เทคโนโลยีสามชนิดที่จะเป็นตัวขับเคลื่อนนวัตกรรม

The Three Technologies that Drive the Innovation

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บทคัดย่อ

อนาคตของเทคโนโลยีจะเป็นในรูปแบบผสมผสาน เอกสารนี้จะอธิบายถึงนวัตกรรมสามประการที่จะมีผลต่อชีวิตประจำวันของเรา ซึ่งประกอบด้วย Big Data, การเรียนรู้ของเครื่องจักร และเครือข่าย 5G ที่จะส่งผลกระทบต่อการเปลี่ยนแปลงในการทำงานตลอดจนชีวิตประจำวันของเรา

Abstract

The future of technology will be the combinatorial one. This paper will describe the three innovations that will shape our everyday life. Technological change is a combination of more and of better technology. Big data, machine learning and the 5G network, altogether will be the driving forces to dramatically transform how we work and live.

1. Introduction

Big Data, Artificial Intelligence and mobile high-speed network are some of the most popular and useful technologies today. Artificial intelligence is in existence from more than a decade, while Big Data came into existence just a few years ago. Computers can be used to store millions of records and data, but the power to analyze this data is provided by the Big Data. But without high-speed data network, those two cannot achieve the highest potential.

We can say that together Big Data and AI are set of two amazing modern technologies that empower machine learning, continuously reiterate and update the data banks, and taking the help of human intervention and recursive experiments for the same. Today, we have brought this blog to provide informational usage of AI and Big Data together to resolve all possible issues related to the data.

Big Data and AI are considered two mechanical giants by data scientists, or other big corporations. Many organizations consider that AI will bring the revolution in their organizational data. Machine learning is considered as an advanced version of AI through which various machines can send or receive data and learn new concepts by analyzing the data. Big data helps the organizations in analyzing their existing data

and in drawing meaningful insights from the same.

Here, for example, we can consider a leather garment manufacturer that exports its garments to the European and do not have any idea about the customer interests than just by collecting data from the market and analyzing it through various algorithms, the merchant can identify the customer behavior and interests. As per their interests, they can provide the cloths. For this, the algorithms can help to find insight and accurate information too.

Mobile communication network likes 5G and AI are helping speed up the pace. Not only do they enable each other, but their fates are somewhat intertwined. 5G provides the infrastructure and massive amounts of data that AI needs to be successful, and AI, driven by advances in machine learning, provides the ability to make sense of the chaos and complexity of 5G.

To be clear, 5G is a set of new technologies, while AI and Big Data are not. The basic algorithms used by machine learning to create AI have been relatively unchanged for the last 30 years. The concept, called backpropagation, is fairly simple. Data sets and the expected outcomes associated with them are input into a processor, and it outputs a pattern. The more data sets and outputs that are used as inputs to the processor, the more accurate the resulting pattern. Machine learning thrives with massive amounts of data, and 5G will create massive amounts of data.

2. Data

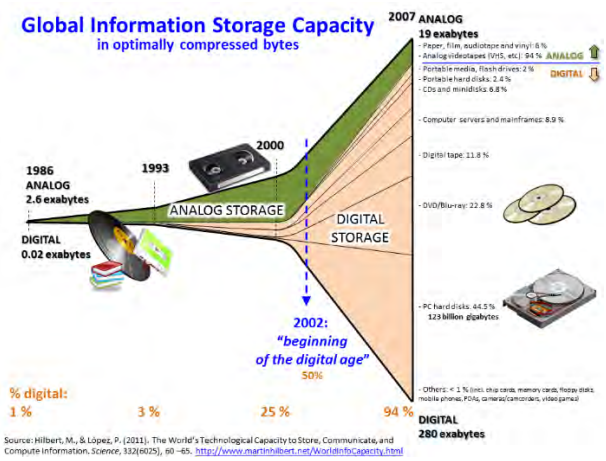

Fig. 1 Global Information Storage Capacity [1]

Big data is a field that treats ways to analyze, systematically extract information from, or otherwise deal with data sets that are too large or complex to be dealt with by traditional data-processing application software. Data with many cases (rows) offer greater statistical power, while data with higher complexity (more attributes or columns) may lead to a higher false discovery rate [2]. Big data challenges include capturing data, data storage, data analysis, search, sharing, transfer, visualization, querying, updating, information privacy and data source. Big data was originally associated with three key concepts: *volume*, *variety*, and *velocity* [3]. Other

concepts later attributed with big data are *veracity (i.e., how much noise is in the data)* [4] and *value* [5].

