A Perspective on Artificial Intelligence and Machine Learning

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There has been tremendous interest in Artificial Intelligence (AI) and Machine Learning (ML) in recent times. The AI resurgence can be attributed to many factors like easy availability of electronic data, cheaper and faster computing, open source nature of software and hardware in this space, investment by large players in anticipation of break thru, & advances in algorithms mimicking nature (Biomimicry) like Deep Neural Networks (DNN). With all these advancements, it is clear that we are in the early stage of cognitive computing. To many of the practitioners in the field it is clear that we are more artificial and less intelligent at present and wants to be less artificial and more intelligent. The main reason for it lies in quality of processing versus quantity of processing. Machines and humans are different. At present computers are extremely powerful in quantity of processing where as they are weak in quality of processing. For example, humans are extremely good at separating noise and signal whereas computers find it very difficult. Today they outperform humans in narrow tasks to great extent by the sheer power of computing force as opposed to the clever nature of solving problems.

There are three stages in AI. Artificial Narrow Intelligence (ANI), Artificial General Intelligence (AGI), & Artificial Super Intelligence (ASI). We are in a stage of transition from artificial narrow intelligence to artificial general intelligence. It is estimated that humanity will achieve AGI by next decade. The era of ANI is characterized by machines which can tackle narrow tasks with basic motor skills. The era of AGI will be characterized by intelligent machines which can tackle any tasks that a human can tackle, be it cognitive or motor skills.

The DARPA perspective on AI categorize the three waves of AI as DESCRIBE, CATEGORIZE, & EXPLAIN. The describe phase is characterized by handcrafted knowledge; the categorize phase characterized by statistical learning; & the explain phase characterized by contextual knowledge. The four dimensions of perceiving, learning, abstracting, & reasoning helps us to evaluate the waves of AI. A high level maturity on all the four dimensions corresponds to advanced AI.

Are heading to a state where silicon life forms reverse engineering carbon life form to be the dominant force going forward?

Terminologies like AI, ML, & DL are interchangeably used today. What is AI and in what way is it different than ML or DL? There are many definitions for AI, but in simple terms it is "*the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings*". AI is about machines augmenting humans and full automation is not in our vicinity. Machine Learning is an application of artificial intelligence (AI) that provides systems the ability to automatically learn and improve from experience without being explicitly programmed. In other words Machine Learning is a sub field within Artificial Intelligence. In recent times the term deep learning is interchangeably used with machine learning more often. It should be noted that deep learning is a sub filed within machine learning focusing on learning thru neural networks. In classical programming we obtained answers from rules and data where as in machine learning we obtain the rules given data and answers. New thinking is required to unlock the massive potential of machine learning.

Machine learning requires computational power of order N square or more as the problem size increases. Some algorithms are computationally more intensive than others. The number of features and number of records decide the computational complexity. Today's HPC clusters and distributed clusters help us to solve very large problems. There are real world problems which still cannot be solved in today's hardware infrastructure. The next generation hardware can be either evolutionary or revolutionary in nature. The evolutionary changes include advances in CPU, GPU, TPU, FPGA, ASIC, etc. With Moore's law coming to an end, other forms of computing are emerging. The revolutionary changes include

neuromorphic computing and quantum computing which can reduce the amount of time required to solve larger problems which are beyond the realm of today's computational power. It should be noted that neuromorphic computing and quantum computing are not general purpose. They add value in solving specific problems and will be used in conjunction with traditional computers going forward.

There are different classification schemes by which we can look at machine learning algorithms. The most widely seen classification is Supervised learning vs Unsupervised learning vs Reinforcement learning. Majority of today's learning is in the space of supervised learning. Machine learning is all about learning from data. Based on the amount data available for training, we can utilize shallow learning and deep learning algorithms. Normally shallow learning algorithms require less data to learn compared to deep learning algorithms which normally requires more data. There is research happening to make deep learning algorithms learn from less data. A more detailed classification scheme is defined in the article "Machine Learning Journey".

Shallow learning is characterized by manual feature engineering. Deep learning tries to avoid manual feature engineering using a technique called representation learning. Hierarchical learning is another characteristic of deep learning. Learning in layers is what makes it transferable from one task to another task.

As noted by Robin Bordoli the CEO of CrowdFlower; Training data, machine learning, and human in the loop form the corner stone of today's AI. It should be highlighted that the training data is as important as the algorithm. The paper "The unreasonable effectiveness of data" can be summarized as "*If you had a choice making better algorithms or getting more data, get more data*". Data pre-processing can take up to 70% of the time in building a machine learning pipeline. The feedback loop after deployment allows the algorithm to adjust to the changing environment and improve itself. Feedbacks from humans are important for the long term sustenance of the machine learning pipeline. This is why term augmentation goes better with AI than automation. Some even prefer to call AI as Augmented Intelligence as opposed to Artificial Intelligence.

