



DIGITAL TRANSFORMATION WITH ARTIFICIAL INTELLIGENCE AND ROBOTIC PROCESS AUTOMATION - ADVANCED APPLICATIONS AND REALISATION OF DESIRED ROI



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Introduction

Artificial intelligence as an idea did not originate post advent of information and communication technology. Its genesis and evolution could be traced in applications of scientists many centuries ago as have been established in published literature of several research scholars. Theoretical and technological narratives for this were underpinned and bolstered by scientists such as Alan Turing, Marvin Minsky, and John McCarthy. The possibility of a computing machine attaining cognitive capabilities of a human being was first experimented and christened by John McCarthy. Readers may know more about genesis, evolution,

fiction, and challenges in applications of artificial intelligence (AI) in one of the author's articles under this column which was published in April 2020¹.

The fountainhead of inspiration for artificial intelligence (AI) as a digital technology is the cognitive capabilities of human beings. Digital scientists are relentlessly aiming to develop computerised solutions by emulating and recreating many cognitive and functional capabilities of human brains equally efficiently in a computing device. They are trying to innovate digitally programmed systems for reasoning and taking decisions. Applications of such AI driven solutions are adding momentum for advancements of individuals, growth of business entities with far reaching potential for value creation in both tangible and intangible terms. The author in his research study could gather that many startup entities, working in this field, have started claiming that AI is gradually outshining human brains in certain activities which need sharper and diversified applications of cognitive skills. However, such claims are not beyond controversies.

Humane Features of Human Beings

Human beings have the power of empathy and sympathy which help conducting themselves with humane qualities namely benevolence, compassion, gentleness, caring, civility, etc. Oxford Dictionary has defined the word 'empathy' as the "Ability to understand and share the feelings of another" and sympathy as the "Feelings of pity and sorrow for someone else's misfortune." These two features help a person handling

Image Source: <https://blogs.3ds.com/northamerica/robotic-process-automation-the-first-step-in-digital-transformation/>

societal and humanitarian issues with applications of brain, mind, and heart. This in turn provide mental support to maintain ethics, societal peace, and rule of law.

Besides cognitive intelligence human beings also have emotional intelligence. The same lexicon has defined it as *“The capacity to be aware of, control and express one’s emotions and to handle interpersonal relationships judiciously and empathetically.”* In other words, emotional intelligence is the combination of attitude, aptitude and competencies backed by power of knowledge, wisdom, and application orientation. Emotional intelligence helps a man effectively coping with both positives and negatives of life. It plays an important role in personal and professional growth of individuals who must take and execute decisions under stressful and challenging situations to ensure least possible sufferings from risks and move ahead with peace and sustainable success for inclusive happiness.

Objective

The above discourse raises certain intriguing questions? Whether that day would come or is already there when a computing device would be able to recognise words and facial expressions that will enable it to read the state of mind and mood of a person. Whether the computing device would be able to ascertain and appreciate the gravity of a given situation and challenges being faced by the user from the voice and data inputs that are being provided as inputs? Would the device be successful in handling, as efficiently as a human being, the dynamics of the user’s mood, mental situation and extend help to win over the prevailing stress and challenges? The next level of question is whether a computing device be able to apply emotional intelligence for affirmatively reacting with expressions of sympathy and empathy during man-machine interactions?

All these would require algorithms of AI and the process of training a computing device to instil and help the device attaining emotional intelligence. It would be of interest to predictively assess what would happen to humanity when all these are achieved by digital

scientists, if at all? One last question is whether robots and robotic process applications would be able to replace some of the qualities of certain small creatures of nature which are friends of human beings and help earning livelihoods.

Finding answer to the above questions require extensive research and predictive analyses. Given the limited scope, this paper would make efforts to examine some of the recent advanced applications of artificial intelligence and the impacts thereof on commercial world, society and the way living life by human beings. Efforts would be made to appreciate how cost-benefit trade-off can be achieved and what all ethical qualities are required for ensuring that no harm is done to humanity while achieving this.

