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MACHINE LEARNING STRATEGIES FOR REAL-WORLD ENGINEERING APPLICATIONS - A REVIEW

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ABSTRACT

Many fields, including intelligent control, decision-making, speech recognition, natural language processing, and computer vision and computer graphics are seeing success with machine learning techniques. In real world engineering applications, Machine learning plays vital role in data analysis and interpretation, enabling automated information driven system to manage big data. This paper provides a information on ML strategies for real time engineering applications focusing on their significance, challenges and future directions. Deep Learning and Machine Learning Techniques have lately gained widespread recognition and use by a number of many technical applications in real-time. Designing automated and intelligent programmers that can manage data in fields like healthcare, cyber-security and intelligent transportation systems requires a working knowledge of machine learning. In machine learning, there are several approaches, such as supervised algorithms, semi-supervised algorithms, unsupervised algorithms, and reinforcement learning. This research offers a thorough examination of managing machine learning-based real-time engineering applications, which will enhance an application's capabilities.

***KEY WORDS**: Cyber Security, Engineering Applications, Machine Learning.*

INTRODUCTION

In this digital era, the data source is becoming part of many things around us, and digital recording[1] is a normal routine that is creating bulk amounts of data from real-time engineering applications. This data can be unstructured, semi-structured, and structured. In a variety of domains, intelligent applications can be built by using the insights extracted from this data. For example, as in[3] author used cyber security data for extracting insights and uses those insights for building intelligent application for cyber-security which is automated and driven by data. Machine learning algorithms' performance and characteristics and nature of the data will decide the efficiency and effectiveness of the solution based on machine learning. The data-driven systems can be effectively built by using the following ML techniques like reinforcement learning, association rule learning, reduction of dimensionality and feature engineering, data clustering, regression, and classification analysis. From ANN, a new technology is originated from the family of machine learning techniques called Deep Learning which is used for analyzing data intelligently[4]. Every machine learning algorithm's purpose is different even various machine learning algorithms applied over the same category will generate different outcomes and depends on the nature and characteristics of data. Hence, it's challenging to select a machine learning algorithm for generating solutions to a target domain. There is a need for understanding the applicability and basic principle of ML algorithms in various Real Time Engineering Applications.

OBJECTIVES

The objective of this study is to explore the machine learning strategies and applications in real world engineering domains. Brief the applications of machine learning in different fields across various sectors including healthcare, security, transportations etc. Also, identify and analyse the challenges associated in implementing the ML strategies for the real world engineering applications and explore potential future directions and research opportunities in the ML for real world engineering applications.

STATE OF THE ART

Computer systems can utilize all client data through machine learning. It acts according to the program's instructions while also adapting to new situations or changes. Algorithms adapt to data and exhibit accordingly with previously unprogrammed behaviors. Acquiring the ability to read and recognize context enables a digital assistant to skim emails and extract vital information. Is type of learning entails the capacity to forecast future customer behaviors? It Enables you to have a deeper understanding of your customers and to be proactive rather than reactive.

ML has become integral in various domains including cyber security, healthcare and transportation etc. In Cyber security, ML techniques play vital role in detecting, predicting and mitigating the cyber threats by analyzing the

network traffic data and anomalies. In Healthcare, ML strategies can widely useful in disease detection/ prediction by analyzing the diagnosis data and also in suggesting the treatment based on the patient history. Similarly, in transportation sector, ML significance in traffic management, and recent driver less vehicle management.

Machine learning is applicable to a wide variety of sectors and industries and has the potential to expand throughout time.

INTRODUCTION TO CYBER SECURITY

For both, services and information, internet is most extensively exploited resource in the present cyberspace. In article[5,] author summarizes that since 2017 as an information source Internet is utilized by almost 48% of the whole population in the world. As concluded in the article [6], this number is hiked up to 82% in advanced countries. The interconnection of distinct devices, networks, and computers is called the Internet, whose preliminary job is to transmit information from one device to another through a network. Internet usage spiked due to the innovations and advancements in mobile device networks and computer systems. As internet is the mostly used by the majority of population as an information source and to exchange the information. As a result, it is more vulnerable and prone to cyber attacks at the hands of cyber criminals[7].

RECENT WORKS ON REAL-TIME ENGINEERING APPLICATIONS

In recent times, the machine learning has played a significant role in development of various engineering applications for getting data insights to optimize the processes, improve efficiency and enhance decision making across diverse sectors such as manufacturing, transportation, energy, healthcare, cybersecurity and more.

