# Artificial Intelligence: Impact on Labour and Employment

**Dr. Parasuram Balasubramanian**
Founder & CEO, Theme Work Analytics, Bangalore, India
balasubp@gmail.com


Among the four factors of production, namely, land, labour, capital and enterprise (Ref.1), there is a significant difference between labour and the rest. There is an intrinsic productivity component in labour whereas all other resources depend on an external stimuli or action to show productivity gains. (Enterprise is the method or glue that stitches together all other productive resources.) Labour productivity can be enhanced by either investing in superior machinery and methods or by motivational factors.

Money as a resource is considered to be secondary as it is an enabler to procure land, building, machinery or materials. It is not taken as a primary factor of production. Hence "Capital" in this context is used to refer to the Machinery with long productive usage.

Motivation of the individual or the team plays a big role in what can be achieved. Innovation can emerge from initiatives-from-within to create major breakthroughs. Neither motivation nor innovation is an attribute of rest of the resources. Hence human-power (or call it labour) stands distinct from other resources since its accomplishment potential is unlimited.

Business history, over the past five centuries, reveals many seminal stories. Adam Smith in 1776, in his Wealth of Nations (Ref.2), highlighted the role of free enterprise in building a nation. The industrializing nations embraced his concepts with fervor; they focused on building intellectual capital and rallied all other resources around it to build the ladder of growth and prosperity.

It took a few more years before David Ricardo expounded the principle of comparative advantage of nations (Ref.3) in 1817. He further stressed the need for a borderless society where everyone cooperates to improve the fortunes of all.

The fast paced shift from agrarian to industrial society pitted Capital against Labour. The substitutability of one for the other became an endless debate both in academia and society at large. The production-oriented society was obsessed with productivity as well. It drove relentlessly in finding opportunities to substitute labour with capital (equipment) as the former required to be motivated, supervised and protected. Thus the seeds for rapid mechanization and automation were sown in the 19th century. Discovery of power sources such as steam, coal and electricity added fuel to this fire.

Mechanization was taken to the next level with Frederick Taylor's concepts of Division of Labour (Ref.4) as applied to manufacturing. He showed how the system productivity could be enhanced many-fold by his assembly line concepts. The concepts emphasized task specialization, focus and repeated execution aspects of manufacturing processes to enhance productivity. Yet it also led incidentally to humans being confined to tasks that are repetitive and limited in range of skills required to perform. That such tasks are a motivation killer was not recognized in that era of productivity euphoria.

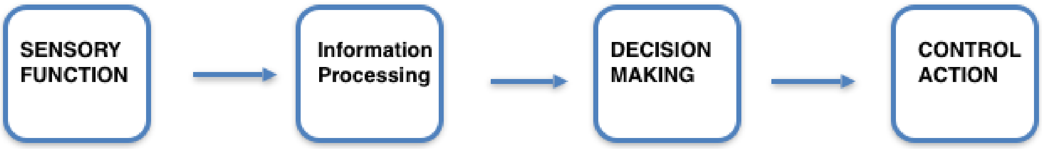
It was Karl Marx and Engel (Das Capital in 1867) who wrote to remind the world of the distinction between emphasizing machine power versus manpower. Their writings have helped to restore balance and fairness in our approach to allocation and utilization of resources.


The resulting unrest of workforce from the large-scale adoption of factory mechanization opened the eyes of academia. Abraham Maslow conceived the theory of human motivation in 1943 (Ref.5) . The two-factor theory of Frederick Herzberg in 1959 coupled with Maslow's need hierarchy helped to refocus on the human resource and place it at the top of the management ladder.

Mechanization and Automation turned out to be a seamless continuum when the focus remained on quality and productivity. (Humans are still needed to operate and control machinery in mechanization. Automation on the other hand, eliminates the human presence altogether.)