AI Ecosystem and Advancements

The current AI ecology comprises of machine learning (ML), robots and robotic process applications (RPA), artificial neural networks (ANNs), etc. In ML computer programs are made to learn in a supervised or non-supervised environment from existing data and apply the attained information/ knowledge to new data. ML has the capability to modify and/or update the old learning points when new data is fed into it. This process helps predicting or providing inferences which can be interpreted for framing further strategic plan and executing actions. Big data analytics has the capability of performing the same when huge volumes of unstructured data are fed into the system. However, none has guaranteed so far that the learning points generated by AI driven systems are always correct and the provided information/inputs for drawing inferences are flawless. Needless to say that human beings also make mistakes.

Rapid advancement of computing technology, power of processing at lightning speed, open-source platforms and collaborative learnings have facilitated newer capabilities of AI and it’s branching out to various areas of cognitive capabilities. Last few decades have witnessed advancement of AI into fields of linguistic, mathematical, and logical reasoning abilities. Digital scientists are trying to progress towards

the next generation of AI applications with orbital changes to the direction of emotional intelligence. It would be worthwhile here to note the famous quote of Ginni Rometty, former CEO and Executive Chairman of IBM. She said, *“Some people call this artificial intelligence, but the reality is this technology will enhance us. So instead of artificial intelligence, I think we’ll augment our intelligence.”*

Let us forget and miss to appreciate that what all has been done and achieved in the field of AI are because of the good work of humanin brain only. Sequential learning capability of Google’s DeepMind is enabling AIs to learn multiple skills. All these are now attributing into AI the ability to comprehend the physical world to a certain extent. These capabilities of AI are being exploited by various industries for performing tasks that need human judgements and interventions. The case in point is unmanned cars, robotic surgeons, humanoids, etc. Hence essentially human beings are making computing devices to attain all these capabilities The following is a summarised enumeration of various advancements and branching outs of AI into various areas:

- ⊙ **Expert Systems:** Solves complex problems as an expert by extracting the required knowledge stored in its knowledge base derived with complex and advanced tools for analyses of both structured and unstructured data and other inputs.
- ⊙ **Natural Language:** Content Extraction, Machine translation, Answer questions, Decision tree, Classifications based on commonalities of attributes, etc.
- ⊙ **Planning:** Creating algorithms for analysing past data, generating strategic plans^{N1} and applications thereof to operations, e. g., marketing, business risk management, defence, healthcare, cybersecurity, public transportation, etc.
- ⊙ **Machine Learning:** Reduce dimensions, Deep learning, Random Forest^{N2}, Regression classifier, Decision trees,

Clustering, etc.

- ⊙ **Vision:** Neural Network, Reduction of dimensions, Deep learning, Convolutional Neural Network, Recurrent Neural Network^{N3}
- ⊙ **Robotics:** Humanoid, Soft robotics, Swarm robotics, Touch robotics, Serpentine robots for both commercial and non-commercial applications. Robots have also been made to, serve food, cook foods, present performing arts like singing and dancing, including appreciation of dancing steps and reproducing the same to the tune of a common song/music

- ⊙ **Speech:** Recognition of speech, Conversions of speech to text and text to speech

