

Deployment of Machine Learning in Online And E-Learning: Bridging the Human Component for Enhanced Learner Outcomes in Higher Education

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Abstract: The advent of Machine Learning (ML) has brought transformative changes to the landscape of online and distance education. This paper explores the pivotal role of ML in advancing sustainable online and e-learning within higher education by enhancing adaptability, personalization, and learner engagement. This review outlines the emergence and forms of ML that comprised supervised, unsupervised, semi-supervised, reinforcement, and deep machine learning. It went further to highlight the pedagogical implications and practical applications of these various machine learning in virtual learning environments. It also examines the evolving role of Learning Management Systems (LMS) and User Experience (UX) in shaping learners' engagement and retention. In addition, it presents information on the potency of machine learning as relates to the human components by predicting student behavior, emotions and performance which has been the greatest concern of scholars in its integration in educational processes thereby bridging emotional, behavioral, and cognitive gaps in virtual instruction. Thus, this paper advocates for the integration of ML as a sustainable solution to personalize learning, prediction of student behavior and performance while fostering inclusive, data-driven pedagogical practices in higher education.

Keywords: Machine learning, e-Learning, Online Learning, Human Components, learner Outcomes and Higher Education

I. Introduction

Designing and deploying technologies for learning is one aspect that can drive quality in online and e-learning in higher education; another aspect is sustaining the design purpose to achieve maximum outcomes as specified in any program proposal. The deployment of machine learning in the educational system, especially, in e-learning and online education promises to address certain learners' needs and institutional concerns during online instruction. Machine learning is one of the fastest technologies that is expanding many industrial field and prototype applications. Robotics, computer vision, manufacturing, medical, knowledge acquisition, execution and control, design, planning, and scheduling are just a few of the fields where its potential has been demonstrated. It enables the creation of statistical models and algorithms that computer systems use to carry out intricate tasks without direct instructions, relying heavily on patterns and inference and as such can be beneficial to students in their educational process.

Research utilizing networks and new media has also revealed a need for machine learning in information retrieval and navigation, revolutionizing education and radically altering research, teaching, and learning. It is a new method of speeding up advancement in the educational system. Machine learning in education, especially in the teaching and learning domains, is one of the best instances of how technology improves human processes. Teachers can use machine learning to identify problematic students early and take appropriate action to increase success and retention. Localization, transcription, text-to-speech, and personalization are increasing the impact and reach of online learning materials (Amazon Web Services, 2023). Machine Learning can be used to enhance e-learning frameworks by not just misleadingly shrewdly learning projects that have been in presence but additionally joins the capacity to arrange learners into these learning frameworks.

The massive demand and growth for online programs have led to Technology Enhanced Learning Environments (TELE) (Ramzi et al, 2020) which has provided free or paid online courses while utilizing e-learning technology enhances learning quality by providing remote collaboration and exchange, as well as access to resources and services. It is generally regarded as an educational technique that permits the flexible transfer of knowledge and skills to numerous receivers at different times and places. Being able to choose their own study materials and schedule their time, location, and speed allows students to be active participants in the learning process. In this age of information and communication technology, the integration of technology offers a new method of learning (Mengchi and Dongmei, 2022). It provides convenience, accessibility, and flexibility, interactivity and is effective for learners at any moment and places with which they can be updated with current information, sought for solutions for their studies, and enhance their experience and knowledge through appropriate interventions, study design and immediate response (Dewan et al., 2020).

Delivery an online or eLearning programme would require a robust and effective learning management system for it to be successful, hence the need for a user friendly and learners' experience. The design philosophy used in Learning Management System development has shifted from being technology-centered to user-centered. The user experience (UX) takes precedence while building a LMS product, because it affects how users interact and perceive the learning platform, user experience (UX) design is a crucial component of e-learning. While poorly designed UX might cause learners to become frustrated and give up on the

learning platform, well designed UX can increase learners' engagement and happiness. Good UX design in e-learning has several important advantages, such as better learning outcomes, higher retention, enhanced accessibility, and increased efficiency (Hinderks et al., 2019). Teachers may develop an e-learning experience that is engaging and available to all students. User experience frequently focuses on the product's value and how users perceive it in order to meet organizational objectives. Although there are many different methods to think about and incorporate user experience into interactive product design; usability, functionality, aesthetics, content, look and feel, and emotional and sensory appeal are all crucial. Maintaining effective UX design requires constant feedback collection, as well as updates and platform enhancements based on that input. Another major cause for the change of the emotions of the students during learning is their experience with the system. It is important that the users are factored when designing learning management system. There are several learning management systems in existence. prominent among them are Moodle, Blackboard, Canvas, Google Classroom, Schoology, Coursera, iSpringLearn and among others which can help optimize learning, enhance institutional data management both for data collection and learners feedback. Most importantly, learners utilize and interact with the LMS in two ways, the first involves the mental response to test questions and secondly, their emotional response gotten through facial expression (Lawpanon et al, 2024). It is a primary knowledge that most human interaction with computer software involves non-verbal communication but with research endeavors by many scholars, the learners' interaction with computers can go just beyond the nonverbal communications as reflected in this article