Further, when we add the concerns of safety, speed and consistency we move into the territory of automation. We add a significantly different goal to the system, viz, elimination of tasks with human involvement in the entire production process. The journey of automation may have started with minimization of human role in factory settings but it has gone far beyond in the past five decades. Automation includes handing over human cognitive skill based tasks as well as muscle power related tasks.

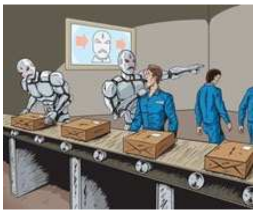
Sensory inputs as obtained from humans often played a key role in the manufacturing activity; seeing (or observing), hearing, smelling and even touching an object enabled us to gather vital data on status of the process or the condition of the product. When this information is processed within a bio system it would result in a control action that intervenes in the process. Hence the elements involved here are sensory, information processing, decision-making and control action.




Automation of systems called for replacing each of these functional elements with a corresponding device, physical or logical. The principal difference is that such a device is inanimate. It can replace a specific human activity with equal or better effectiveness. It won't exhibit fatigue, won't have the need for biological breaks nor would it experience emotions.

Robotic systems with machine vision capability, audio signal absorption and processing ability and capable of initiating control actions with the help of mechanical arms, legs, gears or other parts, penetrated the factory floor in a progressive manner. They became ideal partners in an assembly line as well as in manufacturing individual parts, as this revolution spread.

Completely automated factory became a reality before the dawn of this century. It assumed an indispensable role wherever precision engineering, miniaturization and micro scale manufacturing became necessity; such as in computer chip manufacturing.



From the Industrial Revolution era, the role of mechanization and automation to enhance productivity and throughput has not been disputed; that they often resulted in improved quality of products and services was perceivable: And most of the time, they would lead to higher level of human safety was also accepted.

However, they have also led to tremendous consternation (Ref.6) about loss of jobs in affected sectors such as agriculture, mining and textiles. Thousands of jobs were made redundant and hence eliminated from the factory floor. Labour unions in developed and developing countries alike started raising alarms and followed them up with widespread agitations.

E. F. Schumacher, a German economist reflected this collective concern in his 1973 book "Small is beautiful" (Ref.7). He argued in favour of adopting an appropriate technology from the spectrum of automation; the appropriateness being determined by broader concerns for use of local materials and local talent pool. His thoughts and writings found favour with a majority of developmental economists and developing country policy makers.

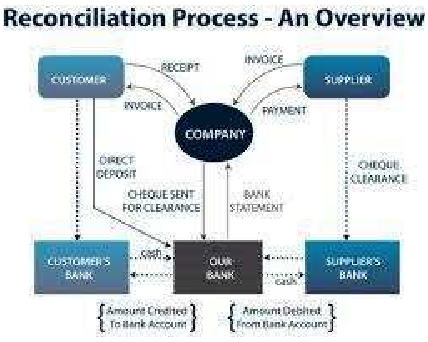
A concern that is over shadowed in this scenario is the societal need to spur demand and consumption as much as improving supply quantity and quality. Economic prosperity of a nation depends equally on production efficiency and consumption capability. If a significant section of populace does not have a productive occupation, there won't be any purchasing power in their hands; or any demand for many goods however efficiently they may have been produced with the help of automation. The supply side of any equation has to be balanced with the demand side at all times.

Jean-Baptiste Say, even two centuries ago (1803) had articulated this concept with his " Treatise on Political Economy" (Ref.8). According to Say's Law our aggregate purchasing power is determined by the aggregate value of what we produce. Total supply has to match the total purchases.

Hence boundaries of automation in a society will be defined not by the aggregate production (it can create with economic efficiency) alone but also based on its ability to create employment and to spread wealth amongst the populace. Without adequate employment and purchasing power in the hands of the people, there won't be any demand for many goods and services.