Overall, recent works on real-time engineering applications using machine learning demonstrate the versatility and effectiveness of ML techniques in addressing complex challenges and enabling intelligent decision-making in dynamic environments. These advancements pave the way for more efficient, reliable, and autonomous systems across a wide range of engineering domains.

Exposure to traffic noise, air pollution, road injuries, and traffic delays are only some of the key issues that urban inhabitants experience on a daily basis. Urban areas are experiencing severe Environmental and quality-of-life difficulties as a result of rapid car expansion, insufficient transportation infrastructure, and a lack of road safety rules. For example, in many urban areas, large trucks violate the typical highways, resulting in traffic congestion and delays. In addition, many bikers have frequent near misses as a result of their clothes, posture changes, partial occlusions, and varying observation angles all posing significant challenges to the Machine Learning (ML) algorithms' detection rates.

Over the last decade, there has been a surge in interest in using machine learning and deep learning methods to analyze and visualize massive amounts of data generated from various sources in order to improve the classification and recognition of pedestrians, bicycles, special vehicles (e.g., emergency vehicles vs. heavy trucks), and License Plate Recognition (LPR) for a safer and more sustainable environment. Although deep models are capable of capturing a wide variety of appearances, adaption to the environment is essential. Over time, for the actions performed as a response reward, actions and observations are given as input to policy functions, and the method that learns from this policy function is called Reinforcement Learning (RL) [8]. There is a wide range of healthcare applications where RL can be used even RL can be used in the detection of disease based on checking symptoms ubiquitously[9]. Another potential use of RL in this domain is Go game[10].

There are two classes of machine learning techniques (a) Unsupervised Learning, (b)Supervised learning as shown in Figure-1. We put down a brief discussion on all the two types of ML approaches as follows: Unsupervised learning in artificial intelligence is a type of machine learning that learns from data without human supervision. Supervised learning is a category of machine learning that uses labeled datasets to train algorithms to predict outcomes and recognize patterns.

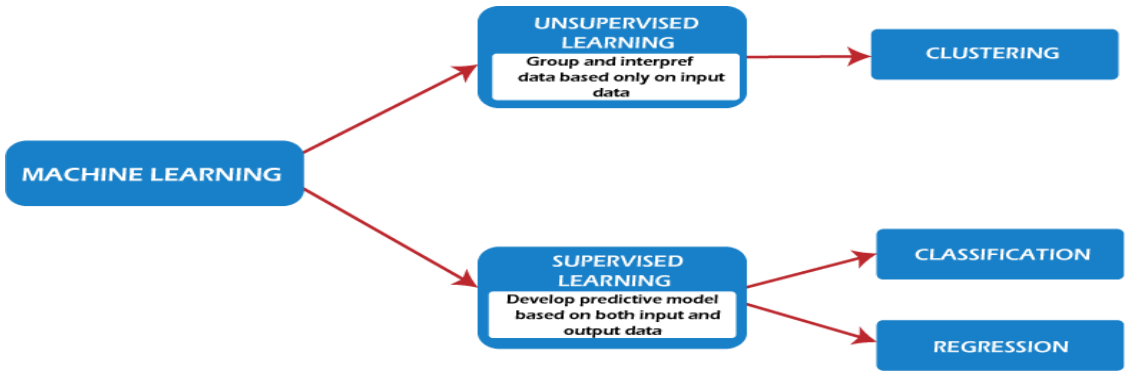

Figure-1: Machine Learning Techniques

Artificial Neural Networks (ANNs) form the base for deep learning success; in artificial neural networks to mirror an image, the human brain functioning interconnected node system sets are present. The neighboring layer's nodes will be consisting of connections with weights coming from nodes from other layers. The output value is generated by given input and weight to the activation function in a node. Figure 2 presents the core concepts in the Artificial Intelligence.