Statement of The Problem

Despite the success and growing popularity of online learning systems, it is evident that most institutions lack the ability to adapt teaching strategies and pedagogy considering learners emotions and behaviours (Al-Fraihat et al., 2020), which are critical factors during face-to-face instruction in the normal traditional learning settings. In the digital space, it is believed that all students share a uniform emotional and psychological state during a lesson, thereby failing to account for their individual differences in terms of readiness to learn, and monitoring students learning progression in most cases. This, among others could account for poor and lack of learners' sustained interest and engagements on learning content and during instruction.

In every natural occurrence, learners differ in their cognitive abilities and emotional states which can directly influence their capacity to comprehend and assimilate course materials. Furthermore, during any given learning session, a student may experience a range of mental and emotional fluctuations, which can significantly impact the learning process. If a learner is unable to effectively absorb and process information, they may become confused, bored, or disengaged, ultimately losing interest in the material (Willingham, 2021). This disengagement can lead to negative emotional states, such as frustration, confusion, depression, or anger, potentially resulting in loss of interest, skipping or ignoring learning sessions.

Machine learning plays significant role in making predictions that have helped e-learning and online education (Ojajuni et al, 2021), yet there are still fears on how online and eLearning courses if deployed can effectively and successfully address the ever changing emotions and behaviors of today's learners.

Aim and Objectives

The aim of the article is to make bare the role of machine learning in promoting sustainable e-learning in higher education by bridging the human component with major emphasis on the following:

Emergence of Machine learning in higher education

Forms of Machine learning

Pedagogical implications of Machine learning in Online and eLearning

Challenges of Machine learning deployment in higher education

Literature Review

Machine Learning, its Emergence and Historical Trend in Higher Education

Machine learning has expanded from a small group of computer engineers who wanted to know if computers could learn to play games to a broad field that has produced learning algorithms that are widely used in commercial systems for computer vision, speech recognition, and many other tasks, as well as a data mining industry that searches for hidden patterns in the massive amounts of online data (Tom, 2020). Though, it has become a household name among the computing community and has gained wide acceptance as a subset of artificial intelligence (AI) which focuses on using data and algorithms to mimic human learning processes while progressively increasing their accuracy. It is a collection of techniques that, in general, "teach" computers how to do things by giving them examples of the proper way to do them, it also teaches a computer system how to make accurate predictions with the collected data. The main difference with traditional computer software is that the code that instructs the machine on how to recognize an apple from a banana was not written by a human rather, a machine-learning model has been trained on a vast amount of data, most likely a vast number of images labeled as including an apple or a banana, to teach it how to consistently distinguish between the fruits. Machine learning concentrates on set of method within Artificial intelligence that are predicated on "learning" to model patterns in data using mathematical functions. Since a substantial portion of machine learning's mathematical foundation is derived from traditional statistics, the field is also referred to as "statistical learning" (Rattan et al, 2022).

Aaron and David (2023), defined machine learning based on different fields: According to them, it can be defined from the Artificial Intelligence view, Software Engineering view and Statistics view.

Artificial Intelligence View: Both the development of human knowledge and intellect and the creation of intelligent machines depend heavily on learning. Years of work in artificial intelligence have demonstrated that automatic learning is essential; building clever machines by programming every rule is not possible. For instance, language is something that humans learn; therefore, rather than trying to teach computers to understand everything, it would make sense to try and help them learn it.

Software Engineering View: Programming computers by example is made possible by machine learning, which can be simpler than writing code the old-fashioned method. Learning technologies will be used more frequently to adjust or personalize (personalize) system performance as large-scale systems and applications become more complicated.

Statistics View: Machine learning is the application of computational techniques to statistical problems, which combines computer science with statistics. Statistics has always focused on attempting to maximize what can be gleaned from relatively little amounts of data because trials are frequently costly to undertake. Modern approaches, on the other hand, focus on learning models from vast quantities of intricate data, necessitating the use of complex models and fast algorithms.

HOW DOES MACHINE LEARNING WORK?