In other words, with more and more farm mechanization, labour needed at the field comes down. But the surplus labour has to find adequate job opportunities in farm machinery production. With automation of mining activities, more and more miners would seek employment elsewhere and the mining machinery manufacturers must be able to provide enough jobs for them. There can be a cross sector effect in this process. In an aggregate sense, jobs displaced or eliminated due to mechanization and automation in all sectors put together, should lead to equivalent number of jobs in producing the additional machinery, equipment and devices needed. It is further possible that a category shift can occur from products to services as well. Hence retraining on skills and cross movement of labour from one industry to another must be facilitated.

The advent of computers from the early 1950s marks a major shift in this mechanization/automation journey. Comptometers and calculators, during the preceding decades, introduced the feasibility of human brainpower being aided by machines but computers magnified this possibility by hundreds of times. Till then we were satisfied with muscle power substituted with machines; and then the era of mind power substitution with machines began.

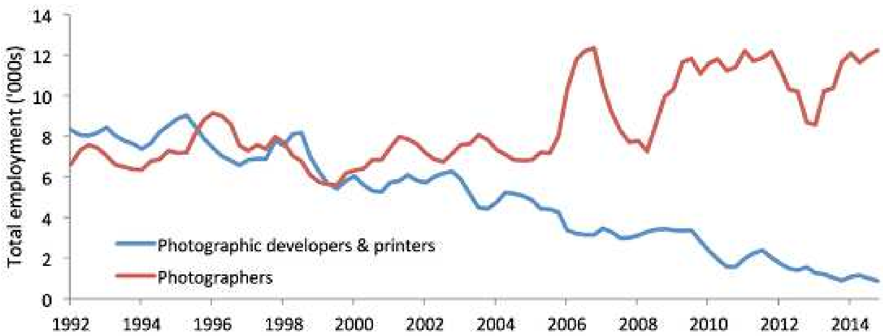


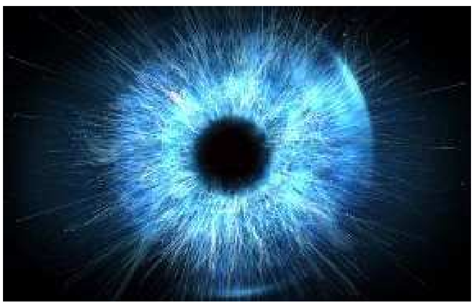

The early stage computers were capable of performing mathematical calculations and posting entries in a ledger accurately. Given their speed, they turned out to be a boon, as many laborious tasks that took many person hours or days to complete could be relegated to computers. Hence the revolution caught on and the information age dawned on us.

Next three decades saw impressive and exponential growth of computing power and as a consequence computer applications moving from the accountant or scientist's office to cover many other functional roles. The introduction of personal computers in mid-seventies and of the Internet in mid-nineties fueled this transformation with further acceleration. Functions such as Production Planning and Scheduling, Transportation and Logistics Management or interbank reconciliation (Ref.9) and credit appraisals came within the ambit of the Information Technology Groups.

Alarmed by the rapid pace with which traditional office jobs were disappearing, the white-collar workers joined the fray to fight the onslaught of computerization. It was a common sight of agitating employees in many countries expressing their concern through many avenues. Labour Union negotiations encompassed this issue to define the terms and reference for activities and functions that can be automated or not. For example, the Bank Employees Unions in India insisted that every computer is a stand-alone computer with no networking and ledger posting of entries not to be permitted.

The response from the tech world was almost unanimous. It re-embraced the arguments of prior decades when factory automation was spreading; that more jobs were being created in newer categories by the diffusion of technology in society than the number of jobs eliminated by it in traditional categories. Macro-economic studies seemed to back up such assertions with aggregate data on net employment generation from year to year. For example, the graph (Ref.10) shows the data from Australia that as laboratory based photographic development and printing jobs were lost they were made up with higher level of employment among field photographers.