Current usage of the term *big data* tends to refer to the use of predictive analytics, user behavior analytics, or certain other advanced data analytics methods that extract value from data, and seldom to a particular size of data set. "There is little doubt that the quantities of data now available are indeed large, but that's not the most relevant characteristic of this new data ecosystem [6]." Analysis of data sets can find new correlations to "spot business trends, prevent diseases, combat crime and so on [7]." Scientists, business executives, practitioners of medicine, advertising and governments alike regularly meet difficulties with large data-sets in areas including Internet search, fintech, urban informatics, and business informatics. Scientists encounter limitations in e-Science work, including meteorology, genomics,[8] connectomics, complex physics simulations, biology and environmental research [9].

Data sets grow rapidly- in part because they are increasingly gathered by cheap and numerous information- sensing Internet of things devices such as mobile devices, aerial (remote sensing), software logs, cameras, microphones, radio-frequency identification (RFID) readers and wireless sensor networks [10], [11]. The world's technological per-capita capacity to store information has roughly doubled every 40 months since the 1980s; [12] as of 2012, every day 2.5 exabytes (2.5×10^{18}) of data are generated [13]. Based on an IDC report prediction, the global data volume will grow exponentially from 4.4 zettabytes to 44 zettabytes between 2013 and 2020 [14]. By 2025, IDC predicts there will be 163 zettabytes of data [15]. One question for large enterprises is determining who should own big-data initiatives that affect the entire organization [16].

Relational database management systems, desktop statistics and software packages used to visualize data often have difficulty handling big data. The work may require "massively parallel software running on tens, hundreds, or even thousands of servers" [17]. What qualifies as being "big data" varies depending on the capabilities of the users and their tools, and expanding capabilities make big data a moving target. "For some organizations, facing hundreds of gigabytes of data for the first time may trigger a need to reconsider data management options. For others, it may take tens or hundreds of terabytes before data size becomes a significant consideration [18]."

Characteristics of Big Data Big data can be described by the following characteristics: [19], [20]

Volume The quantity of generated and stored data. The size of the data determines the value and potential insight, and whether it can be considered big data or not.

Variety The type and nature of the data. This helps people who analyze it to effectively use the resulting insight. Big data draws from text, images, audio, video; plus it completes missing pieces through data fusion.

Velocity In this context, the speed at which the data is generated and processed to meet the demands and challenges that lie in the path of growth and development. Big data is often available in real-time. Compared to small data, big data are produced more continually. Two kinds of velocity related to big data are the frequency of generation and the frequency of handling, recording, and publishing [21].

Veracity It is the extended definition for big data, which refers to the data quality and the data value [22]. The data quality of captured data can vary greatly, affecting the accurate analysis [23].

Data must be processed with advanced tools (analytics and algorithms) to reveal meaningful information. For example, to manage a factory one must consider both visible and invisible issues with various components. Information generation algorithms must detect and address invisible issues such as machine degradation, component wear, etc. on the factory floor [24], [25].

3. Artificial Intelligence

Machine learning (ML) is the scientific study of algorithms and statistical models that computer systems use to effectively perform a specific task without using explicit instructions, relying on patterns and inference instead. It is seen as a subset of artificial intelligence. Machine learning algorithms build a mathematical model of sample data, known as "training data", in order to make predictions or decisions without being explicitly programmed to perform the task [26], [27]. :2 Machine learning algorithms are used in a wide variety of applications, such as email filtering, and computer vision, where it is infeasible to develop an algorithm of specific instructions for performing the task. Machine learning is closely related to computational statistics, which focuses on making predictions using computers. The study of mathematical optimization delivers methods, theory and application domains to the field of machine learning. Data mining is a field of study within machine learning, and focuses on exploratory data analysis through unsupervised learning [28], [29]. In its application across business problems, machine learning is also referred to as predictive analytics.

The name machine learning was coined in 1959 by Arthur Samuel [30]. Tom M. Mitchell provided a widely quoted, more formal definition of the algorithms studied in the machine learning field: "A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P if its performance at tasks in T, as measured by P, improves with experience E [31]." This definition of the tasks in which machine learning is concerned offers a fundamentally operational definition rather than defining the field in cognitive terms. This follows Alan Turing's proposal in his paper "Computing Machinery and Intelligence", in which the question "Can machines think?" is replaced with the question "Can machines do what we (as thinking entities) can do?" [32]. In Turing's proposal the various characteristics that could be possessed by a thinking machine and the various implications in constructing one are exposed.

