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Unfolding the Evolution of Machine Learning and its Expediency

Ritvik Voleti

Computer Science Engineering, KCC Institute of Technology and Management

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Abstract - The era of computers started on executing complex calculations along with not only storing data, and also storing instructions of manipulating data. It got to a level in which the data processed by computer based on the structural model of real world was expressible on the basis of mathematical terms. Computer's only task was to follow and not learning any new instructions. Next process in the right direction was to make instructions set which would help the computer for experiential learning, for extracting the rules from a huge data which would enable to utilize the rules for classifying and predicting. This led to the start of the era of ML (Machine Learning) along with the field of AI (Artificial Intelligence). There was a big breakthrough in the algorithmic implementations which were modeled on the architecture of brain, and with multi-connecting units that share weighted layers that is organized in DL (Deep Learning). Artificial Intelligence was and is continuing to revolutionize various aspects of our lives with applications in research work especially in biomedical research and healthcare is rapidly improving. In this research paper we try to give a glimpse of past, present and future of Machine Learning from identifying key issues and raise essential research related questions which have to be addressed for maximizing the solutions and gaining more knowledge of different issues regarding Machine Learning.

Keywords– Machine Learning, ANN, Perceptron, AI

I. INTRODUCTION

ML is a technological field which answers the query of how systems can memorize automatically and enhance with observation? It isn't about cramming data but is all about understanding complicated patterns thereby making smart choices on the basis of the given data. ML combines probability theory, optimizing combinatorics, statistics, searching, logic, reinforcement learning along with control theory approach. The approaches that are made are due to applications like language processing from vision, pattern recognition, data mining, forecasting, robotics, expert systems and games.

It was explained by Arthur Samuel, like a means for computers for learning with a lack of explicit programming. ML deceives to be a modern invention but surprisingly it goes back in the eighteenth century where it truly began through mathematicians. In that time, Bayes gave an eponymous theorem that predicted likelihood of the occurrence of an event on the basis of key factors in prior knowledge. In modern times, ML algorithms assists the computers for communicating to human beings, in self driving cars, in writing and publishing games analysis. ML will certainly affect majority of the current industries as well as the jobs in it that is why almost each and every manager must have some knowledge of ML and its evolution.

II. EVOLUTION OF MACHINE LEARNING

A. *Neurophysiology ML*

Neural networks were first introduced in mid twentieth century by Walter Pitts, Warren McCulloch who gave a paper on neurons along with the working. Both of them created a model using the electrical circuit which gave the name of neural network. Walter Pitts built a mathematical model to understand neural relationships and Warren built the experimental epistemology for linking both the mind and the brain which laid the foundation on cybernetics. He was the father in neuropsychology, neural networks [1]. When a cell continuously assists at firing a different cell the axon for the primary cell builds synaptic knobs i.e increases them when they exist already within direct contact with soma of second cell. Hebb's concepts in ANN, artificial neurons, and the model could be specified as a mechanism of changing relation between nodes/ neuron along with the modifications to individual nodes. Its weight is key for describing these relationships and neurons that tend to being either positive or are both negative and comprises of weights which is strong and positive. ML is completely built on the concept of the interaction of brain cell. Its model was made by D. Hebb in 1949 and written within one of his books. That book shows the variety of Hebb's theories for the excitement in neuron, neuron communication.

B. *ML in Checkers Game*

Alan Turing in 1950 made the renowned Turing Test. It is an easy to understand test i.e a computer can only pass the test if it can convince any human to be human, and not as a computer. He concluded science to be like a differential equation and made Religion to be the boundary condition [2]. In 1952, the first programmed computer was made that was able to memorize as it was running and was able to play checkers game-made by A. Samuel.

C. *Perceptron*

Frank Rosenblatt in 1957 had merged Hebb's brain-cell interactive model along with the contribution of Arthur Samuel in ML that had made the perceptron. It (perceptron) was specified like a machine and not as a program in the starting years. The software was primarily built for IBM 704, that was installed inside a machine complete custom built named Mark 1 perceptron that was constructed for the sole purpose of image recognition. The software, algorithms got transferable along with being accessible for a variety of machines. His pioneering programming technique shaped the future of instruction set within the processors, because he was the chief person to test the computers in projects excluding computation [3]. The perceptron suffered with problems that had broken many expectations. Even though the perceptron showed glimpse of promise, it failed in recognizing a variety of patterns (visual) that led to increasing frustration and stalled research work in neural network. Neural along with ML Research fields were struggling in the 90s.

