solution analyzes historical transaction data to build a model that can detect fraudulent patterns. This model is then used to process and analyze a large amount of financial transactions as they happen in real time, also known as stream computing [22].

- ***Government***

Government agencies such as public safety and utilities have a particular need for machine learning since they have multiple sources of data that can be mined for insights. Machine learning can also help detect fraud and minimize identity theft. In U.K The Government Digital Service (GDS) has been experimenting with different applications such as predicting page views to do anomaly detection and so far is focusing on demonstrating the capabilities of machine learning algorithms on a number of products and prototype services [23].

- ***Health Care***

Machine learning is a fast-growing trend in the health care industry. The technology can also help medical experts analyze data to identify risks that may lead to improved diagnoses and treatment. IBM research group "The Machine Learning for Healthcare and Life Sciences" is developing and applying machine learning and data mining tools to an array of different challenging problems from clinical genomic analysis, through designing clinical decision support systems, to analyzing real world evidence for personalized medicine.

- ***Marketing and Sales*** Websites recommending items one might like based on previous purchases are using machine learning to analyze our buying history – and promote other items the person would be interested in. This ability to capture data, analyze it and use it to personalize a shopping experience is the future of retail. Microsoft's new cloud based predictive analytics tool called Azure Machine Learning for sales forecasting is in progression and vibrant in this province.
- **Transportation**

Analyzing data to identify patterns and trends is a key to the transportation industry, which relies on making routes more efficient and predicting potential problems to increase profitability. Traffic has been growing in major cities around the world given the increase in densities of cars on roads and the slow development of road infrastructure. Research scientist and developer teams at Microsoft Research pioneered the use of machine learning methods to build predictive models for traffic. The work led early on to prototypes that can infer and predict the flow of traffic at different times into the future based on the analysis of large amounts of data on traffic over months and years. The work was leveraged in revolutionary services, such as traffic maps that show users how traffic is evolving over time, as well as in services that provide traffic-sensitive directions by considering the inferred speeds on roads that are not sensed directly [22].

VII. PRACTICE OF MACHINE LEARNING IN HEALTH CARE

Machine learning algorithms are effective in recognizing complex patterns within rich and massive data. This capability is particularly well-suited to medical applications, especially those that depend on complex proteomic and genomic measurements. As a result, machine learning is frequently used in various disease diagnosis and detection. In clinical applications machine learning algorithms can produce better decisions about treatment plans for patients by means of providing effective healthcare system. Few glimpses on practice of machine learning in health care industry are conferred here.

- Health care organizations are using a technique called Discrete Event Simulation to predict wait times for patients in emergency department waiting rooms. The models use factors such as staffing levels, patient data, emergency department charts, and even the layout of the emergency room itself to predict wait times.
- IBM researchers have found a way to extract heart failure diagnosis criteria from free-text physician notes. They developed a machine learning algorithm that combs through physicians free-form text notes (in the electronic health records) and synthesize the text using a technique called "Natural Language Processing" (NLP). Similar to the way a cardiologist can read through another physician's notes and figure out whether a patient has heart failure, computers can now do the same.
- *Predicting Strokes and Seizures* - Singapore-based startup Healint launched an app called JustShakeIt that enables a user to send an emergency alert to emergency contacts and/or caregivers simply by shaking the phone with one hand. The program uses a machine learning algorithm to distinguish between actual emergency shakes and everyday jostling. In addition to the JustShakeIt app, Healint is working on a model that analyzes patients' cell phone accelerometer data to help identify warning signs for chronic neurological conditions.
- Using the proprietary predictive model, hospitals can predict emergency room admissions. Thus the application of machine learning may benefit patients either by reducing costs, improving accuracy, or disseminating expertise that is in short supply.
- *Machine Learning Techniques in Numerous Disease Predictions and Diagnosis:*
  Machine learning plays a key role in many radiology applications. Machine learning identifies complex patterns automatically and helps radiologists make intelligent decisions on radiology data such as conventional radiographs, CT, MRI, and PET images and radiology reports [19]. In recent time's diagnosis and prediction on various diseases like cardiovascular diseases, cancers, Diabetes, Hepatitis, Asthma [13], Tuberculosis (TB) [1] and Blood Pressure Monitoring [11] have been carried out using various data mining and machine learning predictions techniques.

VIII. CONCLUSION

Machine Learning techniques are momentous in various industrial applications. Health Care industry is facing lot of challenges and Machine Learning prediction techniques are significant in resolving them. Observational study shows that machine learning tools and techniques are essential in numerous disease predictions. There are lot of open problems and future challenges in dealing with massive amounts of heterogeneous, distributed, diverse, highly dynamic data sets and increasingly large amounts of unstructured and non-standardized information with respect to varied types of diseases.

Some of the most important challenges in clinical practice and biomedical research include the need to develop and apply novel tools for the effective integration, analysis and interpretation of complex biomedical data with the aim to identify testable hypothesis, and build accurate models. The algorithms must also handle incomplete, noisy, even contradictory/ambiguous information. As a result, efficient machine learning approaches becomes essential in the health care industry to address these challenges. Machine Learning techniques could revolutionize the entire healthcare industry by providing accurate insights and predictions related to symptoms, diagnoses, procedures and medications.

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