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Review on background to AI principles and industry 4.0 implications and practices

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Abstract

This review paper presents completed case-study materials to share with the community and the new researchers. The goal is to examine latest developments, application, and integration in the areas of AI classification principle and Industry 4.0 and beyond. The objective is to identify the underlying fundamentals. Along with background and fundamentals the review presents developments, standards and importantly the mandates from the local and world establishments and organizations in the areas of Industry 4.0 and beyond. The topics not only can help understand the technology developers in the community but also the research workforce that we produce.

Keywords: Artificial Intelligence; Industry 4.0; Neural Network; System-of-Systems; System Integration; Machine Learning

1 Introduction

This paper presents review on background to Artificial Intelligence (AI) principles and industry 4.0 implications and practices. What is means that the review considers introductory topics on several fundamental research themes that has implications on next generation system-of-systems designs. The review responds to the needs as regards to modern technology systems keeping in view of dissecting AI classification principles for Industry 4.0 applications. It helps understand the scopes of integration strategies from multidisciplinary engineering point of views. Moreover, it is traditionally assumed that applications of AI are largely found only in engineering sciences such as robotics, aerospace technology, mechanisms, autonomous systems, and so on, however, as concluded their applications are widespread including weather forecasting, cloud computing, social media interactions, sale and purchase, sociology, human behavior analysis and prediction. All these applications are now connected to the Internet and such an infrastructure is considered as Industry 4.0 standard. The author utilizes his expertise and experience to compile and consolidate the AI principles and Industry 4.0 terminology and presents a scenario while listing attributes for interdisciplinary System Integration (SI) and SoS.

2 Industry 4.0 and Beyond

Industry 4.0 has become the norm recently. Although Industry 5.0 has already immersed, it overlaps with Industry 4.0. Industry 4.0 is the new age industrial revolution that brings digital and physical technology together which helps in smart factories and supply chains. As Industry 4.0 uses Cyber Physical Systems (CPS) it looks into the key elements such as cloud computing, sensing and robotics, IoT (Internet of Things), and so on in order to increase productivity in an industry. There are multiple challenges for industry 4.0. For example, the integration of digital and physical systems enables cyber threats which could affect the company's data privacy. Industry 4.0 can set and collect vast data across a

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wide scope of activity with a Descriptive Research Design (DRD). In this respect, the Internet establishes a focus on end-to-end processes for additional improvements. Secondary data along with hardware management issues with AI and automation have a greater role. Local industries understand how new technology systems will facilitate aid-on automation in the existing establishment effectively and assist the small-scale industries or novice developers to transfer the technology. Since this study adheres to current academic teaching and research and industry-institute interactions, the citation will benefit the industries and student researchers as both will include Industry 4.0 standards, state-of-the-art IT paradigms and practices in future. The benefit is far reaching as the materials can help them to do projects and pursue research in advanced topics and help build their career. For example, application of AI and role of Industry 4.0 in Food and Agriculture sectors will augment educated workforce because technology driven automated systems support new jobs. For the modern food and agricultural technology system, little or any compilation of state-of-the-art technology systems has been done to examine the connection and integration between the institute and industry. Also, evaluation of local needs in relation to integration of modern technology will play an important role. The estimated revenue generation companies adapting to Industry 4.0 can reach $1 Trillion USD by the year 2030. The key perspectives which help in analyzing the market data for are technologies, countries, regions, and sources of revenue. Examples of the companies that have adopted Industry 4.0 are IBM, QUALCOMM, INTEL, MICROSOFT, and so on. Some of the important Industry 4.0 sectors where AI plays a vital role are listed below [1, 2].