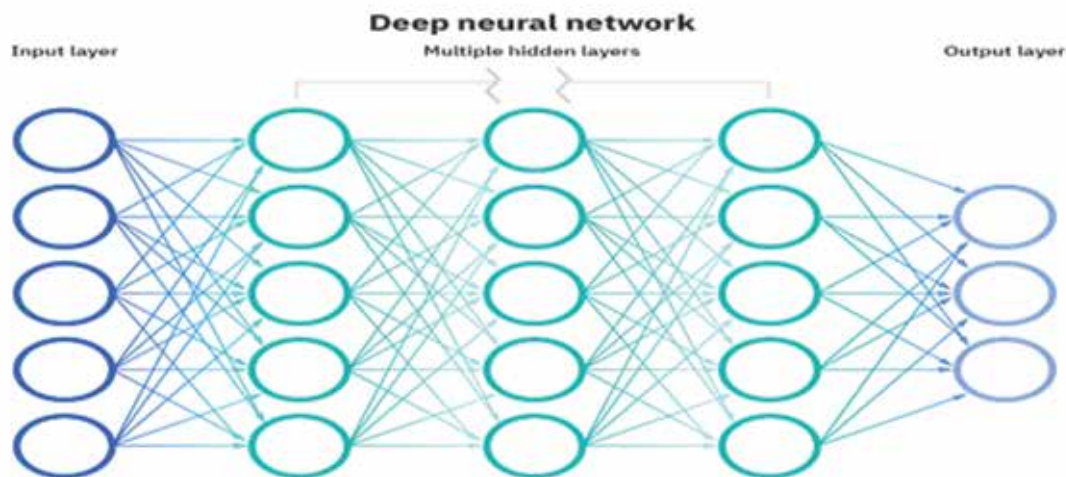
Notes

N1: Data used, and inferences drawn for such planning can be made functional in a Physical-Digital-Physical (PDP) Loop. Data is first collected from transactions conducted at the physical operating place that is the market(s) for buying and selling. In the second step the data is processed/analysed using AI tools to make meaning out of the data and drawing inferences. From the inference so drawn strategic plans with execution tactics are framed for taking back to the marketplace for execution/ conducting business operations. Thus,

the flow continues in the PDP Loop.

N2. “Random forest is a simple but powerful AI process which uses the wisdom of crowds. “In data science speak, the reason that the random forest model works so well is: A large number of relatively uncorrelated models (trees) operating as a committee will outperform any of the individual constituent models”²

N3. “Neural networks are a subset of machine learning and are at the heart of deep learning algorithms. Their name and structure are inspired by the human brain, mimicking the way that biological neurons signal to one another”³. This is also known as Artificial Neural Networks (ANNs).



Source: <https://www.ibm.com/cloud/learn/neural-networks>

To start with an ANN needs training data for understanding and developing capabilities to increase accuracy by fine tuning the algorithm. Once the training process is completed this powerful tool can classify and cluster data at a high speed. Such a power powerful tool is applied for recognition of human speech, animal sounds and images. It can also recognise certain elements in a few minutes as compared to what a human being can do in a few hours. One of the most popular examples of neural networks is Google’s search algorithm.

According to Statista, one of the most eminent and credible entities in digital technology field, “The current wave of growth in the AI industry is as much about the abundant availability of big data as it is about software and hardware. The amount of big data

being generated by today’s increasingly digitized economy is growing at a rate of 40% each year and is expected to reach 163 trillion gigabytes by 2025.⁴” That such exponential growth in big data is impelling and accelerating the pace of AI algorithms with advancements in capabilities prima facie leave no scope to doubt. Because of all these, digital scientists are moving ahead with more and more customization of AI based solution building for meeting versatile sector specific requirements like healthcare, automobile, BFSI, entertainment, healthcare, telecommunication, education and so on.

The author in his previous article¹ under this column has mentioned about the following three stages of Artificial intelligence:

- ⊙ ANI: Artificial Narrow Intelligence - Capability in a specific context, e. g., weather forecasting,
- ⊙ AGI: Artificial General Intelligence - Capability to perform cognitive functions at equal level of a human being across wide variety of domains; and
- ⊙ ASI: Artificial Super Intelligence - Entering the stage of science fiction when AI will surpass all hitherto seen human intelligence.