In 1959 one of a neural network was created by B. Widrow, M. Hoff who made 2 models of it in Stanford University. The primary one was named as ADELIN which was able to recognize binary patterns. MADELINE was the second generation and was able to remove echo in the phone lines i.e was extremely essential real-world app and is still continued to be used in the current times as well. MADALINE is 3-layered having the input layer, hidden layer and the output layer. It was completely linked and was a feed-forward ANN architecture used in classification that utilizes ADALINE units within the hidden layer, output layers so the activation func. is a sign function [4]. MADELINE was a success but a lack of progress was observed till the late 70s due to a number of reasons especially because of V. Neumann architecture.

D. *Nearest Neighbor Algorithms*

During the 60's, nearest neighbor algo was conceived and was the start of simple pattern based recognition. It was useful in mapping routes, and is useful in calculating a output for the travelling salesperson problem i.e searching for the best route. Through this algorithm any salesperson that enters the city that is considered and even repeatedly, the algo will make the program visit the nearby cities till every connected city is visited. M. Pelillo is credited to invent- nearest neighbor rules.

E. *Multilayers Being the Future Direction*

During the 60s, the usage of multilayers brought in a updated path within the neural network field of research. It was found that considering using 2 or even more layers within the perceptron provides very high processing power compared to any perceptron that uses a single layer. Other varieties of networks were made after perceptron gave new path for layers in the neural network along with a variety of continuing expansion. The usage of multi-layer network made the feed-forward networks along with backpropagation. The multi layers, and the

activation (non-linear) separates MLP with the linear perceptron. It is useful in differentiating between linear and non-linearly separable data [5]. In ML **BP** is one of the most used algo to train feedforward networks. Back propagation being generalized is useful for different ANNs and general functions [6].

Backpropagation allows networks in adjusting the hidden neuron layers for adapting the new cases/situations. It shows the errors in backward propagation through an error that is processed during the output, is then backwardly distributed via the layers of network's in learning uses. Backpropagation is used for training neural network (deep neural networks).

ANN's are networks that are comprising of vague computing systems that are modelled by bio-neural networks the animal brains [7]. Artificial Neural Networks are a main part used in ML. It uses both the input, output layers and usually consists of hidden layers that is designed for transforming data from the input which is used by the output layer. Hidden layers specialize in finding patterns excellently that are highly complex for detection by any human programmer which shows that a human cannot detect patterns and cannot teach to recognizing the device.

F. ML and AI taking Separate Routes

AI in research is based on considering knowledge based and logical mechanisms and not just algorithms. In addition to that, research within neural network through CS (computer science), Artificial Intelligence researchers were abandoned and it led to a split between AI and ML. Till that period ML was being utilized like a program that AI trained. In 1982 interests in networks (neural networks) began to increase, when J. Hopfield advised in making a network that had lines and is bidirectional in nature and is similar in process likes neurons. In addition to that during 1982, a new focus was put by Japan in an neural networks that are advanced.

The 80s and 90s didn't bring anything significant in this field. But Deep Blue an IBM Computer during 1997 a typical computer focused in playing chess had beaten the chess champion of that time. The victory of Deep Blue made a significant impact on the field, as AI was fastly improving and reducing the gap between the human intelligence that was able to conquer a humanity's great champions [8]. Afterwards, we have seen many advancement in this field, like the research at Bell Laboratories in 1998 through digit recognition that provided proper accuracy to detect postcodes that are handwritten by the Postal Service. Artificial Intelligence has an key role within medicine, research and has clinical applications [9].

G. AI in 21st Century

AI stood tall by being a research field within the computer science after the WW 2, and it started its growth in software engineering during the 70s [10]. From the dawn of 20th century vast number of businesses figured out that ML would improve on the potential estimate. Henceforth research work is heavily done within the field so that people are always being in front of the queue. An objective in Artificial Intelligence is based on the platform of ML which assists for progressive development in the performance of a model [11].