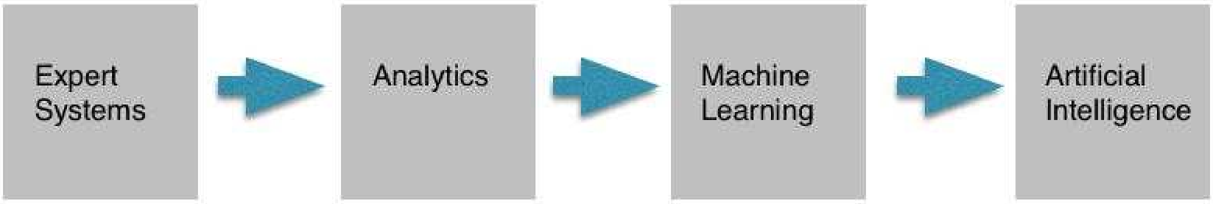


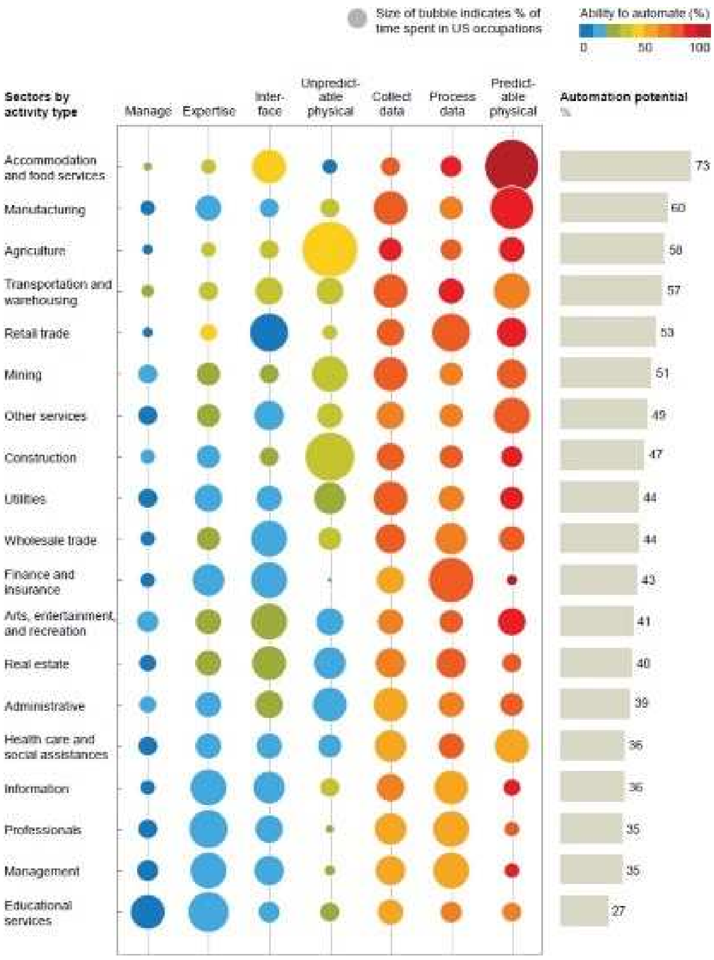
The capability of the computers, meanwhile, was not standing still. Computer scientists began to extend text processing to natural language processing. Audio and video extensions enabled the computers to listen, speak, see and map the external world thereby acquiring some of the human sensory functions (yet at a rudimentary level). Geographical Positioning Systems (GPS) when integrated with mobile computing such as in cell phones opened a new world of exciting possibilities. It is appropriate to say that such developments extended the interaction capabilities of the machines with the human beings. They can take multiple level inputs and provide multi-level outputs. The interface was no longer limited to a keyboard.

A silent revolution was taking place underneath these layers however. It took more than five decades to garner major attention and concern. It is the field of artificial intelligence (AI).

The chronological evolution of AI can be traced as




Even in early 1950s scientists could develop programs that can perform complex and higher order functions that facilitate Decision Making. Computers could perform regression studies to check out beliefs about cause versus effect, could predict or forecast economic trends or allocate limited resources to competing projects or solutions more effectively than human beings. They could perform these calculations in minutes or hours as opposed to the days it took earlier with an army of trained people. They came under a broad category called Expert Systems since they were able to capture (within the program logic) complex rules.



