A Review of Machine Teaching and its Future

Rajiv Kumar[1], Sreekumar Narayanan[2]
Faculty of Computing
Botho University, Gaborone, Botswana
[1]dhiman.rajiv@gmail.com, [2]bothosree@gmail.com

Abstract: The recent strategies for creating machine learning algorithms require experts with significant information on machine learning. This outcomes in preparing wide scope of people who can educate machines. The discipline of machine teaching is placed on generating the optimum training set that can direct a learning algorithm with the most proficiency. The vital advantage of machine teaching is that it put computerization devices under the control of common consumers with no software engineering foundation - that is, subject specialists. The idea is to empower business clients to take machine teaching tools and apply them to issues explicit to their industry divisions. In this paper, we review the various machine teaching paradigms that is useful for the machine learning algorithm to perform efficiently and effectively. The suggestions and directions for futureinvestigation are likewise proposed.

Keywords: Artificial intelligence, machine learning, machine teaching, learning algorithms, teaching process.

1. Introduction

People, clients and domain experts alike, are progressively communicating with artificial intelligence or AI based frameworks. The statistical models fundamental underlying the dynamic based machine learning techniques treat the human activities as passive information, instead of recognizing the key thinking about the client. Machine teaching contemplates an integral issue to dynamic realizing: how to give a machine learner information to get familiar with an objective model with insignificant exertion [1, 2, 3]. Apart from its principal machine learning intrigue, machine teaching has been applied to domain, for example, education [4]and antagonistic attacks [2].

There is no uncertainty that machine learning is one of the significant main thrusts behind the greater part of the advanced techs and gadgets we have today. Regardless of whether it is your shrewd home gadget or that recently gotten self-driving vehicle, ML is assuming an essential job propelling gadgets as well as changing the way individuals connect with machines. Almost certainly, it is probably the most smoking innovation on the planet. In any case, individuals nearly overlook that there is something many refer to as Machine Teaching that additionally assumes a critical function in all the ML use cases.

We have heard a ton about ML, which is additionally observed as a subset of artificial intelligence. What's more, in the event that we attempt to comprehend it by its exacting definition, it is the capacity of algorithms and measurable models of machines or frameworks to consequently take in and improve for a fact without being modified or without utilizing any express guidelines.

At the point when we talk about this searched after innovation, artificial intelligence, individuals will in general consider things like performance modelling, learning algorithm optimization, network design, all the undertakings it can perform. Notwithstanding, this is right through the point of view of a learner [5]. In any case, what it would be the point at which we take a glance at the whole situations through an instructor's viewpoint? Would it be very similar things?

Microsoft has the appropriate response [6]. While the remainder of the world has been constantly centered around the learners side, tech giant Microsoft has taken the educator's viewpoint and investigated the potential outcomes where a machine might do all the assignments that a human can do — regardless of whether it's tied in with speculation, discovering arrangements, and so on. Nonetheless, there was a container that remains as an obstacle for AI to achieve these objectives.

In any case, when you approach investigating an answer for it, you understand the container isn't the innovation however the instructor — the information. Furthermore, this where Machine Teaching comes into the situation. Dissimilar to the conventional methodology of showing machine which about taking care of the machine or the framework with loads of accessible information, machine teaching takes an alternate course to go about it — it takes care of the information as well as told where to look.

For instance, when an instructor shows an understudy how to perceive a bike, the educator enlightens the understudies concerning all the highlights and qualities of the bike and later tests him/her with different things. Also, if the understudies state the Motorbike is the bike, the instructor doesn't state it isn't right; rather, the educators right the understudy by delineating for him/her about the distinctions. Furthermore, this is a

similar circle that machine teaching employs. Instead of separating information and burrowing experiences from it to prepare a model, individuals' aptitude could likewise be a critical main impetus in teaching machines.

Innovation is on an advancing spree and step by step things are simply showing signs of improvement and superior. The equivalent has occurred with machine learning. As per Microsoft[6], who has been exploring and chipping away at Machine Teaching for 10 years at this point, even AI battles and some of the time neglect to learn things without anyone else, yet when individuals begin to manage the machine to do and learn things that we definitely know, things are going to altogether extraordinary.

The machine isn't just a totally different way to deal with machine learning yet it's a way to deal with enable individuals to utilize AI. It doesn't make a difference whether you are an engineer or a SME with restricted information, machine learning makes things simpler — one can give conceptual ideas to an astute framework, and it would play out the machine learning mechanics out of sight.