Machine learning tasks Machine learning tasks are classified into several broad categories. In supervised learning, the algorithm builds a mathematical model from a set of data that contains both the inputs and the desired outputs. For example, if the task were determining whether an image contained a certain object, the training data for a supervised learning algorithm would include images with and without that object (the input), and each image would have a label (the output) designating whether it contained the object. In special cases, the input may be only partially available, or restricted to special feedback. Semi-supervised learning algorithms develop mathematical models from incomplete training data, where a portion of the sample input doesn't have labels.

Classification algorithms and regression algorithms are types of supervised learning. Classification algorithms are used when the outputs are restricted to a limited set of values. For a classification algorithm that filters emails, the input would be an incoming email, and the output would be the name of the folder in which to file the email. For an algorithm that identifies spam emails, the output would be the prediction of either "spam" or "not spam", represented by the Boolean values true and false. Regression algorithms are named for their continuous outputs, meaning they may have any value within a range. Examples of a continuous value are the temperature, length, or price of an object.

In unsupervised learning, the algorithm builds a mathematical model from a set of data which contains only inputs and no desired output labels. Unsupervised learning algorithms are used to find structure in the data, like grouping or clustering of data points. Unsupervised learning can discover patterns in the data, and can group the inputs into categories, as in feature learning.

Dimensionality reduction is the process of reducing the number of "features", or inputs, in a set of data.

Active learning algorithms access the desired outputs (training labels) for a limited set of inputs based on a budget, and optimize the choice of inputs for which it will acquire training labels. When used interactively, these can be presented to a human user for labeling. Reinforcement learning algorithms are given feedback in the form of positive or negative reinforcement in a dynamic environment, and are used in autonomous vehicles or in learning to play a game against a human opponent. Other specialized algorithms in machine learning include topic modeling, where the computer program is given a set of natural language documents and finds other documents that cover similar topics. Machine learning algorithms can be used to find the unobservable probability density function in density estimation problems. Meta learning algorithms learn their own inductive bias based on previous experience. In developmental robotics, robot learning algorithms generate their own sequences of learning experiences, also known as a curriculum, to cumulatively acquire new skills through self-guided exploration and social interaction with humans. These robots use guidance mechanisms such as active learning, maturation, motor synergies, and imitation.

4. Networks

5G (from "5th Generation") is the latest generation of cellular mobile communications. It succeeds the 4G (LTE-A, WiMax), 3G (UMTS, LTE) and 2G (GSM) systems. 5G performance targets high data rate, reduced latency, energy saving, cost reduction, higher system capacity, and massive device connectivity. The first phase of 5G specifications in Release-15 will be completed by April 2019 to accommodate the early commercial deployment. The second phase in Release-16 is due to be completed by April 2020 for submission to the International Telecommunication Union (ITU) as a candidate for IMT-2020 technology [33].

Like the earlier generation 2G, 3G, and 4G mobile networks, 5G networks are digital cellular networks, in which the service area covered by providers is divided into a mosaic of small geographical areas called cells. Analog signals representing sounds and images are digitized in the phone, converted by an analog to digital converter and transmitted as a stream of bits. All the 5G wireless devices in a cell communicate by radio waves with a local antenna array and low power automated transceiver (transmitter and receiver) in the cell, over

frequency channels assigned by the transceiver from a common pool of frequencies, which are reused in geographically separated cells. The local antennas are connected with the telephone network and the Internet by a high bandwidth optical fiber or wireless backhaul connection. Like existing cellphones, when a user crosses from one cell to another, his mobile device is automatically "handed off" seamlessly to the antenna in the new cell.

Their major advantage is that 5G networks achieve much higher data rates than previous cellular networks, up to 10 Gbps; which is faster than current cable internet, and 100 times faster than the previous cellular technology, 4G LTE [34][35]. Another advantage is lower network latency between device and cell, below 1 millisecond, compared with 30 - 70 ms for 4G.[35] Because of the higher data rates, 5G networks will serve not just cellphones but are also envisioned as a general home and office networking provider, competing with wired internet providers like cable. Previous cellular networks provided low data rate internet access suitable for cellphones, but a cell tower could not economically provide enough bandwidth to serve as a general internet provider for home computers.