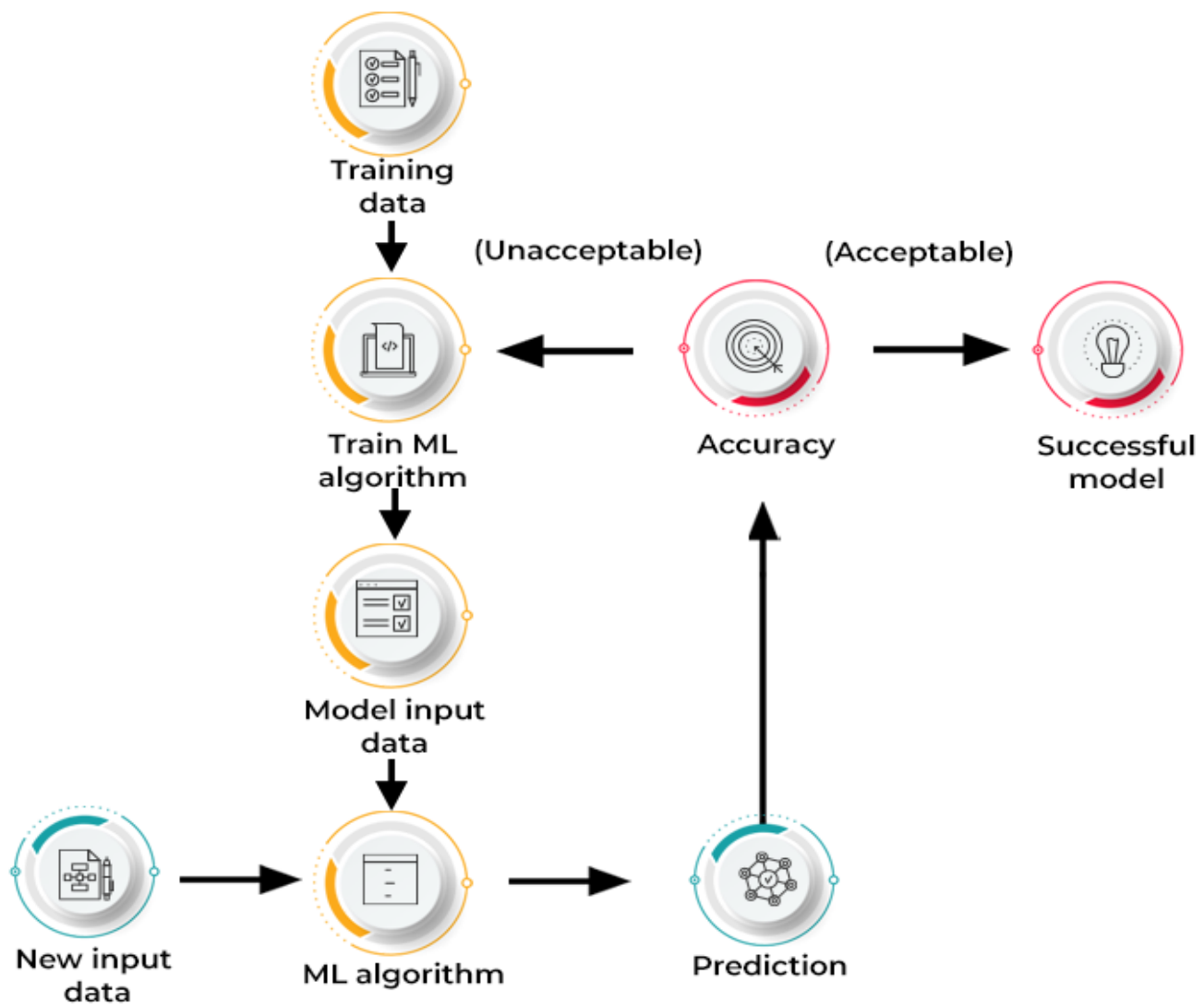


Figure 1.0: How does Machine Learning works ?

Source: <https://www.spiceworks.com/tech/artificial-intelligence/articles/what-is-ml/>

As seen in the following example, a model is produced by molding machine learning algorithms onto a training dataset. The trained machine learning algorithm uses the established model to generate a prediction when it receives new inputted data (Kanade, 2022).

Historical Trend of Machine Learning in Education

1950s–1970s: Foundations of AI and Learning Theories

The concept of machine learning (ML) emerged from early artificial intelligence (AI) research.

Educational technologies focused on programmed instruction (e.g., B.F. Skinner's teaching machines).

These early systems were rule-based and lacked adaptability.

1980s–1990s: Intelligent Tutoring Systems (ITS)

Intelligent Tutoring Systems used basic ML to adapt to learners' responses.

Systems like Andes and Cognitive Tutor began personalizing content using student performance data.

ML algorithms were still limited, but this era laid the groundwork for adaptive learning.

2000s: Data-Driven Education

Rise of Learning Management Systems (LMS) (e.g., Moodle, Blackboard) generated large amounts of educational data.

Basic ML was used for early warning systems, predicting dropouts and suggesting interventions.

Research in educational data mining (EDM) and learning analytics began to grow.

2010s: Deep Learning and Personalization

Advances in deep learning allowed more sophisticated modeling of student behavior.