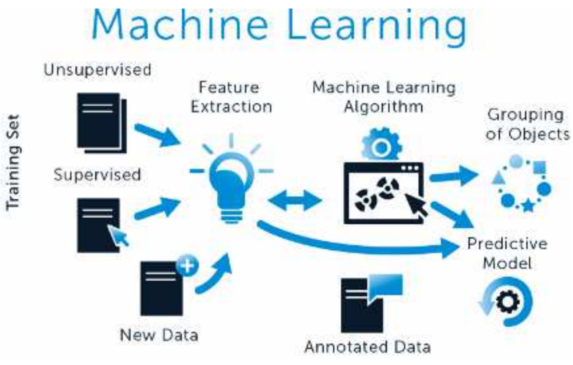

The decades since the beginning of the twenty-first century have seen remarkable growth in these Expert Systems. When the expanded input and output capabilities of the peripheral devices are merged with expanding reasoning power of the computer the emerging developments stretch human comprehension. The diagram in this para (Ref.11) represents the automation potential of various industry segments.

Further, rapid and parallel developments in the fields of Computer Science, Management Science and Behavioural Science have led to the hybrid discipline of Analytics. More and more of the analytical functions performed by humans with the assistance of computers over the decades are being transferred to automated systems in present era. For example, if Claim Processors would use checklists to accept or reject certain insurance claims earlier, these tasks are now assigned to a program thereby reducing costs and improving accuracy.

Computers are more effective in descriptive analytics than humans. They can use a plethora of artifacts such as graphs, charts, network diagrams, drawings and icons based models effortlessly to represent the current status of a system better than most of us. They are very good at projecting trends and predicting the near future with stable systems. This is called predictive analytics. Most of the real world systems are, however, non-deterministic and are subject to wide variations. Past is not an accurate predictor of future in many cases. Hence the acceptance and use of such predictive analytics solutions are limited as of date.

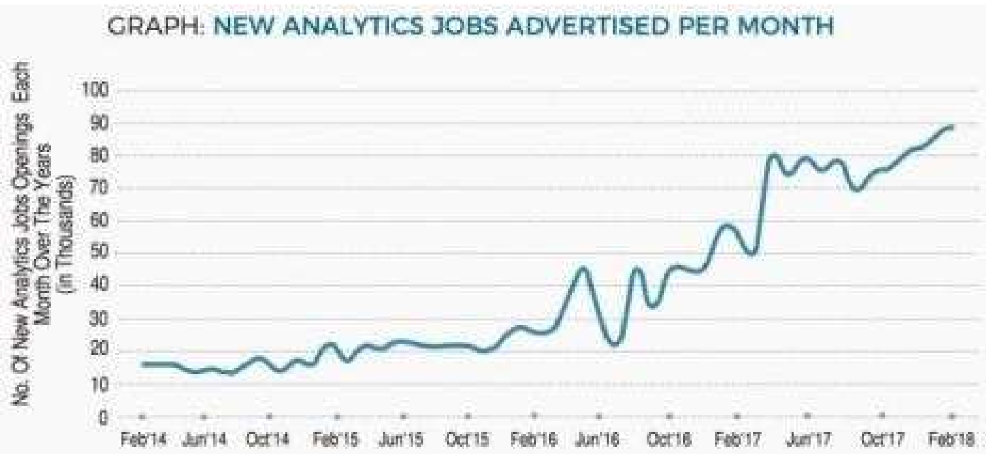
The final aspect called prescriptive analytics (PA) deals with imposing newer controls on existing systems and selecting an appropriate course of action. When systems environment is well controlled, such as in scientific and engineering arena, PA has achieved considerable success. Most societal systems, on the other hand, present unpredictable environments and hence pose a severe challenge to their successful application.