5G networks achieve these higher data rates by using higher frequency radio waves, in or near the millimeter wave band[34] around 28 and 39 GHz while previous cellular networks used frequencies in the microwave band between 700 MHz and 3 GHz. A second lower frequency range in the microwave band, below 6 GHz, will be used by some 5G providers, but this will not have the high speeds of the new frequencies. Because of the more plentiful bandwidth at millimeter wave frequencies, 5G networks will use wider frequency channels to communicate with the wireless device, up to 400 MHz compared with 20 MHz in 4G LTE, which can transmit more data (bits) per second. OFDM (orthogonal frequency division multiplexing) modulation is used, in which multiple carrier waves are transmitted in the frequency channel, so multiple bits of information are being transferred simultaneously, in parallel.

The new 5G wireless devices also have 4G LTE capability, as the new networks use 4G for initially establishing the connection with the cell, as well as in locations where 5G access is not available [36].

The high data rate and low latency of 5G are envisioned as opening up new applications in the near future [36]. One is fast machine-to-machine interaction in the Internet of Things. For example, computers in vehicles on a road could continuously communicate with each other, and with the road, by 5G [36].

Advantages of the 5G Network

Speed 5G promises superior speeds in most conditions to the 4G network. Qualcomm presented a simulation at Mobile World Congress [37][38][39] that predicts 490 Mbit/s median speeds for 3.5 GHz 5G Massive MIMO and 1.4 Gbit/s median speed for 28 GHz mmWave [40]. 5G NR speed in sub-6 GHz bands can be slightly higher than the 4G with a similar amount of spectrum and antennas [41][42], though some 3GPP 5G networks will be slower than some advanced 4G networks, such as T-Mobile's LTE/LAA network, which achieves 500+ Mbit/s in Manhattan [43].

The 5G specification allows LAA (License Assisted Access) as well but it has not yet been demonstrated. Adding LAA to an existing 4G configuration can add hundreds of megabits per second to the speed, but this is an extension of 4G, not a new part of the 5G standard [43].

Low communication latency Latency is the time it takes to pass a message from sender to receiver [44]. Low communication latency is one improvement in 5G.

New use cases Features of 5G network, including extreme high bandwidth, ultra low latency, and high density connections, are expected to enable many new use cases that are impossible to be done via older network standards [45].

Radio convergence One expected benefit of the transition to 5G is the convergence of multiple networking functions to achieve cost, power and complexity reductions. LTE has targeted convergence with Wi-Fi via various efforts, such as License Assisted Access (LAA) and LTE-WLAN Aggregation (LWA), but the differing capabilities of cellular and Wi-Fi have limited the scope of convergence. However, significant improvement in cellular performance specifications in 5G, combined with migration from Distributed Radio Access Network (D-RAN) to Cloud- or Centralized-RAN (C-RAN) and rollout of cellular small cells can potentially narrow the gap between Wi-Fi and cellular networks in dense and indoor deployments. Radio convergence could result in sharing ranging from the aggregation of cellular and Wi-Fi channels to the use of a single silicon device for multiple radio access technologies.

Application of 5G Network

Digital television 3GPP have been studying mixed mode multicast and terrestrial broadcast based on equivalent of MBMS for 5G NR and a further development based on LTE's EnTV [46].

Automobiles 5G Automotive Association have been promoting the C-V2X communication technology that is based on 5G NR for communication between vehicles and

communication between vehicles and infrastructures [47].

Automation (factory and process) 5G Alliance for Connected Industries and Automation - 5G-ACIA promotes 5G for factory automation and process industry [48].

Public safety Mission-critical push-to-talk (MCPTT) and mission-critical video and data are expected to be furthered in 5G [49].

5. Conclusion

Big data is the field that treats ways to analyze, systematically extract information from, or otherwise deal with data sets that are too large or complex to be dealt with by traditional data-processing application software.

Machine learning is the scientific study of algorithms and statistical models that computer systems use to effectively perform a specific task without using explicit instructions, relying on patterns and inference instead. It is seen as a subset of artificial intelligence.

5G is the latest generation of cellular mobile communications. It succeeds the 4G, 3G and 2G systems. 5G performance targets high data rate, reduced latency, energy saving, cost reduction, higher system capacity, and massive device connectivity.

The improvement in technology will be driven by the exponential growth. Moore's law — the steady doubling in integrated circuit capability every eighteen to twenty-four months — celebrated its fiftieth anniversary in 2015, at which time it was still going strong. Some have suggested recently that the law is running up against the limits of physics and thus the doubling will increasingly slow down in the years to come.

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