ML powered adaptive learning platforms like Knewton, DreamBox, and Coursera's recommendation systems.

ML also used for automated grading, essay scoring, and feedback systems.

2020s–Present: AI-Enhanced Learning

Integration of ML in chatbots, virtual tutors, and intelligent assessment tools.

ML supports real-time feedback, personalized learning paths, and student engagement analytics.

Growing concerns about bias, privacy, and the ethical use of student data.

Forms of Machine Learning and its algorithms

There are various forms of machine learning that be used to develops computer algorithms to make decisions or predictions without being programmed as shown in the diagram below:

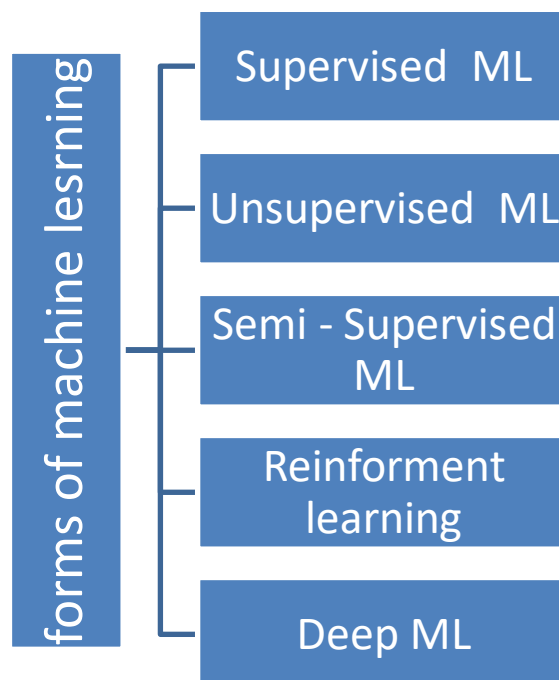


Figure 2. 0: Forms of Machine Learning

Supervised Learning

Supervised learning is a machine learning algorithm that is applied in training a labelled data. It can be grouped into classification or regression; the dataset is classified as a reliable variable using classification, and accuracy is determined using regression. Machine learning supervised algorithms are used most times to predict student's academic performance. Support Vector Machines and logistic regression are utilized in this context to predict the students' academic performance (Bhutto et al., 2020). K-nearest neighbors (KNN) which is a type of supervised learning have been used to process brainwaves of learners collected using a portable Electroencephalogram (Xinyang and Saeid, 2022). where the algorithm generates a function that transforms inputs into desired outputs. One known challenge for a supervised learning task, is the classification problem, which requires the learner to examine several input-output examples of a function in order to comprehend (or estimate) its behavior. A vector is converted into one of several classes using the function.