- Agriculture
- Astronomy
- Automotive Industry
- Data Security
- E-commerce
- Education
- Entertainment
- Finance
- Gaming
- Healthcare
- Robotics
- Social Media
- Travel & Transport

3 Human-cantered automated decision-making

This section emphasizes (a) the meaning of each sub-topics and (b) how these sub-topics are linked together to constitute AI and ML. Human-centered automated decision-making [3] plays an important role in helping the processes at a higher level where tolerable gross and subtle decisions are needed and acceptable. Artificial Intelligence (AI) and Machine Learning (ML) concepts have potential capability to automate such human-centered decision-making. Developments in AI and ML are found in engineering and technology designs, computing, networking, banking/economics, space and agriculture. In the sequel,

- AI and ML and applications,
- Constraint Satisfaction and Minimization,
- Search Algorithms including Games and Adversarial Search,
- Importance of Markov Models,
- RL and ML, and
- Neural Networks (NN); Deep Convolutional NN; and Recursive NN and data engineering will be presented.

4 Artificial Intelligence and Machine Learning

Manufacturing sectors are already investing AI/ML in cloud, analytics, automated workflows, and IoT to augment transformation to Industry 4.0. Industry 4.0 promises transformation by adopting smart factory technologies by reimagining what an intelligent factory can fit into core operations including finance, sales and marketing [4].

Artificial intelligence (AI) is defined as an artificial creation or development that can mimic human-like intelligence to certain degrees and capable of learning, reasoning, planning, and processing by using mathematical tools, scientific principles, and technology systems such as algorithms, biological phenomenon, hardware, and software [5]. AI is a rapidly advancing technology and has received increased attention in recent decades. On the other hand, Machine

Learning (ML) is an idea where machines (usually computing devices, agents, etc.) are trained to learn the way humans learn. The question is how would a machine learn without having a brain? Then we must understand the entire theories (or some theories at least) that facilitate learning for humans and even other animals. Can we develop a program or application or software which can be used to insist on a machine to learn? It is possible. Learning is a continuous process. It never stops. The program should have the algorithm to make it happen. This concept will immediately allow us to define ML as the "Algorithms that generate Algorithms". An algorithm is understood as a sequence of logics which can be realized using some form of instructions, used to solve a problem. Algorithms coordinate enormous amounts of data and converge into valuable information for services i.e., to solve problems. It does so, based on certain instructions and rules constituting a flow of logic. The selection of instructions and rules plays an important role and the researchers have been trying to understand the appropriate matrix (instructions and rules) for different applications such as image recognition, fingerprint recognition, fault detection, behavior detection, etc. It is considered as a model. New ML models are surfacing almost every day. In a nutshell, it can be said that ML constitutes itself as an algorithm or a group of algorithms that must specify itself as someone's Model and it always works with data to learn on something continuously. Here is an example. Let us develop a Model to do multiplication. We can achieve using a concept like 3x5=15 and let us say this as Model 1. We can get the same answer using another concept like 3+3+3+3+3=15 and let us say it as Model 2. We can also get the same answer using even another concept 5+5+5=15 and let us say it as Model 3. Each Model can be realized using a set of instructions and rules and can constitute an algorithm. Which one out of three is good? The answer is each Model is good. Someone can create another algorithm just to select one of the three Models to do multiplication. The selection itself is kind of "learning". If there is plenty of time, Model 2 can be selected, and the results can be achieved by doing additions five times (i.e., 3+3+3+3+3). If there is moderate time, Model 3 can be selected, because it needs only three additions (5+5+5) rather than five. So, depending on how much time we have or whether we are not lazy, we need to "search and select" one Model out of many Models available. We should train the system on how to select. Thus, the selection itself is a kind of "learning". Here a new word called "search" has been introduced. "Searching" itself is an algorithm and there are so many Models available in order to implement the "search".

4.1 History

A generation of scientists, mathematicians, and philosophers with the concept of Artificial Intelligence (AI) can be traced back to 1950. In fact, the AI research area was founded on the campus of Dartmouth College in the summer of 1956. Original AI programs were called "expert systems" [6]. Towards the end of the 1960s, it was predicted that a machine would exist at the beginning of this millennium with an intelligence that would match with the capability of human brains. It did not happen, but the progress was not bad. Many researchers believe that it was because of qualification problems. Based on Moore's Law, it is predicted that it may happen in 2030.

