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Editorial Note

Human Intelligence and Machines

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Current trends in engineering and technology have made a great impact in automation on a day-to-day basis in almost every field. The advantages of automation are manifold -reducing human interventions, increase in productivity, reducing human errors, and to enhance their capability to work; especially in hazardous and danger zone areas. Human labor-intensive tasks/repetitive tasks where human fatigue and error is a usual phenomenon are usually good candidates for automation. Can automation succeed in tasks which need human expertise and intelligence? Its limitations does not allow it to automate every task. Automation is a straightforward algorithm which takes input data and produces output according to the algorithm. When intelligence and cognitive capabilities have to be embedded in a machine to mimic the way human would execute the task, automation becomes conceptually closer to Artificial Intelligence (AI).

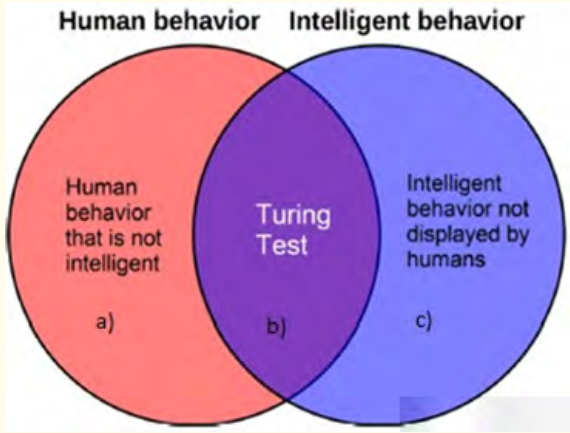

Figure 1: Task Characteristics subjected to Automation and AI.

Figure 1 depicts the three task characteristics (mentioned as a, b, and c) depending on which, it can be subjected to Automation and Artificial Intelligence. The tasks which are simple, voluminous and repetitive, do not need very intelligent humans to execute (Figure 1–red colored section a). The execution of complex tasks which require expertise and skillset needs humans with high level of intelligence quotient (Figure 1–purple colored section b). There exists a category of tasks which is out of scope for humans due to their inherent limitation (Figure 3–blue colored section c). The choice whether a task needs no automation, automation or artificial intelligence will depend on the task and its characteristics. Let us understand this viewpoint with the help of the following Figure 1.

As mentioned in red section a) of Figure1, tasks to be carried out require average human intelligence where work is voluminous and repetitive in nature. Automation of such tasks have been a part of third industrial and digital revolution. Some of these applications are very common and popular in making people's life easier. Automated washing machines, merchandise shopping using automated vending machine, bank transactions using automated teller machine are few examples. These automated solutions work in same manner for every customer. The question arises - Is there a scope of intelligence (AI) getting embedded in these machines? For example, AI enabled washing machine recommends optimal wash cycles based on fabric, water quality, level of dirt, etc. AI powered vending machine for a snack helps in product brand building by understanding the customer behavior and making real time data driven decisions. Task execution in this manner will add customer delight along with satisfaction. Thus, there is always a scope of taking task automations further towards artificial intelligence enabled tasks.

Tasks which require high IQ or human intelligence quotient is mentioned in overlapped purple section b) of Figure 1. Is it possible to automate a part of skilled work and replace a skilled worker? Professionals such as medical practitioners, geologists, radiologists, bankers, engineers, detectives, translators, are skilled humans who learn, unlearn, acquire knowledge after completing courses for a specific number of years and become experts with enriching experience. Their decision making needs intelligence to choose the best heuristic to accomplish their respective task. The task of prediction, classification, regression and recognition require human intelligence and knowledge of domain experts to automate these tasks; which does not seem like an easy job. Automating these tasks require Machine Learning (ML) and Deep Learning (DL), which are subparts of artificial intelligence. There can be many solutions, out of which the optimum solution has to be searched by the learning models and the heuristic algorithms. Human replacement is not possible as artificial intelligence falls short at it. A portion of task can definitely be solved using intelligent automation; such as work of pathologists, radiologists, language translation, biometric attendance, etc. with decent accuracy. Cognitive skills make humans very special as it helps human brains to think, read, learn, remember and reason. The Turing Test named after Alan Turing, an English computer scientist; is a test in artificial intelligence to determine whether a computer is capable of thinking like humans. Till date, AI enabled machines could not pass the Turing Test due to its limitation to reason logically.

Human intelligence have limitations which cannot be displayed as shown in blue portion of Figure 1. Automation in these areas is considered a breakthrough. Machines have huge memory and high computation speed. Humans have limited computational power and memory power. The whole electromagnetic spectrum is not visible to humans. Mathematical computation, data storage, capturing data other than the visible spectrum and inferring knowledge is a big breakthrough in the field of science and technology. For e.g., AI in Remote Sensing has made a tremendous mark in geomatics community in collecting and integrating spatial data over different geographical areas at different times. Technologies like deep learning, is a specialized machine learning technique which is modeled on human brain.