The term artificial intelligence (AI) was coined in 1956 by John McCarthy and others at the Dartmouth Workshop in USA. It came to mean machine intelligence as opposed to human intelligence which has been considered as natural. Cognitive functions that humans can perform, such as learning and problem solving, if mimicked successfully by machines, then it is considered as AI. Given the limited success achieved by such systems in early decades, scientists preferred to call them as Expert Systems. They were of the distinct opinion that human Intelligence, with multi sensor inputs and multi dimensional information processing capabilities was vastly superior and hence cannot be compared.



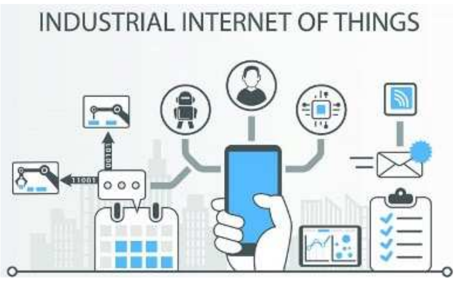

The fundamental question is which cognitive functions can computers and devices perform as effectively as humans can. The answer is still work in progress in most fields. As a corollary we can also ask if it is desirable to let machines perform these tasks instead of human beings.

With large volumes of data available from operations, the endeavour of the scientists is to use the same to train the computer to learn directly from data. This is called Machine Learning (Ref.12). ML expertise is being acquired and refined with the help of many statistical tools. When audio and video data along with images get to be processed in conjunction with conventional data the domain expands to Big Data Analytics. This is a nascent field but likely to expand rapidly in two decades.



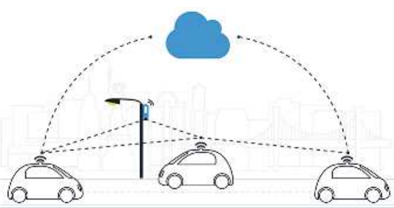

Nevertheless, even as of date, the field of analytics, as applied in the functional areas of manufacturing, logistics, resource planning and performance control has gained strength and has given rise to thousands of new jobs in the economy. As Analytics penetrates into the marketing and human resource management tasks it would be a growing field with tremendous potential to create more jobs in coming decades (Ref.13).

There is further seamless bonding happening between the fields of analytics and sensory functions (capability to accept multiple types of inputs and to provide appropriate outputs) performed by the machines. There are two major applications penetrating in the global markets due to this fusion; namely Industrial Internet of things (IIoT) and Autonomous Vehicles( AV)




IIoT refers to devices interacting with devices directly without human intervention. The ubiquitous Internet has made this possible. Smart devices can accept data coming from sensors and share them with other devices, machines or computers directly. If the data needs to be understood and interpreted to initiate a particular action, a computer interface can be provided in-between to perform this role. There are numerous IIoT projects being implemented now at a unit level in a factory while the long-term goal is to cover the entire factory or workplace with such systems.

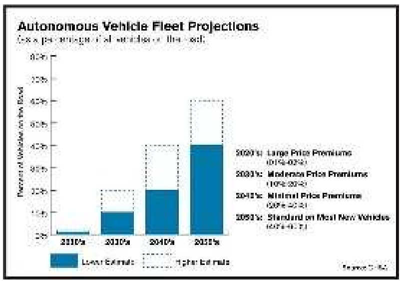
IIoT is currently perceived as a boon for industrial productivity, safety and product quality. It is also considered as yet another short-term threat for employment, particularly in the industrial sector. There is considerable optimism however, that the next wave of boom in jobs in the information technology sector in India, as many as 15 million of them, would come from IIoT (Ref.14).



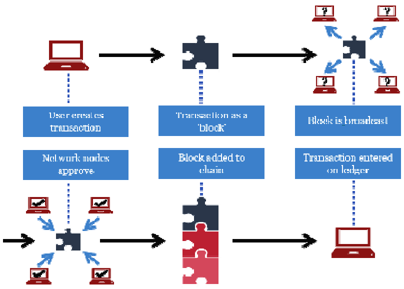
Autonomous Vehicles (AV) is in everyday news with pilot projects being undertaken in many countries at present. These are self-driving vehicles being put to road tests. Their peripheral vision capability is far superior to human beings, their location awareness capability (with assistance from GPS devices) is impressive and their reaction time is a fraction of any human being. Cars, taxis, buses, trucks and military vehicles can all be turned into AVs in our life times.