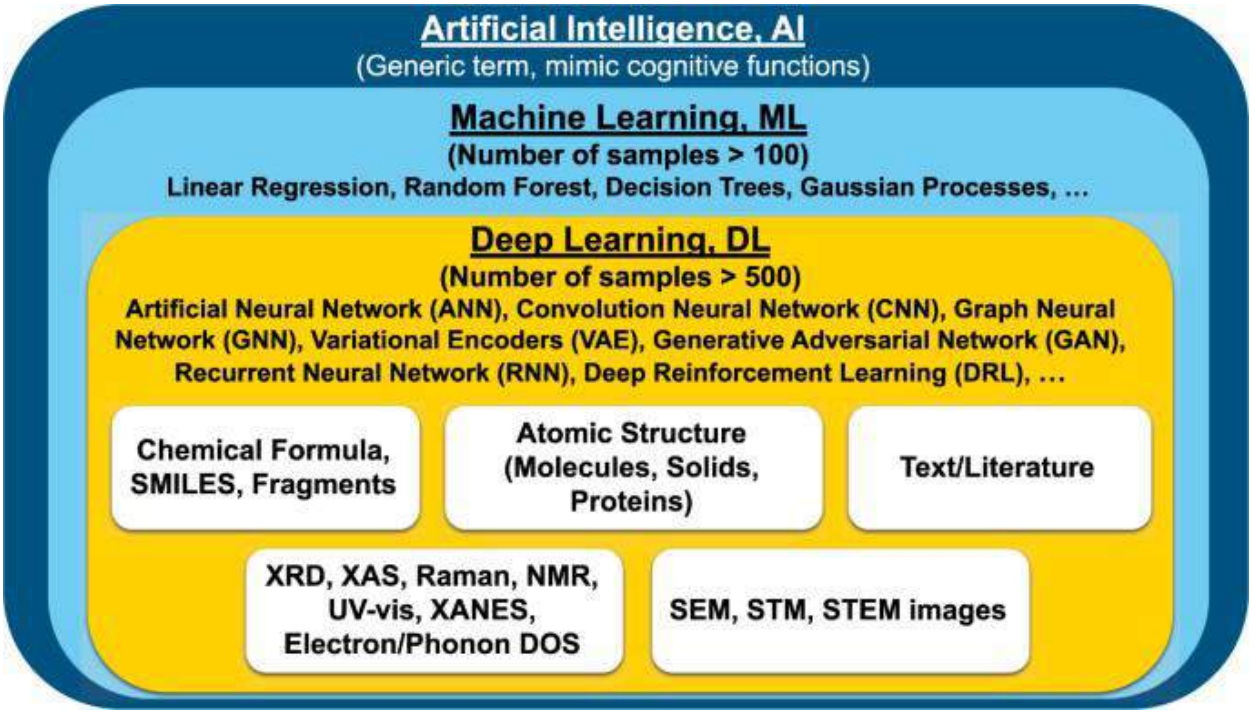

Figure 2: Artificial Intelligence

The sequence of steps involved in building a machine learning model is called machine learning pipeline. It includes different stages from accepting the data to producing the results through the model. The main phases are, Data collection, Data Preprocessing, Feature Engineering, Machine Learning Algorithm and Evaluation. ML pipeline was shown in figure-3.

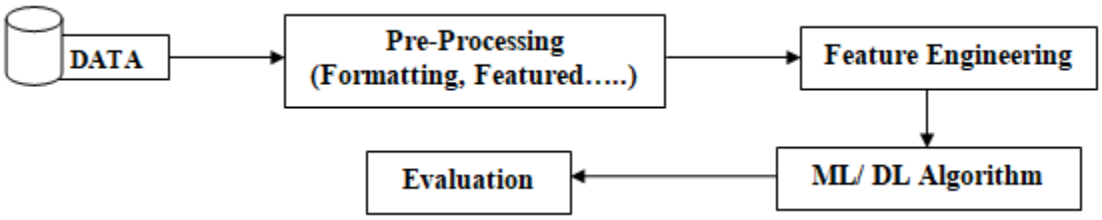

Figure 3: Machine Learning Pipeline

APPLICATIONS AND PRACTICLE CHALLENGES ON MACHINE LEARNING TECHNOLOGY

Machine learning technology has applications across a wide spectrum of industries and domains, from subterranean exploration to celestial observation. Beneath the earth surface, ML is utilized in geosciences applications such as mineral exploration, etc. Above the earth, ML has wide variety of applications like product recommendation in e-

commerce, town planning/ designing in smart-city, route selection in transportation etc. ML also contributing in space research for exploration efforts by tracking celestial bodies, analyzing astronomical data etc. Like this, ML technology became an integral part in our routine life. In this study we focused on the applications of the ML in health sector, education sector and security industry.