At present times AI is a limited version of intelligence and is known as Weak AI or Narrow AI. Weak AI is capable of conducting one task at time and is still incapable of handling and coordinating multiple tasks at a time. Some applications of Weak AI are digital voice assistants, language translator, holiday planner &weather forecast, search engines, movie recommender system, warehouse maintenance, delivery bots and chat bots. Strong AI algorithms should be able to make independent decisions without human interference and mimic exactly like humans. Strong AI has far more to achieve and mimic Human Intelligence to be able to pass the Turing Test.

How to Achieve Strong AI?

Researchers can focus on the following open areas of research essential to achieve Strong AI.

1. Knowledge Representation: Data intensive science in the era of digital revolution generates voluminous raw data in every field such as social media, medical diagnostics, education sector, etc. This has created a significant mark in the way we handle, store and manage data efficiently to generate and represent knowledge, used for further reasoning. Study and proper implementation of Big Data Analytics leverages learning by machines and makes AI smarter and stronger.
2. Automated Reasoning – Humans think logically and rationally. Despite major advances in AI, machines still do not possess the

ability to exhibit intelligence by thinking rationally. Tools and techniques for automated reasoning is based on propositional logic, deductive reasoning, probabilistic, Fuzzy, Bayesian, verification technology etc. It can be most commonly used as proof assistants, to solve problems in hardware verification and circuit design.

3. Machine Learning (ML) – For understanding the underlying patterns from input data, based on types of ML techniques - supervised, semi supervised, unsupervised and reinforcement learning. Supervised learning requires huge amount of labeled data for training to accomplish object classification and speech recognition tasks. To overcome this, transfer learning has proved to be very helpful in speeding up the learning process by reducing the training time. Researchers may focus on the popular, state of art, pre-trained models such as family of Visual Geometry Group (VGG), InceptionN, Xception, ResNet and its variants. Supervised learning is more popular and mostly used. To mimic humans, self-learning is also one of the common and natural approach used. This approach can be implemented using semi-supervised learning (SSL), unsupervised and reinforcement ML algorithms. There are many real time case studies where labeled examples are quite few or almost none, such as in fake content classification, drug discovery and new disease classification (Cancer/Covid). Lot of work still needs to be achieved using these approaches with very high accuracy.
4. Natural Language Processing (NLP) is a component of AI where automatic computation of human languages take place. Natural Language Understanding (NLU) component helps machines to understand the semantics and sentiments of the language being communicated. Natural Language Generation (NLG) produces semantically correct sentences using deep learning models such as Recurrent Neural Network (RNN), Long Short-Term Memory(LSTM), Transformer. Machines have the preliminary capability to read and understand human languages in the form of speech or text. However, a fully developed intelligent conversational AI system still remains an open area of research. For example, Voice Assistant app (Siri or Alexa) is often unable to generate its own thoughts while conversing with a subject (human) in order to achieve a full-blown conservation. This can be proved by performing a thought experiment known as Imitation Game or Turing Test. It uses a method of inquiry to test whether machines can think like humans. There is always a scope of developing cognitive assistant/chat bots for various domains such as elderly care in healthcare, prospective talent search in recruitment, sentiment analysis in social media, etc.
5. Vision – Computer Vision (CV) is a part of AI used for interpreting visual data. Machines gain high level understanding from digital images of different types and from various sources like videos. CV is interdisciplinary and performs tasks such as image segmentation, object recognition and identification, and pattern matching in various application domains. Modern CV software inspired by human brain is based on Convolutional Neural Networks (CNN), a type of Deep Learning algorithm. Open areas of research in this field is to make CV applications ubiquitous, scalable, mobile enabled and real time service oriented. Edge computing, a new model has emerged recently.
6. Motor Control –Motor Skill Learning is acquired by training for taking action on nearby objects. Various forms of human movements can be acquired by artificial agents or robots to act in real time environment. Not all robots are AI robots. To perform repetitive, heavy and exhausting tasks, AI is not required. The role of AI in Robotics and Automation is employing Internet of Things (IoT), cognitive computing, cloud computing and is the future technology of Industry 4.0. Researchers can implement Industry 4.0 to create a friendly ecosystem, effective process management and build smart cities and smart plants.

One day Alan Turing's vision may come true –a machine may pass the Turing Test. A machine that self–learns from its experience, thinks logically and rationally, possess emotional intelligence, cognitive skills and can handle multiple tasks at a time, may become a reality.

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