5 Constraint Satisfaction and Minimization

The digital transformation of production systems entails optimization tools. The impact of Industry 4.0 solutions concerns optimization tasks and algorithms. Constraint satisfaction has a role in AI. Constraint satisfaction [7] is the process of looking for (searching) a solution to a set of constraints that impose conditions that the variables must satisfy. Which variable(s)? When writing algorithms for constraint satisfaction, we must define some variable(s) to reflect or take care of the problem domain. Then we must have a problem, in the first place. AI algorithms [8] must recognize the problem through variables which should satisfy the constraints. Once satisfied, a solution to the problem may be achieved. Whether it is AI, or simply I (intelligence), a solution is defined as a set of values or outcomes for the defined variables that satisfies all the constraints laid out. In AI, we define a solution as a point in the feasible region. Techniques are used for developing constraint satisfaction rules. Since AI involves learning, degree (less or more) of satisfaction to constraints may vary. Second, to find an optimal level of satisfaction, we need to involve an additional sub-process to constraint satisfaction. This new process can be defined as minimization. In other words, constraint satisfaction minimization is a process of optimizing constraints functions which are usually configured around some variables. The function is usually called cost-function or energy-function. Note that for any kind of optimization or minimization we usually use the word cost or energy. Because, for example, when cost and energy is saved while developing a product, we say that the product is an optimal product. We encounter two types of constraints: hard and soft constraints. Hard constraints are rigid, and soft constraints are flexible, but both need optimization. Soft constraints may have a higher ability to learn. Some human brains are rigid, and some are flexible (elastic), although all brains are flexible. This happens because of the way the brains have learnt in the past. While the rigid-constraint brains do not allow themselves to change, the soft-constraint brains allow.

6 Search Algorithms

AI implications are gradually accomplishing various goals of Industry 4.0. The significant technological feature of AI is search and critical for Industry 4.0. For AI, search algorithms are inevitable. Whatever we think, say, and do in the real world, we always begin with a *search*. We do it so fast that by the time we think, say, and do the search within the back of our brain is already done. That is, we think, we say, and we do only after the search is over. We then must mimic a similar process in AI. That is in AI, *search* is inevitable. In order to implement search, we must have search algorithms. There are lots of these algorithms classified and available because searching is the universal technique of problem solving in AI. Now, we are ready to define the term search, scientifically or technically. Search in AI is the process of navigating from an originating-state to a goal-state by transitioning through intermediate-state(s). Search algorithm recognizes states within the Search Space, which is a collection of states. The following figure might not convey enough meaning regarding search right now, but it has a concrete meaning. Uninformed search is primarily needed when within the problem there is no information available about the cost of navigating between the states [9].

6.1 Games and Adversarial Search

Search algorithms will never leave AI alone. Search is not just a "search engine''. It is a concept or implementation idea. This section will define game and adversarial search. Game search is defined as a different type of search for AI. Consider a game (say chess). To win a game, intelligence is needed. In a more technical way, it is worthwhile to say that games are modeled as a search problem that involves a heuristic evaluation function. A heuristic is a mental shortcut method that eases the cognitive load of making a decision. Heuristic approaches are considered to be trial and error, a rule of thumb or an educated guess. A heuristic technique may not be optimal, but the approach is a kind of self-discovery that employs an experiential method that is not necessarily perfect or rational, but is sufficient for reaching an immediate, short-term objective. On the other hand, adversarial search entails examination of the problem which arises (i) if there is a need to plan beforehand of the situation, and (ii) if other agents are planning against the current situation. Just as in the game. As we know, in a game two or more players search with conflicting goals to try to explore the same search space for the solution beginning (originating) state to intermediate state to winning (goal) state, for example. Planning is needed under the assumption that the opponents will maximize advantage at their end. As mentioned, intelligence is needed to win a game. So, in AI, to win a game, or in other words, to make an intelligent move, game-like situational thoughts and actions must be implemented. Any action (doing) needs a search algorithm beforehand as mentioned in the previous section. Threats target critical infrastructure such as Cyber-Physical-Systems of various architectures within Industry 4.0 processes. In spite of the development of artificial, computational, and autonomous, decision-making will remain human-centric. In this respect, Industry 5.0 would be a new revolutionary wave of the human-machine symbiosis [10].