The rest of this paper is organized as follows: In Section2,we introduce the related work of machine teaching and machine learning. In Section 3, we describe machine teaching that is paradigm shift to machine leaning and we also categorize the various types of machine teaching Insection4, we summarize the applications of machine teaching while section 5 discuss the advantages of machine teaching. In Section 6, we present future research directions. Finally, the conclusion is given in section 7.

2. Related Work

Machine learning is the motor which is assisting with driving advances in the improvement of AI. It is astonishingly utilized in both scholarly community and industry to drive the improvement of 'intelligent products' with the capacity to make precise forecasts utilizing various wellsprings of information[7].These days, machine learning algorithms are effectively utilized for classification, regression, clustering, or dimensionality decrease undertakings of huge arrangements of particularly high-dimensional information[8].

Truth be told, machine learning has demonstrated to have superhuman capacities in various fields, (for example, playing go[9]self-driving vehicles [10]picture grouping [11] etc.). Accordingly, colossal pieces of our everyday life, for instance, image and speech recognition[12, 13], web-look[14]extortion location [15]email/spam sifting [16]credit ratings [17]and a lot more are fueled by machine learning algorithms.While information driven exploration, and more explicitly machine learning, have effectively a long history in biology [18] or chemistry [19]they just rose to prominence as of late in the field of strong state materials science.Machine learning will be progressively utilized in mix with Natural Language Processing (NLP) to comprehend unstructured content information. By consolidating ML with NLP methods, scientists have had the option to get new bits of knowledge from remarks from clinical episode reports [20], social media activity [21, 22], doctor performance feedback [23], and persistent reports after fruitful malignancy medicines[24]. Naturally produced data from unstructured information could be incredibly valuable not exclusively to pick up understanding into quality, security, and execution, yet additionally for early finding. As of late, a mechanized examination of free-discourse gathered during face to face meets brought about the capacity to foresee progress to psychosis with ideal exactness in a gathering of high-hazard young people[25].A typical name for both decision tree induction and rule induction is Inductive Learning. This is the methodology continued in machine learning, called Instance Based Learning [26]. By this sort of machine learning the real information occasions from the preparation dataset are put away in memory with the objective to portray the dataset. Regular delegates of instance -based learning are the k-closest neighbor [27]algorithm and Support Vector Machine (SVM)[28].

The fundamental focal points of the instance-based learning algorithms are the capacity to show complex targets and the way that there is no loss of data brought about by speculation of the training data. Then again, the expenses at classification time can be high since all the grouping figuring's are done at the hour of appearance of occurrences to be characterized.Yu et al. describe a novel method of lithography hotspot detection. They used clustering to produce hotspot and non-hotspot clusters. The critical features were extracted from the produced clusters. Those features were used to train an SVM model [29].

2.1 Machine teaching

Machine teaching is tied in with streamlining things by building multi-reason instruments that can be given to business clients. At that point, the attention is on the best way to instruct clients to do it well, instead of how to build up the calculation. Customary machine learning requires volumes of named information that can be tedious and costly to create, the Machine Teaching Group site says.Machine teaching use the human capacity to deteriorate and disclose ideas to prepare machine learning models, which is significantly more effective than utilizing marks alone. With the human instructor and the machine learning model cooperating in a constant intuitive cycle, we can significantly accelerate model-building time. Machine teaching is the control of machine learning. The machine learning algorithm characterizes a dynamical framework where the state (for example

model) is driven by training data. Machine teaching plans the ideal training data to drive the learning algorithm to an objective model.

