Machine Learning, the Next Milestone in Human Evolution

Dr. Subburaj Ramasamy
Principal Consultant, Machine Learning Consultancy, Chennai
Senior Director/Scientist "G" (Retd.),
Ministry of Electronics and Information Technology, ERTL(W), Mumbai, ETDC & CFR, Chennai.
subburaj.spr@gmail.com

The day by day developments pertaining to machine learning (which also includes deep learning) for Artificial Intelligence (AI) is keenly watched by Professionals, bureaucrats, top management of Fortune 500 companies and Governments all over the world since it is strategically important not to miss this new technology and to catch up early so as to reap the benefits of this determining technology of the future. This article addresses the various milestones in the evolution of Machine Learning and AI, Major Types of Machine Learning algorithms, widely used programming languages, some current applications, and future directions.

PREAMBLE

Human civilizations have been witnessing many path-breaking inventions since the Industrial Revolution of the 18th Century. Artificial Intelligence (AI) through Machine Learning is expected to be the next major milestone in Science and Technology. According to a Forbes report, world leaders in Information Technology including, Google, Microsoft, Spotify, IBM, Apple, Uber, Skype, Salesforce, Tesla, Shell, Netflix, Facebook, Amazon, Intel, and eBay are planning to invest US$ 203 billion just for AI research [1].

During the past five decades, the lives of ordinary human beings have been undergoing continual improvements and quality of life has improved manifold. The IBM PC spearheaded the Information Technology bubble in the early 1970s. It enabled computer communications, chiseled by the DARPA project in the US, by many persons and organizations. Handheld mobile phones and later smart phones really took technology to each individual whether it is a street vendor or a multi-billionaire, thus giving a practical demonstration of Inclusiveness at one go, which National leaders could not achieve fully for centuries, but mobile technology achieved it in a short timeframe. Today, the total number of mobile phones in use is far greater than the human population in the world.

HISTORY

A century ago cognitive function comprising of the four steps namely perception, reasoning, learning and problem solving was the prerogative of human minds. Artificial Intelligence (AI) is a discipline created to mimic cognitive functions of the human mind in machines. Some of the technologies evolved to enable AI to solve business problems are Robotics, autonomous vehicle, and machine learning.

Machine learning is the technique by which one can predict the future with the past data. Amazing! There are many contributors to the emergence of Machine Learning as a practical technique with a large number of applications. Machine Learning algorithms were proposed decades ago. Artificial Neural Networks (ANN) was also proposed decades before. Then if we ponder over the question as to why Machine learning was not in the limelight much earlier and why suddenly everyone from students to Prime Ministers of countries are concerned about it? It is because the necessary computing power was not available ever before at affordable costs. For instance, when India entered supercomputing Research in the late 1980s the target was to build a supercomputer with peak computing speed of 1 Giga floating point operations per second (GFLOPS) at a cost of crores of Indian Rupees (INR). Today the Graphical Processing Units abbreviated as GPU with a speed of 16312.32 GFLOPs for single precision and 509.76 GFLOPS for double precision floating point numbers [2] are available off-the-shelf in thousands of INR. In fact, the availability of such enormous computing power at affordable costs is one of the drivers for accelerated growth of Artificial Intelligence through machine learning.

The next important reason for the current interest in Machine Learning (ML) is the explosion of the Internet and later social media. Social media produces exabytes of data every day. What is an exabyte? It is 10^{18} bytes. Try to express this in decimal number format and see the number of zeros after 1. (It is 1 followed by 18 zeros.). Since the inception of computers and till the year 2005, 130 Exabyte of data were created by human beings; by the year 2010 it was 1200 Exabyte, by the year 2015 it was 7900 Exabyte and by the end of the year 2020, it will be 40900 Exabyte of data that would have been created. Don't underestimate this phenomenal growth of data creation. An intelligent Data Scientist can derive innumerable hypotheses with this data and earn billions of dollar profit. This can determine the future of peoples and Nations. Essentially the growth of speed of computing and generation of the phenomenally high volume of data are the prime movers of Machine Learning.

It is interesting to view the timeline in the evolution of AI and Machine Learning [3].

- 1805: French Mathematician Adrien-Marie Legendre publishes the least square method for regression. The method is still used popularly in supervised ML and Software Reliability Engineering.
- 1958: French Mathematician Frank Rosenblatt develops the Perceptron algorithm, an early type of artificial neural network (ANN).
- 1959: American computer scientist Arthur Samuel coins the term "machine learning".
- 1965: Birth of Deep Learning - Ukrainian mathematician Alexey Grigorevich Ivakhnenko develops the first learning algorithms for supervised multilayer artificial neural networks (ANNs).
- 1989: French computer scientist Yann LeCun, now director of AI research for Facebook, and others publish a paper describing how a type of artificial neural network called a convolutional neural network (CNN) is well suited for shape-recognition tasks.
- 1991: The European Organization for Nuclear Research (CERN) opens up the World Wide Web to the public.
- 1997: Recurrent Neural Networks were used to make improvements in the conversion of speech to text.
- 2002: Amazon launches its cloud-based storage and computing power to users.
- 2004: Facebook launched
- 2004: Computer scientist Jeff Dean (current head of Google Brain) and Google software engineer Sanjay Ghemawat develop MapReduce to deal with immense amounts of data by parallelizing processes across large data sets using a substantial number of computers.
- 2005: YouTube launched
- 2006: Inspired by Google's MapReduce, computer scientists Doug Cutting and Mike Cafarella develop the Hadoop software to store and process very large data sets.
- 2006: Geoffrey Hinton proposes a methodology to accelerate backpropagation algorithm in Deep Neural Networks
- 2007: Apple launches the smart phone
- 2017: Google announced an upgraded version of the tensor processing unit (TPU) with 180 million teraflops of computing power.