There is hardly any doubt about the present position that AI has achieved the level ANI. However, any amount reading of published literature may not help a researcher to reach a conclusion

with conviction whether AI has reached the level of ‘General Intelligence’ with the versatility and perfection across wide variety of domains that a human being can perform in matters of cognitive intelligence. There seems to be no doubt that ASI is still a distant dream. However, one may not lose sight of the famous quote of Ray Kurzweil, a famous American Inventor and futurist. He said, “*Artificial intelligence will reach human levels by around 2029. Follow that out further to, say, 2045, we will have multiplied the intelligence, the human biological machine intelligence of our civilization a billion-fold.*”

Certain Unique Applications of AI

The author in his previous article² on artificial intelligence has provided narratives for many innovations using AI and ML. Keeping in view the above discourse it would be worthwhile to briefly mention about certain recent developments in the field of artificial intelligence, advanced applications and impacts thereof. Based on the limited research of the author and due to the limitation of space the following summary is being presented in this regard:

- ⊙ **AI for medical diagnoses and treatment:** Innovative applications of AI are helping medical science in numerous ways. Millions of pathology reports, X Ray plates, ECG reports, sonography plates, 3D MRI and CT Scan images, outcomes from medicinal treatments and operations done have been/ are being studied along with patient conditions pre and post treatments. AI based algorithms, and its ability to process natural language have made machines to read, learn, and attain predictive abilities with near cent percent accuracy. All these are helping doctors and clinicians for the following:
 - ⤴ Conclusively understand and appreciate past cases in terms of patients’ symptoms and physical conditions, findings of tests performed, diagnoses done, effects of treatments, rates of recovery and survival,
 - ⤴ Diagnose patients’ ailments in future with more conviction in prognosis and offer improved line/ method of treatment and physical operations with enhanced effectiveness to remedy sufferings,
 - ⤴ Remote monitoring of patients’ ailments/health conditions, perceivable impacts of treatments done, and providing corrective actions if desired results are not achieved,
 - ⤴ Predict developments that may happen with treatment in terms of recovery, time required and unfortunate event of fatality, if at all.

Due to limitation of space examples are not being quoted. However, readers may be aware of how medical professionals and pharmacists around the world have developed instant knowledges about the mutations of Covid-19 virus, approved vaccines, medicines, etc., and dynamically decided about line of treatment based on data analyses and interpretation with the advanced applications of AI algorithms.

- ⊙ **Artificially intelligent personal companion:** Microsoft is developing Xiaoice as an artificially intelligent

personal companionship product. This product would also facilitate the process of work force management in many ways, which in turn would help speeding up its further development and the process for wider adoption. Microsoft has claimed to have developed Xiaoice in its Software Technology Center in 2014 “*based on emotional computing framework. It’s consumer adoption in China is a stunning achievement that Microsoft has not talked much about in the West*”.

- ⊙ **Robot personal assistant:** Emotech, a London based company has developed the prototype of an artificially intelligent and voice-controlled Robot Assistant with unique personality. It has been christened as Olly. It is a cup shaped device with an eyeball which can blink while interacting with its user.



Source: <https://techcrunch.com/2015/12/07/olly/>

Emotech founders are reported to have claimed that “*Based on the AI and the machine learning, we create a special persuading system which [along with the owner] will give Olly special personality, Your Olly will be different to my Olly. Because your personality is different to mine, and your lifestyle is different. “For example... I’m quite curious about everything, so my Olly is more pro-active, talks fast and any time when I try to communicate with Olly, Olly always try to give me more information, more options to suggest. But if the person who is more serious, is more logical, all the information Olly will give is not like my very emotional [Olly] but that one will be very data driven.”* Readers might have observed from this claim that Olly would have versatile capabilities in terms of understanding the requirements of its master and assist accordingly. Hence the capability of the software is not unidirectional as is presently being seen in certain similar applications like that of Alexa.