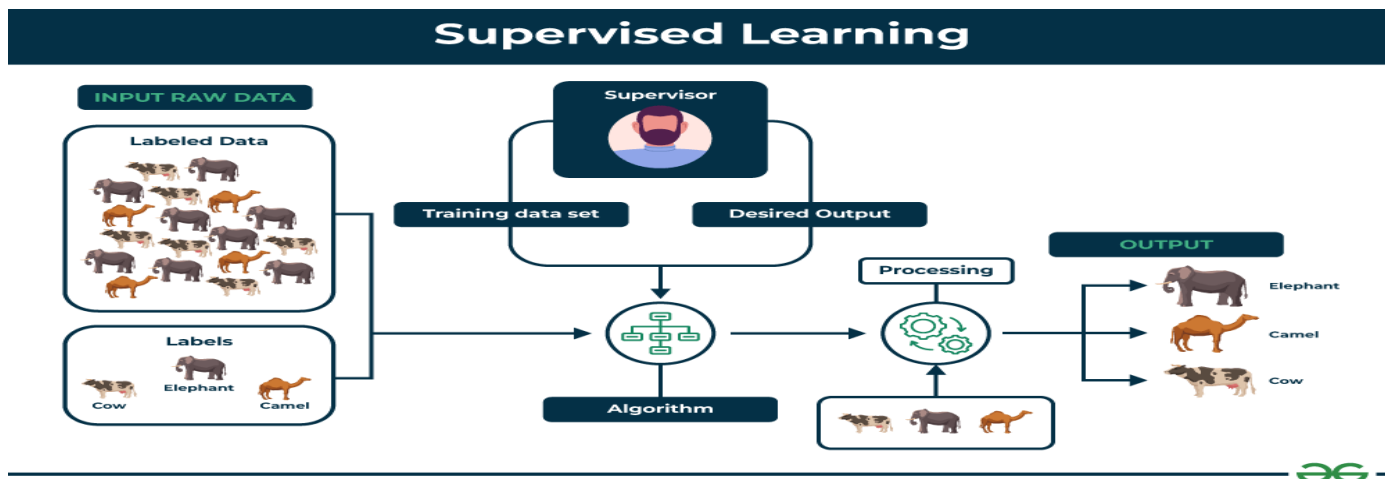


Figure 3. 0: Supervised Learning

Source: adopted from <https://www.geeksforgeeks.org/types-of-machine-learning/>

Unsupervised Learning

Unsupervised machine learning, (ML) techniques are used to examine and classify unlabeled data sets. Given that it doesn't require supervision during training, it is the ideal machine learning method for identifying trends, clusters, and distinctions in unstructured data. Tasks like client segmentation, exploratory data analysis, and photo identification are among its strong points. To find student clusters with similar learning behaviors, e-learning activities have been analyzed using unsupervised learning methods. (Emre and Muhammet, 2021) used the k-means method, an unsupervised machine learning algorithm, to predict the students' achievement in their course. With data mining in mind, the apriori algorithm—a type of unsupervised machine learning—was developed. It has been used to retrieve information from databases with a large number of transactions, such one that lists the items that supermarket patrons have bought. In shopping cart analysis, it is used to find the group of items that customers are more likely to purchase together as well as to determine the negative impacts of prescription drugs (Marca and Bedle, 2022). Unsupervised learning methods use a lot of unlabeled data to develop intricate, extremely non-linear models with millions of parameters.

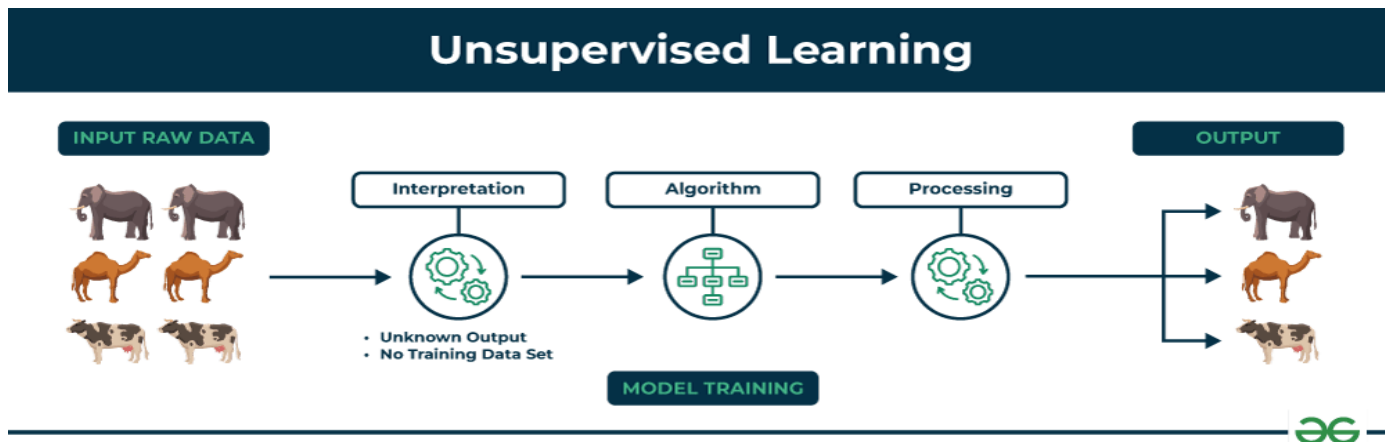


Figure 4. 0: Unsupervised Learning

Source: adopted from <https://www.geeksforgeeks.org/types-of-machine-learning/>

Semi-supervised Learning

According to Reddy et al. (2020), semi-supervised learning improves classification accuracy by combining labeled and unlabeled data, usually with less labeled data. To create an appropriate classifier or function, labeled and unlabeled instances are mixed. This method is especially helpful in situations where it would be impracticable to classify all of the data that is accessible. Comparing supervised and unsupervised learning to semi-supervised learning (SSL), the latter is more recent, additionally, semi-supervised learning has the advantage of reducing the impact of biases that may be introduced by human operators, even if they are considered experts. It is a useful technique when working with data that includes both labeled and unlabeled samples. To be precise, semi-supervised learning (SSL) is a machine learning technique that trains a prediction model using a large amount of unlabeled data and a small amount of labeled data. These methods comprised unlabeled data regression, constrained clustering for grouping both labeled and unlabeled data, dimensionality reduction for labeled data, and semi-supervised classification for classifying the partially labeled data. Semi-supervised learning aims to make predictions on both unlabeled data in the training set and future test data sets. Based on these goals, there are two varieties of semi-supervised learning: inductive semi-supervised learning and transductive learning. In transductive learning, labels are predicted for certain unlabeled datasets, but inductive semi-supervised learning trains a function $f(XY)$ that can reliably predict future data. Real-time applications for this kind of learning include speech recognition, web content classification, natural language processing, spam filtering, video surveillance, protein sequence classification, and more (Duarte and Berton, 2023).