2.2 Why Machine teaching?

Machine teaching considers a batch setting, where the instructor plans a negligible dataset to cause the learner to become familiar with the objective model [1, 2, 3]. Instructing with regards to training, with vulnerability about the learner's state, has been defined as arranging in incompletely discernible Markov decision processes [4, 30]. A hypothetical investigation of the instructor mindful learner was introduced in [31, 32]where the instructor and the learner know about their participation. The instructor oversees planning the entirety of the learning information (while conceivably utilizing cooperation to test the condition of the learner) and is not permitted to be conflicting concerning the genuine information appropriation.In AI framework building, machine teaching empowers a domain expert to fabricate a machine learning model quicker and better than essentially giving named trained data. Dr Ali Akbari, senior artificial intelligence lead at Unisys APAC says, the motivation behind machine encouraging apparatuses is to make the innovation straightforward enough for anyone to utilize. It is computerizing crafted by information researchers, yet it does not mean putting them out of a job. It is simply changing the way we work. In the event that the dreary pieces of a data scientist's activity are mechanized, we can zero in additional on the inventive parts.This implies data scientists are at long last robotizing their own positions yet should not something be said about the individual who is utilizing the machine, the person who is instructing it to carry out their responsibility.Is there a danger for them? Indeed, the aim of the product is basically to make individuals' positions simpler, it is about further acquainting AI with the work environment and permitting individuals to zero in on different parts of their work. There is, obviously, an expanded danger of mistake when a portion of the machine's choices are being educated through input from a solitary individual, instead of a mass of information.In the event that we are preparing and training these algorithms utilizing information that isn't finished or that is one-sided, at that point we are making a machine learning instrument that won't settle on a reasonable choice."If we are training and teaching these algorithms using data that is not complete or that is biased, then we are creating a machine learning tool that won't make a fair decision.

2.3 Machine teaching and ethics

AI, machine learning and machine teaching are undeniably powerful offerings for the future of human society – that fact is universally accepted. However, with this power comes the risk of mismanagement.

According to Robert Wickham, Salesforce's vice president and growth program manager, Asia-Pacific region [33], AI will provide great opportunity and great potential. At the same time, you have to take an ethical approach to ensure you're designing for the outcomes that you want and in a thoughtful, responsible way.

There are four dimensions to ensuring that the ethical, human side of AI is properly governed, Wickham says. These apply equally to those developing and using the software. This is shown in table I.

Table I: Dimension of the AI

	Not yet using AI	Evaluation stage	Mature Practice
Research and development	23%	54%	63%
Customer services	16%	33%	48%
IT	20%	34%	39%
Operations, facilities, fleet management	6%	22%	32%
Marketing, advertise, PR	5%	20%	35%
Finance and accounting	6%	16%	23%
Manufacturing and production	6%	13%	27%
Sales	5%	13%	26%
Purchasing, logistics and supply chain	3%	11%	18%
Human resources	3%	8%	16%
Distribution	2%	6%	12%
Legal	1%	5%	8%

The first is accountability, meaning that while the production of an AI system focuses on building capabilities, it is always with a view to being accountable to customers and to society.The second is that the

cycle must be straightforward. Part of where AI has introduced difficulties in the past is with 'black box algorithms' the place you see a result, however you can't clarify the cycle by which the calculations went to those results.Third is the way that AI must be created to increase the human condition, as opposed to supplant the human condition."Finally, ethics in AI is about being inclusive," Wickham says. "This speaks not only to diversity, but also to creating something that is not focused on the creators but is instead focused on the user. It involves having a view that your users are going to span the spectrum and creating a system that allows for that."

3. Machine Teaching: A Paradigm Shift to Machine Learning

Machine teaching is considered as the subfield of artificial intelligence (AI). The main task of machine teaching is to obtain the knowledge directly from the people rather than extract the information from the machines. The main idea is to bring the relevant output to the users so that the conceptual data can be processed by AI system in more meaningful and valuable way.

The machine learning is also the subfield of AI which improve the accuracy of the machine over a period of time by predicting the outcome based on the historical data without the interference of the explicit programming. On the other hand, machine teaching provides the optimum training sets which allow the machine learning algorithm to be more efficient and accurate. These learning algorithms use the optimal training sets to improve the predicting results without explicit programming. For example, if we simply give the ball to the children to play the soccer game and tell them to make the goal. We can tell them number of ways to reach the ball to the goal. The children may find the association between the ball and goal by learning themselves. The machine learning is exactly doing the same, it gives hundreds of data to the users to analyze and make association between inputs and outputs. On the other hand, if we teach the children to play the soccer step by step. They have to avoid the goalie to put the ball in front of the goal and kick the ball towards the goal to score. The machine teaching is doing the exact same, it teaches the machine step by step and reaches towards their expected outcomes. The aim of machine teaching is to solve complex problems into smaller easier problems that can be processed effectively and efficiently by the ML system. We can say that machine teaching is the inverse problem to ML [3] that is shown in the figure 1:
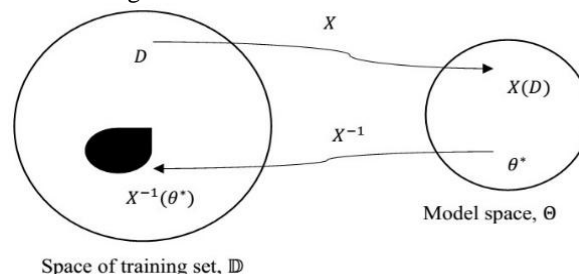

Figure 1. Machine teaching (MT) - Areverse problem of machine learning (ML)

Here, the learning algorithm is X which accepts the data from the training set $\mathbb{D}$ and decode it into the model $X(D)$. On the other hand, the teacher has the message in the target model which is θ^*. The teacher encodes the target model θ^* by using the inverse process of X and obtain the teaching sets which is $X^{-1}(\theta^*)$.