The above [3] gives not only the evolution of ML but computers in general. ML already finds its applications in smart mobile phones and it is not far off when ML becomes highly pervasive even among non-programmer professionals.

ML TYPES

The major categories of ML are listed below:
- Supervised Learning
- Unsupervised Learning
- Reinforcement Learning

We briefly discuss the salient points about them now.

Supervised Learning (SL)

The goal in SL is to learn a mapping from inputs X to outputs y, given a labeled set of input-output pairs as expressed below [4]:

D={(Xi,yi)}; i=1 to N.

- Here D is called the training set and
- N is the number of training examples.

Each training input Xi is a D - dimensional vector of numbers, representing, say, the height and age of a person. These are called features, attributes or covariates. In general, however, Xi could be a complex structured object, such as an image, a sentence, an email message, a time series, a molecular shape, a graph, etc.

The form of the output or response variable yi could be a categorical or nominal variable from some finite set, $y_i \in \{1,..., C\}$ (such as male or female), or a real-valued scalar (such as the height of a person). When yi is real-valued, the problem is known as regression. When yi is categorical, the problem is known as Classification or pattern recognition. Another variant, known as ordinal regression, occurs where label space yi has some natural ordering, such as grades A–F.

Some common regression problems are given below:
- Weather prediction
- Estimating the selling price of a house

Linear regression, Polynomial regression and classification and regression trees (CART) are widely used SL algorithms.

Some examples of Classification follow:
- Facial Recognition System
- Handwriting Recognition System

The popular classification algorithms are given below:
- Logistic Regression
- K Nearest Neighbour
- Naïve Bayes
- Support Vector Machines
- Random Forest
- Artificial Neural Networks
- Convolutional Neural Network

Unsupervised Learning

Unsupervised learning algorithms analyze the features without being given an explicit response variable. The Unsupervised ML algorithms identify groups of data that exhibit similar behavior. For instance, there are a collection of children. The features known are their age, their height and their weight at birth. If we plot the three features in a scatter plot we will get distinct patterns. We may find three clusters. We may identify the clusters as obese children, average children, and thin children. We do this labeling after we plot the features whereas in classification the labels are predetermined. This is an example of Unsupervised Learning. Some examples of unsupervised learning are given below:

- E-commerce User Groups
- Biological cells or specimen clustering
- URLs clustering

The popular clustering algorithms include the following [5]:

- K means clustering
- Hierarchical clustering
- K Medoids clustering

Reinforcement learning

These algorithms are used when there is insufficient data. So the learning in Reinforcement algorithm is by trial and error. The goal is to maximize rewards it receives for its actions. The only way to learn about the environment of the business problem is to interact with it. For instance, in advancing loans to customers in a financial institution calls for Reinforcement Learning. This is the area of the future. Google Deepmind uses Reinforcement Learning to play games.

PROGRAMMING LANGUAGES FOR MACHINE LEARNING

Python and R languages are preferred for ML applications. It may be noted that both these languages are open source i.e. they are available free for download from the World Wide Web (www). Brief notes on these two languages which contain rich libraries to carry out complex tasks are given below.

Python

Python is a powerful, flexible, object oriented and interpreted language that is easy to learn, easy to use, and has powerful libraries for carrying out complex machine language tasks in concise codes. Estimating parameters or weights of machine learning model is critical, challenging and interesting task. The following 2 lines of Python code can be used to train an Artificial Neural Network (ANN) to find the weights of already specified ANN. The total number of weights of the ANN could be as large as needed and the code is independent of the same.

```
classifier.compile(optimizer='adam', loss='binary_crossentropy', metrics=['accuracy'])
classifier.fit(X_train, y_train, batch_size=10, nb_epoch=100)
```

The reader need not try to understand the code. But what is intended to be conveyed is that because of the open source libraries available in Python compact code can be written.

Its simple syntax is very accessible to programming novices and will look familiar to anyone with experience in C/C++ or Java. For over a decade, Python has been used in scientific computing and highly quantitative domains such as finance, oil and gas, physics, and signal processing. It has been used to improve Space Shuttle mission design, process images from the Hubble Space Telescope, and was instrumental in orchestrating the physics experiments which led to the discovery of the Higgs Boson (the so-called "God particle").