Data and algorithm forms the core of machine learning excluding human. The data used for training can be either structured or unstructured (voice, image, & text). Algorithms can be of many types. From an outcome perspective they can be seen as classification or regression in supervised learning, clustering and dimensionality reduction in unsupervised learning. Anomaly detection and reinforcement learning are two additional types of algorithms which purely do not fall into either supervised or unsupervised. Algorithms can be either generative or discriminative depending on the probability distribution. A generative model learns the joint probability distribution p(x,y) and a discriminative model learns the conditional probability distribution p(y|x).

When you try to answer the question "Is this A or B?", you in turn are trying to classify it. For example given an image, answering a question like is this cat or dog falls in classification task. Trying to answer the question "How much or How many?", you are trying to perform regression. For example given the specification of a house in a locality, answering a question like what will be the value of the house falls in regression. Trying to understand how the data is organized is called clustering. An example could be organizing the population into low income, middle income, & high income assuming there are three groups in the population. Some classification tasks can be changed to clustering tasks by just rephrasing the question that we are trying to answer. Given a set of image of animals, we could ask how many different types of animals are in the given set of images? At times data might have weird values. When you try answer the question "Is this Weird?", we in turn are performing anomaly or outlier detection. There are many practical situations in which we need to understand what should i do next? Reinforcement learning is used when you need to answer such a question. Dimensionality reduction is similar in concept to lossy compression. How can we reduce the dimension of the problem without losing much on the final outcome?

Machine learning is applied in many applications today without our knowledge. Recommendation is one of the best examples of its usage. The recommendation becomes more specific as the system starts understanding the preferences of the user and changes with the change in preference. It is not prefect, but it works and companies have gained revenue gains because of the learning. Identifying the churn of customers or employees is another example where machine learning is applied today. Anomaly detection, fraud identification, computer vision (object classification, object detection, & object segmentation), language translation are other areas where machine learning is applied today. It is becoming more difficult to find applications that don't use learning as a fundamental tool.

There are many algorithms for solving classification, regression, clustering, anomaly, dimensionality reduction, & reinforcement learning tasks. General guidance is available for choosing the right algorithm for the task at hand. It is still not sure if it is a science or an art in choosing the algorithm / algorithms for a given task. A good understanding of linear regression, logistic regression, tree methods and tree ensembles, support vector machines, principal component analysis, K-

means clustering, hierarchical clustering, & multi-layer perceptron should be sufficient to start your career and apply them in real life.

Basic to advanced knowledge in math, stats, probability, linear algebra, & visualization helps one to apply machine learning well. The choices of programming languages are many, but Python & R are more popular with engineers and data scientists. Java / Scala is preferred in some enterprises because they tend to use distributed machine learning as opposed to machine learning using high performance computing.

There are many courses freely available for learning ML. MOOCs are the most favorite forms of learning. ML courses from Coursera, edX, & Udacity provide the jump start. It is an experimental science and requires extensive practice before one can become master at it. A right balance between theory and practice is required to become an expert in the field. Continuous learning should be part of the day to day activities to keep pace with the changes happening in this space.

References:

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- A Brief History of AI - https://www.salesforce.com/video/1713120/
- DARPA Perspective on AI - https://www.darpa.mil/about-us/darpa-perspective-on-ai
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Beautiful Lines

- No lock is manufactured without a key. Similarly, god won't give problems without solutions.
- Changing the face can change nothing. But facing the change can change everything. Don't complain about others, change yourself if you want peace.
- Every successful person has a painful story. Every painful story has a successful ending.
- If a problem can be solved no need to worry about it. If a problem cannot be solved what is the use of worrying.
- No one can go back and change a bad beginning. But anyone can start now and create a successful ending.
- Easy to judge the mistakes of others. Difficult is to recognise our own mistakes. It is easier to protect your feet with slippers than to cover the earth with carpet.
- Mistakes are painful when they happen. But years later, collection of mistakes is called experience, which leads to success.
- Life laughs at you when you are unhappy. Life smiles at you when you are happy. Life salutes you when you make others happy.

Strange But True

- Inspite of so many colors - Black & White is considered Class.
- Inspite of so many voices words & sounds - Silence is considered ultimate.
- Inspite of so much to eat - Fasting is considered healthy.
- Inspite of so much to travel & explore - Meditating under trees & mountains is considered superior.
- Inspite of so much to see - Closing your eyes & looking within is Apex.
- Inspite of listening to all the outside world - Voice from inside You is eternal.
- Inspite of a Sweet charming Life - A Peaceful life Soul is Solace & Divine.

There is a report by a NASA scientist that America is creating 6th and 7th generation super computers based on Sanskrit language. Project deadline is 2025 for 6th generation and 2034 for 7th generation computer. After this there will be a revolution all over the world to learn Sanskrit. However, trend has picked up in the Western world. Indians are waiting for the moment when Sanskrit Scholars from overseas countries will come to teach them.

Sanskrit is a highly regularized language. In fact, NASA declared it to be the *“only unambiguous spoken language on the planet”* – and very suitable for computer comprehension.