7 Markov Models and Reasoning

Researchers have proposed a workflow to conduct comparison of Monte Carlo methods [8] for Industry 4.0 applications in terms of process KPIs the methods are studied comprehensively. Based on the workflow, the Monte Carlo model selection brings benefits such as increased efficiency and productivity in Smart Manufacturing. The results have shown that the two Monte Carlo methods can be selected based on the data availability. MCMC is recommended in the Smart Manufacturing application due to its reliability and potential of improvement. In AI, decision-making must be studied. Reasoning is needed in making a *decision.* Technical knowledge is required on how reasoning is implemented. Reasoning is a kind of dependability analysis technique. IF-THEN is the simplest form of reasoning to understand dependability. There are also complex ones. Such background information is known as assumption for prediction. Theories and techniques establish some form of Models to take care of reasoning building blocks that inherit reasoning algorithms to the solution to the problem at hand. To establish a framework for reasoning we need to have background knowledge. Background study tells us that *the future states depend only on the current state, not on the events that occurred before it*. Markov, a Russian mathematician, cited some properties to develop a Model which is good for creating reasonings for AI. It is called the Markov model. Markov model is a stochastic (probability and statistics) model that is used to model randomly changing systems. Bearing in mind that everything is changing continuously, our AI framework must adapt to the environment in real-time. All the constituents such as Constraint Satisfaction, Search, Reasoning, etc. so far, we studied, and their Models must inherit features to reflect randomness. Markov Models are good in that respect in the sense that they are good for predictive modeling and probabilistic forecasting. Markov modeling technique confers dependability analysis of complex systems. It takes care of system behavior and reliability. Within Markov models, Markov Chains are studied. Markov chains statistically model random processes. A Markov chain is a probabilistic automaton.

8 Reinforcement Learning (RL)

Reinforcement learning (RL) methods solve complex optimization problems. RL methods inherit the right approaches for various problems. As high levels of optimizations cannot be satisfied with human interventions, self-learning solutions such as RL techniques have been proven to be efficient. RL framework and a classification of RL methods are seen to be possibilities in building Industry 4.0 architectures [11].

There is a saying that says, "We learn from our mistakes." Philosophically, what it means is that a successful learning or a learning is successful (replace the word successful with acceptable) through several trials. Some people may disagree by saying that several trials are not a necessary condition for learning to happen. Because, someone can learn something in one attempt or in one-go. However, it is not right. The concept *learning* by itself is embedded with a hidden phrase "several trials". Learning on something involves acquiring, getting, analyzing, rejecting, discriminating, conceptualizing, perceiving, storing, and using these attributes again to learn another thing. One-go type learning never exists. However, one-go type learning may happen only if the system has already had some learned information beforehand, and currently, the system is evolving its learning by positioning itself at an intermediate state. Underneath "several trials" can be understood as some form of *reinforcement*. So, Reinforcement Learning (RL) is a process where the *agent* learns iteratively until it achieves that it succeeded. It is better to mention a universal word "*agent*" instead of saying "System", "I", "We", "Someone", and so on. Within AI, researchers, scientists, and stakeholders use the word agent very often. Agent learns. We will encounter tons of usage of this term. RL is in fact a training scheme for an agent that can inherit a Machine Learning model. The agent learns to achieve a goal in a complex and uncertain environment which may be static or dynamic. RL also occurs under game-like situations. The RL algorithm employs trial and error to come up with a solution to the problem. Let us consider the problem of finding the shortest route in a maze. First, the agent (maybe a robo-mouse) must learn to move around the maze several ways and several times during a period called the learning stage. And, when fully learned, the agent, when asked to do so, can explore the maze in real-time and reach the goal (destination) through a shortest route. Note that there may be 100s of points (A, B, C, ….) within that maze region. From A to D there can be one shortest route. From S to L, there can also be a shortest route. From D to M there can be a shortest route. And so on. So, there can be plenty of small versions of the shortest routes from origin to destination within the maze region. Our agent needs to learn about all these small versions of the shortest routes during the training stage period. While learning, the agent reinforces itself all these intermittent states and assembles them together to come up with a successful learning, so if the agent is left (start) at point D, for example, it can reach at the destination since the holistic RL training was already done during the learning stage. Let us think a little bit more about RL. While learning, the RL based AI gets either rewards or penalties for the actions it performs with an objective to maximize the total reward. RL is a basic learning technique. The other two basic learning techniques are supervised learning and unsupervised learning. Reinforcement learning falls under Machine Learning (ML) and is concerned with how the agent ought to take actions within the problem space in order to maximize the cumulative reward. Maximum cumulative reward signifies successful learning. Action means learning-steps. Problem space means, maze for example.