In the medical domain, ML can be used in predicting diseases, suggesting the required treatment and or surgery if required based the insight of the diagnosis data. All we witnessed in variety of reasons the machine learning plays a crucial role in protecting the human life and safety of the society during the covid-19 pandemic. ML techniques can also be used for forecasting the detection of cyber attacks, terrorism attacks and security threats to personal or to society. As in[11], the catastrophic consequences cannot be avoided by having faith blindly in the ML predictions. As in article[12], author states that ML approaches are used in various domains, but in some domains as an alternative to accuracy and speed ML approaches require correctness at very high levels. Here we discuss and summarize various machine learning techniques application areas. By making use of data-driven predictive analytics, intelligent decisions are made by applying machine learning techniques. To predict the unknown outcomes by relying on the earlier events by exploiting and capturing the relationship between the predicted variables and explanatory variables is the basis for predictive analytics, for example, credit card fraud identification and criminal identification after a crime. In the retail industry, predictive analytics and intelligent decision-making can be used for out-of-stock situation avoidance, inventory management, behavior, and preferences of the consumer are better understood and logistics and warehouse are optimized. Support Vector Machines, Decision Trees, and ANN are the most widely used techniques in the above areas [8, 10]. Predicting the outcome accurately can help every organization like social networking, transportation, sales and marketing, healthcare[13].

While machine learning offers promising results and is already proving beneficial to businesses around the world, it is not without its hurdles and issues. For instance, machine learning is useful for spotting patterns, but it performs poorly at generalizing knowledge. There is also the issue of “algorithm weariness” among users. In ML, for model training, decent amount of data (in terms of quality and quantity) and resources (in terms of computation/ processing, storage and network bandwidth) that provide high performances are needed. Is challenge is addressed by involving multiple GPU’s. In Real Time Engineering Applications, an ML approach is needed which is modeled to address a particular problem robustly. As the same model designed to address one task in real-time engineering application cannot address all the tasks in a variety of domains, so there is a need to design a model for each task in the Real Time Engineering Applications. ML approaches should have the skill to prevent issues in the early stages as this is an important challenge to address in most real-time engineering applications. With latest advancements in the technology, lightweight computing models like edge computing were introduced

to increase the effectiveness of machine learning applications by reducing the time and space complexities. Data privacy and security were the two major challenges in this type of cloud computing model.

CHALLENGES AND FUTURE RESEARCH DIRECTIONS

In this review, quite a few research issues are raised by studying the applicability of variety of ML approaches in the analysis of applications and intelligent data. Here, opportunities in research and potential future directions are summarized and discussed. Research directions are summarized as follows: (i) While dealing with real-world data, there is a need for focusing on the in-detail study of the data capturing techniques as ML mostly deals with complex and high volume of data (ii) there is a huge requirement for fine-tuning the preprocessing techniques or to have novel data preprocessing techniques to deal with real-world data associated with application domains (iii) Identifying the appropriate machine learning technique for the target application is also one of the research interests (iv) there is a huge interest in the academia in existing machine learning hybrid algorithms enhancement or modification and also in proposing novel hybrid algorithms for their applicability to the target applications domain Machine learning techniques' performance over the data and the data's nature and characteristics will decide the efficiency and effectiveness of the machine learning solutions. Data collection in various application domains like agriculture, healthcare, cyber- security etc. is complicated because of the generation of huge amounts of data in very less time by these application domains. To proceed further in the analysis of the data in machine learning bases applications.

CONCLUSION AND FUTURE SCOPE

In this study on machine learning algorithms, a comprehensive review is conducted for applications and intelligent analysis of data. Here, the real-world issues and how solutions are prepared by using a variety of learning algorithms are discussed briefly. Machine Learning techniques' performance and characteristics of the data will decide the machine learning model's success. To generate intelligent decision-making, machine learning algorithms need to be acquainted with target application knowledge and trained with data collected from various real- world situations. For highlighting the applicability of ML approaches to variety of issues in the real world and variety of application areas are discussed in this review. At last, research directions and other challenges are discussed and summarized. All the challenges in the target applications domain must be addressed by using solutions effectively. For both industry professionals and academia, this study will serve as a reference point and from the technical perspective; this study also works as a benchmark for the decision makers on a variety of application domains and various real-world situations. Machine Learning's application is not restricted to any one sector. Rather, it is spreading across a wide range of industries, including banking and finance, information technology, media and

entertainment, gaming, and the automobile sector. Because the breadth of Machine Learning is so broad, there are several areas where academics are trying to revolutionize the world in the future.

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