- ⊙ **Humanoid:** Readers must have heard about the humanoid Sophia. This she humanoid can give interviews, deliver keynote speeches in conferences, interact with participants and answer their in questions. It has also successfully attended various talk shows including Jimmy Fallon’s ‘The Tonight Show’. Sophia has already attained celebrity status and been conferred with citizenship of Saudi Arabia. The creator of Hong Kong based company Hansen Robotics has plans to create more such humanoids with wide range of capabilities like those of Sophia, which according to them can “*..... have immediate applications as media personalities in movies and TV shows, entertainment*

animatronics in museums and theme parks, and for university research and medical training applications.⁷”

- ⊙ **Plantix for agricultural crop management:** Plantix is a unique application of a startup called PEAT. It is powered by AI for image recognition and is uniquely capable to study images of crops and classify those images according to reasons based on previously learnt knowledge. Based on such segregation Plantix can prompt the specific disease the plants of a particular field area are suffering, reasons thereof, and provide names of insects and pests that have attacked the standing crop. It can also prescribe the remedial actions and insecticides/pesticides to be used for remediation. The camera of Plantix can be set on a running mode for videography and continuous monitoring. All these in turn would reduce human interventions and errors of judgement which in turn would lead to higher yield of harvest and higher income of farmers.
- ⊙ **RoboBees for framers that pollinate crops:** These small robots have embedded AI and GPS systems and are fitted with powerful cameras equivalent to the eyes of bees. These can fly like a drone, withstand waves of breeze and water, and mimic buzzing sound of flying bees.

Such RoboBees can help farmers to identify field areas where there are needs for pollinating crops for efficient sprouting to ensure higher crop yields. World is presently facing receding trend in population of honeybees and these RoboBees are being made to do what nature’s tiny creatures can do

This solution would go a long way to solve the problem arising from such shortage. This innovative application of robotic process automation and AI was first patented by researchers of Harvard University. Mass applications of these RoboBees are being worked out by Walmart to help Beehive farmers. Research is also on to for developing artificial beehives with applications of robots for continuous caring and monitoring of this endangered specie of pollinators contributing for livelihood of farmers.

- ⊙ **Expert AI Perfumers:** Researchers from IBM in collaboration with a German perfume manufacturer have used the power of AI based solutions for enhancing and diversifying the capacity human perfumers for smelling. This solution would help creating new perfumes using inputs provided by the AI based digital solution.

The researchers have first exhausted olfaction analysis of existing fragrances generated

by various chemical formulae. AI Perfumer was then used to study the historical trend of selling each of the existing perfumes by that manufacturer. Chemical compositions of those high selling perfumes were further experimented by varying chemical compositions using outputs provided by the solution. This process helped producing more variety of perfumes with unique fragrance befitting demographic patterns and choice of customers in different geographical regions.

- ⊙ **Artificially Intelligent Toothbrush:** Tooth decays and resultant sufferings are very common ailments of people across the world. The R&D group of Kolibree has developed a toothbrush called Ara, an award-winning innovation, which has embedded AI powered IoT, sensors below its bristles and Bluetooth connectivity. It can detect brushing duration, pattern movements, mouth area covered, frequency of the use, and transfer the information to an App of the user’s smart phone. Post this the software can compare the detected pattern and habit with the ideal ones as suggested by dentists. This in turn can advise the user what corrections she/he should affect in her/his way of brushing teeth for improved health and hygiene of teeth and gum.



Source: <https://www.iiotworlds.com/spazzolino-con-intelligenza-artificiale-2/>

⊙ **RoboJudge for Beauty Contests:** Artificially intelligent robots are being appointed for judging beauty contestants. All data and information related to desired features that are ideal for winning related to look, facial expression, body measurement, skin texture and complexion, smiling patterns, etc. are fast being fed into the AI based solution. For initial screening of several photos and data of each contestant are fed into the system to generate the short list. Robots are appointed for judging the winner. However,

spectacles are not allowed. Days are not very far when Humanoids would be engaged for interacting with contestants with intelligent questions for finally declaring the winner and runner ups.