We can divide the complete process of ML [34] and their related knowledge in following four part that is shown in the figure 2:
1. Problem understanding
2. Subject matter expert
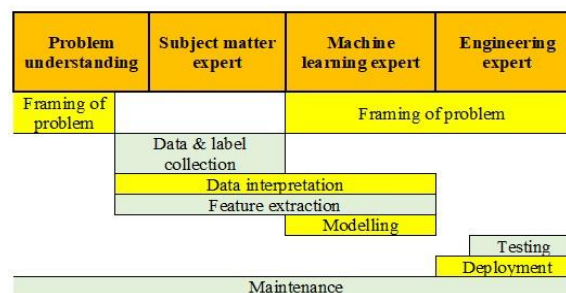3. Machine learning expert
4. Engineering expert

Figure 2. A complete process of machine learning

Generally, non-experts examine the impact of the features on the performance of the model. If the performance is better, then other features are added to evaluate the model, otherwise, they go back and forth to re-examine the features of the model. This is a very cumbersome task. On the other hand, ML experts start the model by building the basic model and evaluate the possible solutions of the model, their weights and decide further to add the new features in the model. This incremental approach debugs the component of the model in each iteration. This process includes the chosen learning algorithm, signal information, representation of the signal and design of a features [34]. The non-expert's view on the performance of the model has been shown in figure 3.

Figure 3. Performance of model by Non-experts

The ML expert's view on the performance of the model has been shown in figure 4.
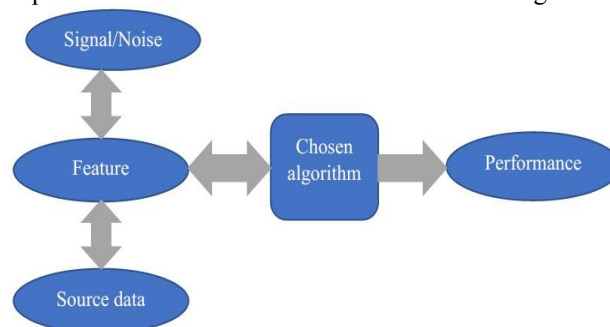

Figure 4. Performance of model by ML experts

Now, the question arises "To what extent the machine learning algorithms works efficiently and accurately". The answer is: "It depend on the ability of the organization to build the system. To achieve this task, the organization need efficient teachers".

The deep understanding of the machine learning algorithms is required to construct the machine learning system. This clearly indicate the huge gap between the mandate for machine learning schemes and the organization to shape them. This gap can be reduced by increasing the number of teachers who can teach machines.

"While machine learning focuses on creating new algorithms and improving the accuracy of learners, the machine teaching discipline focuses on the efficacy of the teachers. Machine teaching as a discipline is a paradigm shift that follows and extends principles of software engineering and programming languages" [35]. The teacher has a deep knowledge of the data, procedures and design principles of interface and conception.

We can broadly classify the machine teaching into four parts which are shown in figure 5:
   a. Batch teaching
   b. Sequential machine teaching
   c. Iterative machine teaching
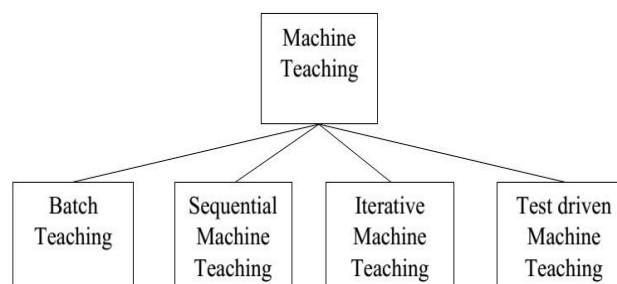   d. Test-driven machine teaching

Figure 5. Types of Machine Teaching

3.1 Batch teaching

In traditional machine teaching, the teacher constructs the batch set of examples and give it to student (or machine) in one shot to execute by the learning algorithm. The task of learning algorithm is reach to the target with the help of these batch sets. This concept is namedas the teaching measurement of the student model [36].