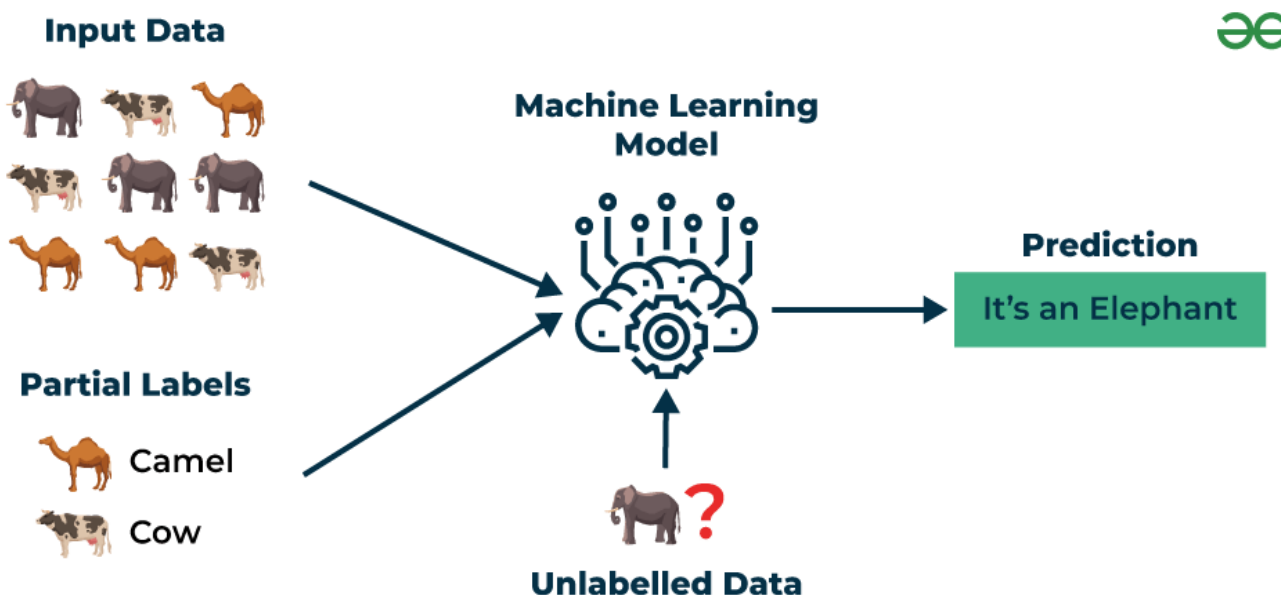


Figure5. 0: Semi Supervised Learning.

Source: Adopted from <https://www.geeksforgeeks.org/types-of-machine-learning/>

Reinforcement Learning

Dasgupta (2023) described reinforcement learning as a machine learning technique where an agent must decide the best way to complete a task that has been assigned to it. In order to do this, rewards are given to the many acts the agent can perform in various scenarios or environmental conditions. At first, the agent is clueless about what would be the best course of action. It examines its action options through trial and error using reinforcement learning to determine the optimal course of action for finishing the task it has been given guided. It is a kind of instruction driven by a certain goal. Through interaction with an unfamiliar environment, an agent learns by making mistakes. For a child, doing something and watching what happens is the most typical method of learning. Through interaction with an unfamiliar environment, usually through trial and error, an agent gains knowledge. For children, doing something and watching what happens is the most typical method of learning. The environment provides the agent with feedback in the form of rewards (or penalties), which it then use to train itself and gain experience and environmental knowledge (Muddasar et al, 2020). According to Priyanka's (2024) hypothesis, reinforcement learning differs from supervised learning in that the agent reads automatic utilizing responses devoid of tagged input. It is assumed that the agent will learn solely from his own experience because there is no labeled research. The agent persists in performing these three tasks (taking action, maintaining or adjusting position, and receiving feedback) to understand and navigate the environment. Through these activities, the agent gains insight into which actions yield positive feedback or rewards and which lead to negative feedback. Successful actions result in positive points for the agent, while unsuccessful ones lead to negative points. A foundation for creating situated agents that pick up new behaviors through interaction with their surroundings is provided by reinforcement learning (RL).