The projected societal benefits of AVs are immense and impressive. They would cut down road accidents and fatalities and make journeys much safer than today. They can result in better fleet utilization as no vehicle needs to be idle for an extended period of time. They can cut down the number of vehicles on road at any given moment. They can optimize journey route, time and cost much better than us.

The common perception and fear is that AVs would be the stealth job killers whenever the market becomes ready. Personal car drivers, taxi drivers, truck drivers, school bus drivers and utility vehicle drivers are amongst the categories of jobs that could suffer severe erosion. Traffic marshals, accident claim experts, motor vehicle insurers and lawyers dealing with accident victims and cases are next in line for reduction in job opportunities. One study estimates that nearly 300,000 jobs will be lost per year in USA alone.




The AV technology is far from being fully developed and tested. Its major impact on the job market is perceived to be at least two decades away. But the analysts project significant employment growth due to AV technology development and market capture (Ref.15) in the intervening period. Need for Electrical and Robotics Engineers, Industrial Engineers, Field Service Technicians, Functional Safety Engineers and Navigation Software Engineers are projected to grow at a faster pace.




Beyond IIoT and AV, another technology opening up slowly is Blockchain(Ref.16). When successfully developed and implemented, it would eliminate the need for each firm maintaining a ledger to keep track of its commercial transactions. Instead, transactions of hundreds of collaborating firms can be kept in a central ledger and the system will provide access to relevant and appropriate transactions alone to every firm.

The current method of double entry book keeping has been in vogue for three centuries. It has lead to the creation of an army of jobs as accounts clerks, accountants and loan recovery agents within a firm. It has also created the need for many intermediaries who would help to reconcile the transactions across firms. With Blockchain technology the need for these jobs and intermediary firms will dwindle.

AI is the over arching theme of most of the technologies being developed at present. Analytics, Big Data, Machine Learning, IioT and AV are covered in its ambit while Blockchain can be an allied technology. Is AI like an octopus spreading its tentacles in multiple directions to catch its prey? Or is it more like a banyan tree spreading its branches far and wide with deep roots to the soil and providing shade to one and all? Will it eliminate too many white-collar middle range jobs with repetitive and predictable logic but will create insufficient high-end jobs? Should it be regulated right now to control where it may take us?

There are many unanswered questions. Yet we can rely on fundamental economic laws such as Say's Law or sociologist Herbert Blumer's theory of social interaction. We can deduce that for automation, AI or for any technology to succeed it has to create enough jobs to engage most of the populace. To recall the message of Say's Law, the increase in supply of goods and services has to match with the increase in purchasing power of the entire populace. Hence the need for widespread creation of new employment as old category of jobs gets eliminated. It is likely that many factory and office based jobs will be lost forever and certain categories completed wiped out. But there would be newer and adequate number of jobs created in new categories, in different sectors is the lesson learnt from economic history.