3.2 Sequential machine teaching

In the sequential machine teaching, the teacher teaches crowd workers to classify the query in better way. The teacher considers the setting where the learner is not iterative and does not have any particular optimization learning algorithm [37].

3.3 Iterative machine teaching

In the case of iterative machine teaching, the teacher model communicates and influence the student model in multiple rounds while the student model remain passive during this process. The advantage of this model is that it describes the complexity of the model to the complexity of the algorithm. The teacher model can be different depending on the learning algorithms of the students of the same student model [38]. The Comparison of iterative machine teachingparadigm with other paradigms has been shown in figure 6:
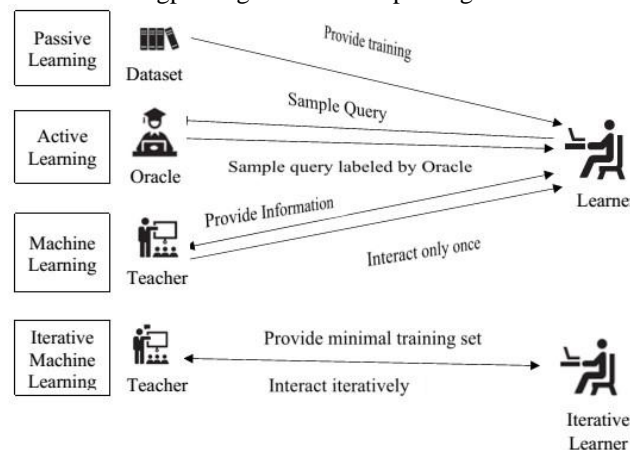

Figure 6. Iterative machine teaching and other learning paradigms

3.4 Test-driven machine teaching

The aim of this model is to select the test cases for the selected users as the major interfaces between learning algorithms and participants. It not only makes easy to teach the learning model, but also intelligently and actively supports the robust teaching activities and process [34]. The workflow of test-driven machine teaching is shown in the figure 7:
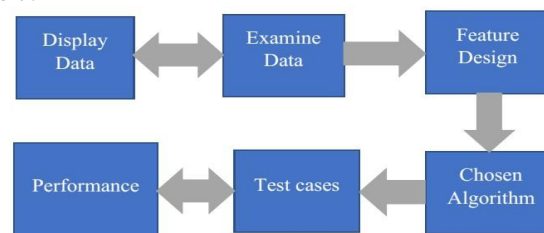

Figure 7. Workflow of Test-driven Machine Teaching

    a. Display data: It checks the quality of the data, requires users to select the test cases and suggests the neglected data in the region.
    b. Examine data: It actively examines the data to elicit a test set and develop the holistic understanding of the data.
    c. Feature design: It suggests or guides the design of the feature set and algorithm picks.
    d. Chosen algorithm: It makes informed features and algorithm picks.
    e. Test cases: It communicates model behavior and suggests the debugging strategies.
    f. Performance: It examines the performance of the model based on its behavior on concrete data instances. It also revises features and algorithms under guidance and strategically.

The process of machine teaching is similar to programming languages. Although, there are significant differences between machine teaching and programming. This is shown in the figure 8:
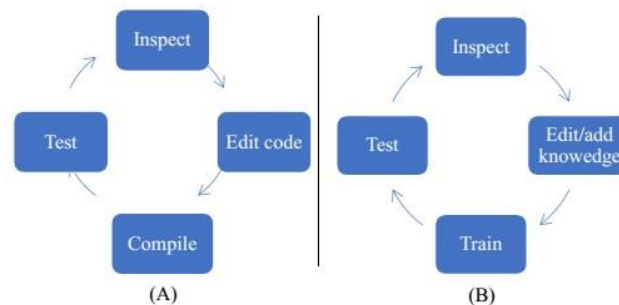

Figure 8. Debugging in (A) Programming and (B) Machine Teaching

The machine teaching expresses these steps as shown in figure 8(b). "For teaching, the language is a means of expressing teacher knowledge into a form that a machine learning algorithm can leverage for training. The new teaching languages will be developed that allow the teacher to communicate different types of knowledge and to communicate knowledge more effectively" [35]. The comparison between programming language and machine teaching is shown in the table II[35] .