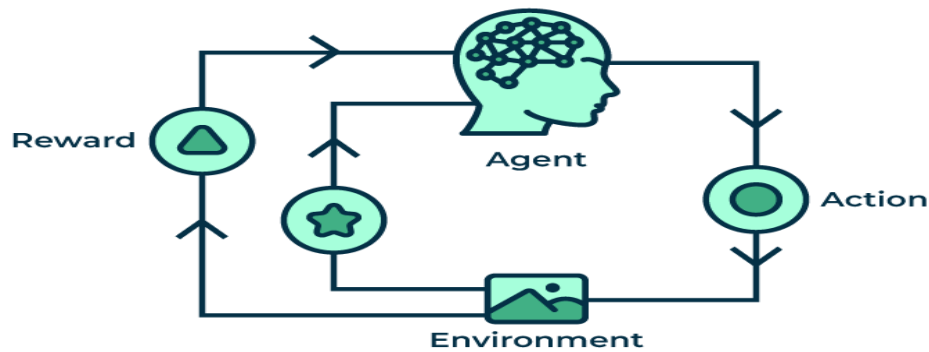


Figure 6. 0: Reinforcement machine learning

Source: Adopted from <https://www.geeksforgeeks.org/types-of-machine-learning/>

Deep Learning

Machine learning algorithms assist in modeling abstract high-level representations of data through processing layers that contain complex structures, and deep learning is a ubiquitous technology. Due to its potential benefits, including feature extraction and data classification problems, deep learning has drawn increasing attention in the fields of automated speech recognition, computer vision, natural language processing, drug discovery toxicology, audio recognition, bioinformatics, and automated vehicle driving. The overall potential cost benefits are evidence in project maintenance and renovation where there are increased field's broad range of applications and ongoing development (Indrakumari et al, 2021).



Figure 7: Deep Machine Learning

Source: https://www.google.com/search?q=image+of+deep+machine+learning&oeq=image+of+deep+machine+learning&gs_lcrpTxC1DA8arM&vssid=

Pedagogical implications of Machine learning in Online and Distance Education

The term "e-learning" has been around since 1999, when it was first introduced at a CBT systems seminar. Other words like "online learning" and "virtual learning" have begun to emerge in an effort to give a more accurate definition. However, the fundamental concepts of e-learning are not new; in fact, some evidence suggests that e-learning may have started as early as the 19th century. E-learning resources and delivery methods expanded in the second half of the 20th century as a result of the advancements in computers and the internet. The MAC's arrival in the 1980s allowed people to have computers in their homes, which made it easier to learn specific skills and expertise. Then, in the ensuing ten years, people started to really benefit from virtual learning settings, and they had access to a multitude of online resources and e-learning chances.

E-learning is the practice of learning remotely via computers and usually the internet. E-learning is a group of technologies that are frequently integrated into a management system or learning systems. Students can learn and communicate with tutors and other students in e-learning environments. Flexible learning or blended learning are giving way to "online learning" or "e-learning," most likely as a result of the widespread adoption of learning management systems. This most likely illustrates how much learning management systems have impacted mainstream education especially in fostering equitable and open access to learning to a larger population irrespective of distance, culture and location. The growth of distance and eLearning is greatly attributed to the emergence of Internet-based information technologies, especially the World Wide Web.

The benefits of e-Learning Platforms

Flexibility and Convenience: E-learning systems allow learners to access educational resources and materials at their convenience; it is adaptable, where every student is at liberty to select the time and location that works best for him or her.

Accessibility: Learners from different geographic areas can access the same educational content. A larger audience with a range of backgrounds and learning requirements is reached, increasing educational opportunities and fostering inclusivity.

Cost-Effectiveness: E-learning systems are often more cost-effective than traditional in-person training or education. It is cost-effective by providing educational opportunities without requiring a lot of facilities.

Engaging and Interactive Learning Experiences: E-learning systems incorporate various multimedia elements, interactive activities, and gamified features to enhance learner engagement. Through the use of videos, animations, quizzes, and simulations, e-learning promotes active participation, knowledge retention, and practical application of learned concepts.

Individualized Learning: E-learning systems can adapt to individual learner needs by offering personalized learning paths and content recommendations. Learners can progress through the material at their own pace, focusing on areas of interest or where additional support is required. This individualized approach enhances the learning experience and increases learner satisfaction.

Continuous Learning and Professional Development: E-learning systems enable organizations and individuals to foster a culture of continuous learning by providing a repository of educational resources, e-learning systems support ongoing professional development, upskill, and knowledge retention.

Lack of manpower: The lack of instructors, lab technicians, facilitators, and other academic staff is partially offset by e-learning.

Users Experience in e-learning Systems

The linkages between e-learning and UX are two critical phenomena that information technologist (IT) considers in the design and development of learning management system for educational and training purposes. UX is concerned with examining how those IT systems are used and that the UX of any LMS platforms may have impact on the process of online teaching and learning. There are two main factors that could affect the results and outcomes of online learning. These are the opinions of learners regarding e-learning and the information technology for e-learning, including its dependability, usability, and quality. The experience and opinions of users regarding these systems have a significant impact on the success of e-learning, both on the students or instructors. It is a dynamic notion that encompasses all aspects of end users' experiences, behaviors, perceptions, feelings, and thoughts about learning management systems (LMSs), as well as how they reflect on, anticipate, and use these systems to maximize the hedonic and/or functional value of e-learning.

