THE FOURTH INDUSTRIAL REVOLUTION: AN UPDATED EXPLANATION – Part 1

During 2022 our Chairman, Dr Smith, conducted 12 presentations to approximately 2,000 students, but when he asked the question - "Do you know what the Fourth Industrial Revolution (4IR) is all about?" - he could count the number who did on the fingers of both hands. The reality is that 4IR has the potential to have a profound effect on humanity, as exemplified by the current discussions on AI. So what follows is the first in a series of articles explaining not only the themes and characteristics of 4IR, but the technologies involved because, as the picture above states, it is here now!

The Fourth Industrial Revolution, 4IR, or Industry 4.0, conceptualizes rapid change to technology, industries, and societal patterns and processes in the 21st century due to increasing interconnectivity and smart automation. The term has been used widely in scientific literature, and in 2015 was popularized by Klaus Schwab, the World Economic Forum Founder and Executive Chairman. Schwab asserts that the changes seen are more than just improvements to efficiency, but express a significant shift in industrial capitalism.

A part of this phase of industrial change is the joining together of technologies such as artificial intelligence and gene editing with advanced robotics that blur the lines between the physical, digital, and biological worlds. Throughout this, fundamental shifts are taking place in how the global production and supply network operates through ongoing automation of traditional manufacturing and industrial practices, using modern smart technology, large-scale machine-to-machine communication (M2M), and the internet of things (IoT). This integration results in increasing automation, improving communication and self-monitoring, and the use of smart machines that can analyse and diagnose issues without the need for human intervention.

It also represents a social, political, and economic shift from the digital age of the late 1990s and early 2000s to an era of embedded connectivity distinguished by the omni-use and commonness of technology throughout society (e.g. a metaverse) that changes the ways humans experience and know the world around them. It posits that we have created and are entering an augmented social reality compared to just the natural senses and industrial ability of humans alone.

The four themes that summarize Industry 4.0 are:

- *Inter-connection* - the ability of machines, devices, sensors, and people to connect and communicate with each other via the Internet of Things or the Internet of People.

- *Information transparency* - the transparency afforded by Industry 4.0 technology thereby providing operators with comprehensive information to take decisions. Inter-connectivity allows operators to collect immense amounts of data and information from all points in the manufacturing process, and identify key areas that can benefit from improvement to increase functionality.

- *Technical assistance* - the technological facility of systems to assist humans in decision-making and problem-solving, and the ability to help humans with difficult or unsafe tasks.

- *Decentralized decisions* - the ability of Cyber Physical Systems (computer systems in which a mechanism is controlled or monitored by computer-based algorithms) to take decisions on their own and to perform their tasks as autonomously as possible. Only in the case of exceptions, interference, or conflicting goals, are tasks delegated to a higher level.

Furthermore, proponents of the Fourth Industrial Revolution suggest it is a distinct revolution rather than simply a prolongation of the Third Industrial Revolution. This is due to the following characteristics:

- *Velocity* - exponential speed at which incumbent industries are affected and displaced.

- *Scope and systems impact* - the large number of sectors and firms that are affected.

- *Paradigm shift in technology policy* - new policies designed for this new way of 'doing' are present. An example is Singapore's formal recognition of Industry 4.0 in its innovation policies.

Because aerospace and space are two industries - albeit amongst many others such as medicine for example - that epitomise 4IR, we use it as a framework for an element of our Presentations and, in so doing, briefly refer to the principal technologies which, remember, are developing exponentially and are often fused together. But during those presentations we are always limited by the time available; consequently, over this series of article we explain in more detail those technologies, starting today with Big Data and the Internet of Things (IoT).

Big Data

Big Data refers to data sets that are too large or complex to be dealt with by traditional data-processing application software. Data with many fields (rows) offer greater statistical power, while data with higher complexity (more attributes or columns) may lead to a higher false discovery rate. Big Data analysis 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*. The analysis of big data presents challenges in sampling, and thus previously allowing for only observations and sampling. A fourth concept, *veracity,* refers to the quality or insightfulness of the data. Without sufficient investment in expertise for big data veracity, the volume and variety of data can produce costs and risks that exceed an organization's capacity to create and capture *value* from big data.

Current usage of the term Big Data tends to refer to the use of predictive analytics, user behaviour analytics, or certain other advanced data analytical methods that extract value from Big 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. Analysis of data sets can find new correlations to identify business trends, prevent diseases, combat crime and so on. Scientists, business executives, medical practitioners, advertising companies and governments alike, regularly meet difficulties with large data-sets in areas including Internet searches, fintech, healthcare analytics, geographic information systems, urban informatics, and business informatics. Scientists encounter limitations in e-Science work, including meteorology, genomics, connectomics, complex physics simulations, biology, and environmental research.

The size and number of available data sets have grown rapidly as data is collected by items such as mobile devices, cheap and numerous information-sensing Internet of Things devices, aerial (remote sensing) devices, software logs, cameras, microphones, radio-frequency identification readers and wireless sensor networks. The world's technological per-capita capacity to store information has roughly doubled every 40 months since the 1980s; as of 2012, every day 2.5 exabytes (2.5×2^{60} bytes) of data were generated. Based on an IDC report, the global data volume was predicted to grow exponentially from 4.4 zettabytes to 44 zettabytes between 2013 and 2020. By 2025, IDC predicted there would be 163 zettabytes of data. One question for large enterprises is determining who should own big-data initiatives that affect the entire organization.

Relational database management systems and desktop statistical software packages used to visualize data often have difficulty processing and analysing Big Data. The processing and analysis of Big Data may require massive parallel software running on tens, hundreds, or even thousands of servers. What qualifies as Big Data varies depending on the capabilities of those analysing it and their tools. Furthermore, 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.

The question the ACP asks is: “What happens when quantum computing becomes a reality?” But we’ll come to that later. In the meantime we now consider the second 4IR technology – the Internet of Things – because that is where much of this data is coming from!

Internet of Things

The Internet of things (IoT) describes physical objects with sensors (or groups of such objects), processing ability, software, and other technologies that connect and exchange data with other devices and systems over the Internet or other communications networks. Internet of things has been considered a misnomer because devices do not need to be connected to the public internet, they only need to be connected to a network and be individually addressable.

The field has evolved due to the convergence of multiple technologies, including ubiquitous computing, commodity sensors, increasingly powerful embedded systems, and machine learning. Traditional fields of embedded systems, wireless sensor networks, control systems, automation (including home and building automation), independently and collectively enable the IoT.

In the consumer market, IoT technology is most synonymous with products pertaining to the concept of the "smart home", including devices and appliances (such as lighting fixtures, thermostats, home security systems, cameras, and other home appliances) that support one or more common ecosystems, and can be controlled via devices associated with that ecosystem, such as smart phones and smart speakers. IoT is also used in healthcare systems.

There are a number of concerns about the risks in the growth of IoT technologies and products, especially in the areas of privacy and security; consequently, industry and governmental moves to address these concerns have begun, including the development of international and local standards, guidelines, and regulatory frameworks.

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