Table II: Contrast between machine teaching and programming language

SN	Programming	Machine Teaching
1	Complier	Machine Learning algorithms
2	Operating systems	Training, Sampling, Feature sets
3	Programming languages	Labels, Features
4	Programming expertise	Teaching expertise
5	Development processes	Teaching processes

The potential teachers and their characteristics are shown in the table III[35]:

Table III: Potential teachers and their characteristics

SN	Potential teachers	Characteristics
1	Machine learning experts	Having good knowledge of ML and improve the performance of ML algorithmsand/or architecture.
2	Data scientist/analysists	Examine big data, sense trends and correlation using ML. Ability to train the ML models to abstract useful information.
3	Domain experts	Understand the semantics of the problem.
4	Machine teacher experts	Allow developers or subject matter experts with little or no knowledge of Artificial intelligence to communicateintangiblenotions to ansmartarrangement, which then perform the ML algorithms in the background.

4. Applications of Machine Teaching

Machine teaching has various applications which are as:
   a. In education applications, the dynamical system is a human student. The teacher enhances the training set to help the student to learn theobject model.
   b. In security applications, the dynamical system is a ML algorithm. It modifies the training set to force machine learning into building a nefarious model.

c.   In AI systems, machine teaching enables the machine learning model accurate, fast, efficient and effective as oppose to simply providing training sets to the learning algorithms. In model optimization and compression, machine teaching is useful the prune the redundant data and quantify the data with less amount of memory.

d.   In transfer learning, the machine teaching is useful for human learners to apply and leverage their experience to solve new problems and support the future learning.

e.   In curriculum learning, machine teaching adaptively selects a sequence of training subsets for the successive stages in machine learning algorithms. It will useful for the learner models to take the better decision accurately, effectively and timely.

f.   In knowledge distillation, the learned information will be transformed from one model to other with faster speed and it handle the problems due to lack of unlabeled data.

5.   Advantages of Machine Teaching

a.   Machine teaching is used to make technology, for example, automation tools are usable to subject experts with little or no knowledge of computer field

b.   The scientists can spend more time on more productive and valuable tasks rather than to spend time on developing the training sets. It ensures AI designed in responsibly and thoughtful ways.

c.   Machine teaching takes advantage of human expertise to make AI systems more powerful by telling them what to focus on. It removes the time-consuming exploration process.

d.   Machine teaching able to advanceinformation from individuals instead of extract information from the data alone and it will help for machine learning algorithms to solve the complex problems.

e.   When there is little or no training data exists for the machine learning algorithms, the machine teaching is quite helpful because an organization's demands are very specific.

f.   Machine teaching is useful to reduce the valuable time for an intelligent agent to find the possible solutions.

g.   Adding a machine teaching layer into learning model can drastically reduce the time, it takes to find the potential solutions of real-world complex problems.

6.   Future of Machine Teaching

The following things will become the reality in the field of machine teaching in the future:

a.   Machine teaching is useful for machine learning algorithms to analysis the data in more appropriate ways. In future, the fine-tuned personalization and hyper-targeting can be achievable for the customer at huge scale.

b.   The search engine will be more optimized, focused and specific according to the user' perspective.

c.   The redundant task by the programmers will be completely obsolete in the future and replaced by the robotic process automation.

d.   There will be no requirement of code environment in the future. The packages will not only supply the code information to the programmers, but also to put appropriately at the right place.

e.   Quantum computing will be the new paradigm in the future. It will lead into faster processing, accelerated learning and increased capabilities.

7.   Conclusion

Machine teaching teaches to machines in such a way that is closer to how people learn. The concept of machine teaching can be applied to the complex problems to be truly solvable by the machine learning algorithms in an efficient and effective manner. Machine teaching is a paradigm shift that follow and extend the principle of traditional programming languages. Machine teaching is the new paradigm to build the machine learning systems.

This paper reviewed the various machine teaching paradigms such as batch teaching, sequential machine teaching, iterative machine teaching and test-driven machine teaching in the context of machine learning models. We have discussed the various applications of machine teaching in education, security, AI etc. The advantage of machine teaching is also discussed that make machine learning models more powerful and accurate. The future directions of machine teaching are also elaborate which will enable the human to work closely with the machines and perform the work in more accurate and faster way.

Conflict of Interest

The authors articulate no conflicts of interest. This paper does not comprise any studies with human or animals done by any of the authors. The article gives a review of machine teaching and its future.

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