III. CURRENT ML TECHNOLOGY

ML algorithms is extensively utilized for obtaining solutions of varying problems like predicting the financial market, autonomous self-driving vehicles. Lately, ML was well-defined as an ability of computers for performing with no explicit programming as Stanford University elaborated. ML has brought in brand new ideas and skills, within supervised learning, unsupervised learning. Latest algorithms used in robots, IoT's, chatbots, analytics tools, etc. Many software's of deep learning along with its libraries consists of Theano [12], Caffe [13], Torch7 [14], Tensorflow [15] is empowering the advanced GPU-accelerated through deep learning uses.

- ML powered techniques helps in all the manufacturing aspects like reducing the cost of labor, limiting defects in products, decrease in the unplanned downtimes, enhancing transition periods and improving the speed of production.
- It interprets large amount of data in a period of time. It provides valuable assistance as it combines and interprets data in an efficient way to support the managers for taking smart decisions.
- ML techniques are mostly difficult to understand as to how Artificial Intelligence took any decision, so through the help of explainable Artificial Intelligence there is emphasis on visualizing and simplifying how Machine Learning networks take crucial decisions unlike a usual black-box.

- AI has transformed to a such a high level that it has the potential to contest against our brain especially in daily tasks like writing.
- Machine Learning's smart gathering data, processing, analyzing big data sets would enhance the biometric performance of our systems. Keeping with a smart biometrics system isn't just not quickness, accuracy in performance matching but it something which Machine Learning is specialized to do.
- RL(Reinforcement learning) in 2020 has shown bright sparks and is a leading ML learning algorithm. Reinforcement Learning is a deep learning specialized application which takes in its share of experiences for improving itself and is showing signs of a big potential within AI, such has been its effectiveness.
- Also, the fields like NLP, computer vision surprised and is continuing to impress with crucial breakthroughs which none expected. There has been transformation within our lives by using facial recognition technology in smartphones, translating software, autonomous self-driving vehicles, etc. Sci-fi is converting to reality and things looks highly positive for attaining AGI (Artificial General Intelligence).

ML models are nowadays very much learning continuously and are adaptive, it makes it to be highly accurate based on the longevity of the operated models. Machine Learning algorithms aggregated with latest computing technologies provide better efficiency, scalability. When ML is merged alongside business analytics it could potentially resolve many organizational complexities.

IV. ENCOURAGING FUTURE PROMISES

Latest advancements in ML techniques, has a chunk of successful applications in a number of technological fields like planetary science, bioinformatics and brings with it a lot of powerful modern tools that are provided to practicing scientists [16]. ML field is seeing a boom in growth worldwide due to computer vision technology. The human error rate within computer vision is just 3 percent. This showcases the strength of current computers as being just superior in ability to recognize and analyze images compared to the humans. From 2011 there has been a rapid increase that shows the massive impact it has created in recently times. ML has been transforming the past, the present and the future which is all to be seen [17].

Practical uses in ML will continue to grow if observing trends in the development of algorithm, hardware performance continues to enhance. Deep-learning algo. is useful for detecting objects, text within images and facial images, etc. Advancements in deep learning algo includes case studies like:

- Autonomous Self-driving vehicles not only detect objects, like pedestrians but also predict the likelihood of what action these objects will perform.
- Systems will have the potential to observe, score, and provide its own analysis/report for any sporting event.
- Systems can recognize and then neutralize various attempts of hacking along with any type of a fraudulent activity, even in cases of newly discovered vulnerabilities.
- Throughout the world we see researchers continuing to work on making robots which would have the ability to mimic human brain. Research work is prospering in fields having great future prospects like Artificial Intelligence, Machine Learning, Computer Vision, etc. We could possibly see robots having the capability to perform number of tasks identical to humans. Robots can recognize our emotional condition and adapt its interactions with humans.

This only is able to scratch the surface of how smart machines would provide us with futuristic aids. Computers devices could never have ability to think like a human being but they would hopefully be rightly suitable for tasks that would need plenty of patience, resistance and speed compared to majority of human beings will have.