⊙ **AI powered machines composing lyrics and music for superhit songs:** Readers may be aware that AI based cognitive tools can read lyrics, listen to music, and observe musical melody patterns of thousands of songs/ orchestrated music and store for its subsequent use. The system can then study reported

mathematically indicated indices to judge popularity level of each song and read critic's comments. The AI powered tool can then correlate and combine these two sets of information to write melodious lyrics and compose music/songs. *"IBM's Watson Beat is a cognitive cloud-based music program developed using AI and machine learning that can assist artists in creation of original compositions. Built on IBM's famed artificial intelligence platform Watson Beat uses users' audio samples to compose original music."⁸*



Source: <https://medium.com/syncedreview/ais-growing-role-in-musical-composition-ec105417899>

AI based solutions have also been ideated for machines to suggest and play the most suitable music/songs based on interpretation of captured images, facial expressions and movements of body, hand legs of a dancer. AI based software with cognitive abilities are also being applied simultaneously with Blockchain platforms for protection of IPRs and musical rights of singers and musicians by detection and prevention of piracy.

⊙ **Serpentine robots for rescue operations:** Natural disasters like earthquake and

flood causing landslides, land caving and falling of houses buildings in huge heaps of debris with human beings trapped in those are now frequent events humanity is experiencing. Lots of precious lives are being lost and wealth being destroyed. Serpentine or snake robots help while conducting rescue operations by detecting living and other objects to be recovered. These are designed using a software like that of Google Sketchup. To attain capabilities of penetrating through small holes and moving ahead with flexible motions like that of a

snake, these robots are built with multiple actuatable joints. These provide multiple degrees of liberty in movements towards frequently changed directions. Some of such snake bots can also swim deep into water bodies.

These serpentine robots can be fitted with high powered sensors and cameras to detect living/biological substances with features of human beings, animals, explosives, precious items, etc. Bluetooth fitted into the robot can emit signals and send pictures to the connected computing device.

The handler of snake robot can use a remote-control device to instruct the robot to penetrate huge heaps of debris following a particular path, or swim into water bodies following her/his directions. Else the robot can also independently move ahead following the signals from the implanted sensors. Such serpentine robots thus can help saving hundreds of lives and recover desired objects by first spotting those and then sending signals and images for rescuing team to search the exact spot prompted by the robot.

ROI from AI Projects

Readers by now must have understood that projects for digital transformation of operations with applications of various tools from the stable of artificial intelligence and robotic process automation is different from any other project in areas of information and communication technology. AI driven initiatives are largely dependent on collection of data of past and present periods, safely preserve those and use for the right cause. It would be worthwhile to quote here from an article of MIT's Sloan Management Review of August 2021 titled 'Achieving Return on AI Projects'. It writes:

“Several surveys suggest a low level of returns thus far, in part because many AI systems were never deployed: A 2021 IBM survey, for instance, found that only 21% of 5,501 companies said they had “deployed AI across the business,” while the remainder said they are exploring AI, developing proofs of concept, or using pre-built AI applications. Similarly, a VentureBeat analysis suggests that 87% of AI models are never put into production. And a 2019 MIT Sloan Management Review/Boston Consulting Group survey found that 7 out of 10 companies reported no value from their AI investments. This makes sense: If there is no production deployment, there is no economic value”.

The author of this article has made efforts to think through the above research findings which are not that encouraging. From the perspective of a finance professional, as the author is, success of AI based projects in all probability depends on certain factors which can be christened as '12Rs of Success' for digital transformation with AI Technology'. Those are:

- ⊙ Selection of the 1 Right AI Project and
- ⊙ executing the same using the 2 Right set of Data
- ⊙ for the 3 Right Purpose
- ⊙ at the 4 Right Time
- ⊙ with the 5 Right Analyses and MLs
- ⊙ deploying the 6 Right Tool(s)/ Software and
- ⊙ 7 Right Manpower
- ⊙ for generating the 8 Right Outputs
- ⊙ that are relevant for taking the 9 Right Decision and
- ⊙ updating past learning points at 10. Right Intervals with again the right set of data
- ⊙ at the 11 Right Cost
- ⊙ for the 12 Right Return.