The R language

R is one of the statistical packages such as SPSS, SAS, and NCSS. Like Python, it is compatible with Windows, Macintosh, UNIX, and Linux platforms and offers extensible, open source libraries and computing environment. The R environment provides similar functions as Python offers. It also results in compact code due to its large number of libraries. There are no license requirements both for R and Python. At the same time, they provide a large number of libraries for data analytics and machine learning. Therefore the Machine Learning architects can convert their algorithms to machine code with ease and with no surprises by using any of the two languages.

APPLICATIONS

There are many applications of Machine Learning and Artificial Intelligence. For instance, a machine learning powered computer could defeat the world chess champion. In another instance, Machine Learning negated the diagnosis of the world's leading doctors of malignant cancer in a patient. Driverless cars are going to be seen on the road soon. The Business to Customer (B to C) segment is witnessing fast growth with Amazon and NetFlix generating huge income through their eCommerce worldwide. As a corollary to this, independent Recommendation systems sector is expected to catch up. Recommending what books or Television Receiver consumers may buy based on preferences of other customers with similar attributes is what Recommender System does [6]. The disciplines of Software Reliability Engineering and ML are both branches of Statistical Learning and ML has already been applied to Software Reliability Growth Modeling [7]. Some applications where AI has already made inroads are given below:

- Facial Recognition
- Speech Recognition
- Speech to text and vice versa
- Recommendation Systems
- Medical Diagnostics
- Selection of most attractive advertisement, given many variants of the same with Reinforcement Learning

There are many other applications where AI will be increasingly used:

- Healthcare
- Retail business
- Travel
- Transport and logistics
- Media and Entertainment
- Education
- Agriculture

The list is neither complete nor exhaustive and an intelligent mind can identify many innovative applications of Machine Learning and AI.

SUMMARY AND CONCLUSION

The gainful usage of machine learning for Artificial Intelligence has been facilitated by growing computing power and explosion of data. It will gain further momentum with increasing computing power and development of new algorithms.

Reinforcement Learning is an area to be watched for its further stride and penetration in new sectors such as aerospace and defense. The concern at the moment is the accuracy levels achieved by various machine learning algorithms and therefore it will attract more research in this area. Machine learning discipline has grown very large with many disciplines and aggressive research programs by business leaders worldwide. It is going to change our way of thinking and make life more and more productive and efficient thereby improving quality of life.

REFERENCES

[1] Govind Appu, Artificial Intelligence Technology, An Overview (2018). primesolwa@gmail.com.
[2] https://en.wikipedia.org/wiki/List_of_Nvidia_graphics_processing_units downloaded on January 3, 2019
[3] Michael Chui, Vishnu Kamalnath and Brian McCarthy (2018). An Executives Guide to AI. McKinsey & Co.
[4] Kevin P. Murphy, "Machine Learning: A Probabilistic Perspective", MIT Press, 2012
[5] Gareth James, Daniella Witten, Trevor Hastie, Robert Tibshirani. "An introduction to statistical learning". Springer, 4th Print, 2014
[6] A. Razia Sulthana and Subburaj Ramasamy (2019).   Ontology and context-based recommendation system using Neuro-Fuzzy Classification. ELSEVIER Computers and Electrical Engineering (Article in Press).
[7] Subburaj Ramasamy and Indhurani Lakshmanan. Machine Learning Approach for Software Reliability Growth Modeling with Infinite Testing Effort Function. Hindawi Mathematical Problems in Engineering Volume 2017, Article ID 8040346, 6 pages

About the Author

Dr. Subburaj Ramasamy is author of 7 books in English on topics such as Total Quality Management, Software Reliability Engineering, Computer Programming in C, and C++. He published his first Tamil fiction entitled "Oru Thanga Thayin Kathai" as an eBook in Amazon and as a paper pack in India. He is currently an independent Consultant on Machine Learning and Software Reliability Engineering. He was Professor and Consultant in the SRM Institute of Science and Technology, Chenn ai, India for more than 8 years. He served the Government of India organizations in various capacities. He served as Senior Director and Head of Electronics Testing and Reliability Centres in India for 18 years and in recognition of his distinguished contributions to Standardization, Testing, Metrology and Quality Control he received a National award - 17th IETE Lal C Verman award for the year 2003. He is an alumnus of Indian Institute of Technology, Delhi, Madurai University and University of Madras. He was authorized trainer of Carnegie Mellon University/SEI, USA for Software CMM and Certified by Stanford University/Course era on Machine Learning. He is currently active academic researcher having guided till completion one Ph.D. scholar in the area of Recommendation System and another in the area of Software Release Time study, having published more than 65 research papers in International Journals and Conferences. He is considered to be a creative person having contributed to setting up of few R&D Centres and Software Testing and Training laboratory by the Ministry of Electronics and Information Technology in India.

iToons — Sunil Agarwal & Ajit Ninan

He's not missing the flight... Forgot his phone in the tray