V. Challenges surrounding Machine Learning

As we have witnessed a plethora of transformation in IT industry each and every day presents its own challenges and a set of opportunities. [18] There is a dark cloud of challenges and shortcomings that restrict this prospective technology [19]. Ethics are many times neglected by system parameters – By default any sort of computer doesn't have much know how about ethics. Even if an algo. may form a budget to maximize productivity but it is of no use with a lack of ethics being programmed in a model, as it would remove school budgets or hospices as it doesn't

immediately increase GDP. The result of lack of ethics make any Machine Learning code scripts reduces scrutiny and therefore interpretability is mainly has to be sacrificed for effectiveness and usability [20].

Bias Problem – The quantity of training data provided is a key factor to determine whether any Artificial Intelligence system would be good in nature or bad. For addressing large bias which could be added in the predictions from collectively influencing techniques and max. entropy constraint will be inflicted on inference step that would force predictions to be having similar distribution like the observed labels [21]. Limited diversity is prevalent within the Artificial Intelligence field of research, development and culture in workplace also shapes the technological industry [22]. Therefore, ethical issues has to be accepted and resolved from the start.

Humans influenced by machines – Surprisingly, we do not observe when we are influenced by the manipulation of algorithms. Humans being surpassed will cause more replication, not just reaching but exceeding important unique features of humans like cognition in a high-level that is linked through a conscious perception [23].

Incorrect correlations - An incorrect correlation takes place when independent things with one other showcases a behavior that is highly similar and that may show an illusion of being connected. In worst cases beyond the particular correlations may imply causation [24].

Trust Deficit – A key factor for a reason to worry for Artificial Intelligence is the fear of unknown behavior within any deep learning model that would be predicting the output. Any layman would find it tedious to interpret the complex set of inputs which would be devising a output. AI cannot provide with a secure world on the basis of IT security along with any future cyberwar-attacks preventive warning [25].

Feedback loops – If we consider false correlation a harming thing it only gets worse when we talk about the feedback loops. Feedback loops are a state that can possibly affect any algorithmic decisions not theoretically but in reality that could certainly delude the algo. feeling that it has determined correctly.

Malicious Data Threats-ML algorithms being the so-called data hungry in nature, need millions of experiences/observations for accomplishing the required performance expectations [26]. Machine Learning is currently based on vector data, limiting the value for the richer, text data and graph clusters in non-vector relation are also a key part these days [27]. We get a distorted and an harmful data either through an accident or by a malicious action by someone. It can cause a big harm to the security of a ML model thereby affecting the confidentiality, integrity and authentication i.e CIA.

Threats concerning autonomous weapons- It also has a big potential to create fully autonomous weapons. If we move on with this it can have some serious complications as it is giving machines the control to take a big call on machines for key decisions that can make or break the future of mankind. Hence, we must be careful especially with the concept of giving machines the impetus to attack other human beings. Apart from that, various machines/applications that are based on Artificial Intelligence are having several vulnerabilities within themselves to resolve [28].

Security along with Data Privacy - The key factor on the basis of which every ML and deep learning models rely on are the data availability, resources used for training the models. Theoretical analysis worldwide for data protection, privacy, security and safety provides only hypothetical solutions, but are very difficult to implement in reality [29]. Attacks like data poisoning in which the training data is manipulated intentionally through ambiguous data which can sabotage the training data phase for any type of learning algorithm [30], [31].

Conclusion

Machine learning being important for the people is an understatement as it helps for managing their tasks in a far more efficient way. But we cannot also neglect the dangers and the vulnerabilities that surround ML and hence must resolve the issues as early as in the developmental stage so that in case of any issue we can easily monitor the algorithms. Future engineers to survive this bombarding technological market need to improve their knowledge in latest technological advancements because of the high competition. ML, even though has experienced several downs in the past but is continuing to expand and showing great signs for the future with advancement in important issues.

It consists of scaling the Machine Learning methods up by a big sample size and finding an efficient balance in the discriminative, generative methods, and putting emphasis on concentrating on the highly efficacious data like active learning. We are hopeful of making big strides of progress in core Machine Learning research areas for the future. Finally, there must be a level headed approach for the future ML models and so humans must have the final control over the machines as we cannot afford to give the authority to the machines to shape the mankind in a regretting fashion.

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