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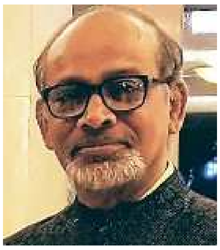
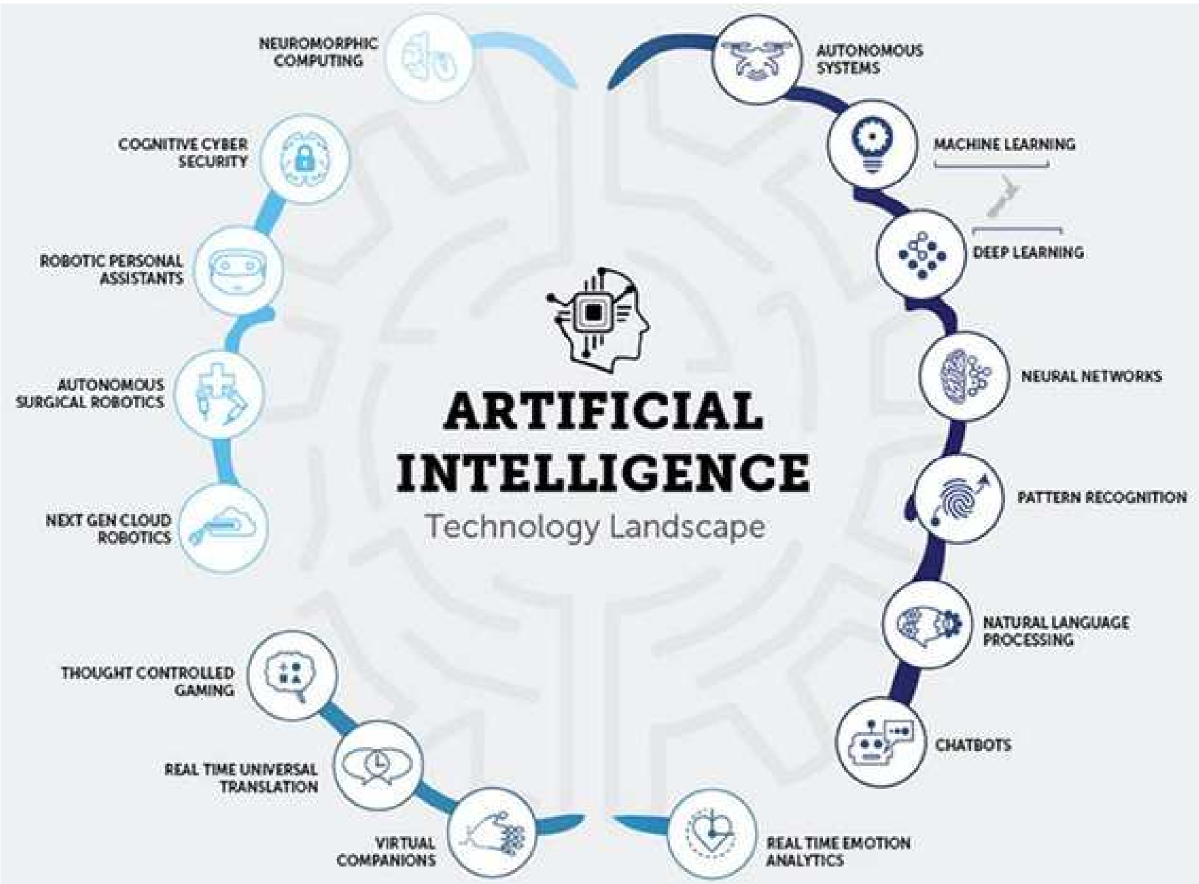
**About the author**



Dr. Parasuram Balasubramanian has been a Consultant, Group Leader, CIO, CEO and Profit Centre Head in Information Technology industry in his career spanning four decades. He has played a note-worthy role in establishing analytics practice in India and India as a premier offshore service destination. He was instrumental in introducing high quality standards for software delivery services and in building up the skill sets of thousands of employees. He has worked in India, Jamaica and USA. Over the years, he has sustained considerable interest in academics and executive training. He has been a guest faculty and invited speaker in numerous colleges, executive training programs and industry fora. He has written chapters in Handbook of Operations Research [CRC press], Handbook of Automation [Elsevier Publishers] and in Cultural Factors in Systems Design : Decision Making and Action [ CRC Press]. He has Engineering and Management degrees from IIT, Madras; and a Doctorate from the School of Industrial Engineering at Purdue University in 1977 specializing in Operations Research. He has been recognized as an Outstanding Industrial Engineering Alumnus by Purdue University in March 2001; Fellow at Infosys Technologies Limited in 2002 and made a Honorary Fellow of the Indian Institute of Materials Management in 2005

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