A single aspect of a single user's interaction with a stand-alone application to every facet of numerous users' interactions with the business and its integration of services from various disciplines make up the too-flexible unit of analysis for user experience (UX).

II. Pragmatism, emotion, affect, experience, value, pleasure, beauty, hedonic quality, and other theoretical models are among the many with differing emphasis have shattered and confused the UX research field. All things considered, user experience (UX) is often focused on the value of the product and how customers view it in order to achieve organizational goals.

Challenges with Implementing Machine Learning Algorithms

Reddy et al. (2020) discussed several obstacles related to the implementation of machine learning algorithms. Some of which are;

Lack of representative training data: The availability of data is frequently the biggest obstacle faced in machine. To create effective models and algorithms, data is necessary. When data is not present or the existing data does not reflect the issue being addressed, it can make completing the project difficult or even impossible. In order to make accurate predictions, it is crucial to collect training data that accurately represents the new cases that need to be generalized. This is relevant regardless of whether one chooses instance-based learning or model-based learning. Insufficient data can negatively impact model training, and both internal and external data may be necessary for proper training. A small data sample can cause noise, and incorrect sampling methods can result in bias even with a large data set.

Data Provenance: Data provenance refers to the history of a piece of data, including where it came from, how it was generated, and how it has been processed and transformed over time. The concept of data provenance is important in fields such as data science, where the accuracy and reliability of results depend on the quality and integrity of the data used. By tracking data provenance, it is possible to determine the origin and evolution of data, and assess its reliability and trustworthiness. This information can be used to improve the quality of data-driven decision-making and to ensure that data is used ethically and in compliance with regulations.

Standards and platforms: Standards and platforms in machine learning encompass a range of guidelines and resources aimed at maintaining consistency and interoperability in the implementation of machine learning models and algorithms. These standards encompass best practices for data preparation, model selection, evaluation, and deployment, with the goal of promoting transparency, reproducibility, and collaboration in machine learning projects. Common examples of machine learning standards include CRISP-DM, the Seven Steps of Modeling, and the Pareto principle. Platforms, in contrast, are tools and services that offer the necessary infrastructure for building, training, and deploying machine learning models. These platforms frequently comprise

libraries for machine learning algorithms, data visualization and analysis tools, and cloud-based hosting services for models. Notable machine learning platforms include TensorFlow, PyTorch, and scikitlearn. To sum up, the use of standards and platforms in machine learning helps to guarantee the consistent and effective development and deployment of models, while promoting transparency, reproducibility, and collaboration in the field.

Trust on data: Trust in data is a crucial factor in the development and deployment of machine learning models. In machine learning, trust in data refers to the confidence or assurance that the data used to train models is accurate, reliable, and free of bias. If the data used to train a machine learning model is unreliable, biased, or contains inaccuracies, the model's predictions will be similarly flawed. This can result in incorrect decisions and harmful outcomes, leading to a loss of trust in the technology. To establish trust in data for machine learning, organizations must implement best practices for data management, such as data quality control, data governance, and data security measures. They must also be transparent about their data sources, processing methods, and potential limitations. In summary, trust in data is a critical factor in the development and deployment of machine learning models. Ensuring the accuracy and reliability of the data used to train models helps to establish trust in the technology and avoid harmful outcomes.

Security Challenges: Machine learning has many potential benefits, but also poses several security challenges. These include ensuring data privacy and security, model security from attacks, avoiding bias and ensuring fairness, having explainable and interpretable models, and designing models that are robust and generalize well to new data. Addressing these challenges is crucial for the safe deployment of machine learning models.

II. Conclusion

Machine Learning is a subset of artificial intelligence that develops computer algorithms for automatic improvement through experience and the use of data collected, thereby enabling computers to learn from data and make decisions or predictions without being programmed to do so. Its performances are often improved over time making its processes more accurate and effective as they process more data. Hence, Machine learning deployment in higher education can enhance learning quality by enabling personalized learning experiences, improving assessment methods, and providing data-driven insights for educators. By analyzing student data, ML algorithms can identify individual learning strengths and weaknesses, adapt teaching materials and methods, and predict student performance which will lead to more effective and engaging learning, ultimately supporting sustainable online and eLearning in higher education by addressing the fear by many scholars regarding the human component in the learning process such as behavior, emotions, and cognition,

III. Suggestions

Educational institutions should promote the use of ML to personalize learning experiences and predict student outcomes while ensuring inclusivity and ethical data practices.

Training for academic staff and administrative personnel should be organised to build capacity for optimizing ML tools.

Machine learning concepts should be integrated into LMS architecture during system design to enable intelligent data capture and analyses of course content delivery, improved learning outcomes, learner's emotions and behavioural patterns.

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