Striking one single chord that resonates all the above 12Rs in an orchestrated manner is essentially a difficult task and that needs deployment the right manpower with requisite knowledge and experience. It needs intensive efforts for changing mind set and longstanding impacts of organisational genomics, setting aside legacies and ushering in the new policies and processes for digital transformation. At the organisation and CXO levels the following prerequisites are to be met before embarking on the journey:

- ⊙ Appropriate re-articulation of the vision and mission of the organisation subsuming the intent for digital transformation

of business duly aligned with business strategies,

- ⊙ Unwavering commitment for deployment of resources both in terms of finance and trained manpower,
- ⊙ Steadfast pledge for maintaining ethics and morality in data and AI project management as are followed for corporate governance of the entity,
- ⊙ Treat every single project as a separate profit centre with pre-defined result oriented KRAs and KPIs, including returns in tangible terms for close-circuit monitoring of progress and embedding the same into the balance score card of employees responsible for the project,
- ⊙ Excellent professional and working relationships between members of both data management and operating teams for collection, first-hand analysis, and preservation of data,
- ⊙ Successfully conduct change management and making human resources ready by training and development and creating an environment for continuous learning, unlearning, and relearning.

It may not be necessary for every organisation to internally manufacture products and develop/ customise software with applications of artificial intelligence and robotic process automation befitting the organisational requirements. All these may be quite time consuming and expensive with involvement of considerable quantum of capital investments. Not all organisations can afford such large quantum of funds and wait for the development process to be completed before commercial exploitation starts. Thousands of startups all around the world are developing products, platforms and

customised application-oriented software which can be used for multiple purposes to meet multifarious business requirements. Glimpses of a few of these have been narrated in a preceding section of this article. Digital giants and consulting firms also provide services for implementation of digital technologies. Business organisations can collaborate with such startups adopting one or more of the following options:

- ⊙ Mergers and acquisitions of one or more startup entities which has developed such products and software,
- ⊙ Entering contractual arrangements for strategic alliance with mutually agreed terms and conditions,
- ⊙ Use manufacturing facilities of those entities with leasing arrangements and obtain annual licences for software use paying annual fees including for maintenance,
- ⊙ Participate in crowdfunding of identified startups whose products and software applications are found to be relevant and desirable for adoption once those are ready with condition for collaboration in future. Readers may read more about strategies and options for such crowdfunding in one of his article⁹ published under this column, and
- ⊙ Engage digital giants and/or consulting firms for help and support during the journey of digital transformation with AI based projects.

Mindful adoption of one or more of the above strategies would help organisations to improve profit and profitability from such projects.

Artificial Intelligence and Ethics

Any such article on digital technologies remains incomplete without discussions on the related

dimensions of ethics and risks. In the second half of his earlier article² the author has briefly dealt with such aspects related to digital transformation with AI and RPA. He would urge readers to refer the same. Another article is being ideated to cover these dimensions in more details and examples from real life, which can be published under this Column in near future.

Conclusion

Artificial intelligence and robotic process automation is no longer a wishful thinking. Neither those can be wished away. Selective and cautious applications of these technologies would certainly be able to generate benefits for humanity, Business organisations, government agencies and large NGOs would have to adopt and move ahead with digital transformation including projects with applications of AI and RPA sooner and later. This hypothesis has affirmatively been proved already by many startups and digital giants like Google, IBM, Apple, Facebook etc. If startups can graduate to Unicorn status, why not established business can earn profit from digital transformation projects. Names of many such startups have also been referred in this article and the authors earlier articles.

It is never a desirable proposition that losses are incurred as have been suffered by many of the organisations covered in the research survey results and reported in the aforesaid article of MIT Sloan Management Review. The author is of the view that one or more extensive empirical research(es) should be conducted to understand and appreciate the reasons for not generating desirable results from such projects. The objective should be to find out reasons for such projects generating losses or less than desirable ROI. However certain measures have been suggested above by the author which commercial organisations may find useful to adopt for ensuring profit and profitability from AI and RPA based projects. MA

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All these websites have been accessed during August 2021.

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