9 Machine Learning (Statistical)

A group of agents can constitute a machine. A machine can be a computer or robot. Machines can be anything where AI can reside. A machine can be a software! Like human beings or some animals, a machine can learn. When we want a machine to learn, we can call it the "Machine Learning" (ML) paradigm. Machine Learning paradigm can be of two types: non-parametric and parametric: accordingly, non-parametric model-based ML and parametric model-based ML exist. Parametrics are statistical models. Statistical ML uses statistical parameters such as mean, variance, and whatnot, to model the learning paradigm. Between statistics and Statistical Machine Learning (SML), the former draws population inferences from a sample space and latter is a kind of approach that finds generalizable predictive patterns within the sample space. SML allows machines or agents to learn and discern patterns to be used for decision-making. Learning methods are combined to come up with powerful tools and techniques for sophisticated analysis of various kinds of data and information in many problem spaces including image processing, speech processing, robotics and navigation, economics, and so on. Machine learning and reasoning for predictive maintenance in Industry 4.0 in regards to current status and challenges can be found in [12]. The authors have discussed predictive maintenance to highlight the challenges faced in both implementation and use-case. The predictive maintenance is a hot topic in the context of Industry 4.0 but with several challenges to be better investigated in the area of reasoning.

10 NN; Deep CNN; RNN

Industry 4.0 accommodates a wide-spread opportunities for enterprises to update state-of-the-art technologies and tools to optimize operational processes. Besides drive analytics, autonomous systems are crucial to the application of

Industry 4.0. Artificial Neural Networks or ANN empower digital connectivity and AI augmentation with the ability to manifest some degrees of intelligence without human intervention. Some of the Industry 4.0 business models are to (i) enhance application of data-driven optimization models, (ii) validate and test, (iii) enhance predictive maintenance, and so on [13].

Neural Networks (NN) are biological connection patterns of the brain. Human brain is considered as a giant 3D network of neurons where information is received, processed, stored, understood, perceived, retrieved, again and again. Human beings are intelligent because of their brain structure (networked pattern) and the way the brain's network patterns collectively work in order to produce decision threads. Using their intelligence, some intelligent, smart, clever, and wise people have been trying to mimic the brain using Technology Systems and Algorithms (TSA). Long way to go, but so far, some developments in this area have been made. We call this development the Artificial Neural Network (ANN). ANN is not a brain, but a paradigm or framework using which the paradigm tries to mimic the way the brain works or produce decision threads. TSA that tries to realize a brain, three basic ingredients: Theory (principles), Hardware, and Software. Algorithms are different from Software. An algorithm is a set of logical sequences with some rules. In order to formulate the rules for the logical sequence of a process the theory includes a mathematical basis. The algorithm can be realized using a Computer language, and when realized it can be considered as a Software application. To execute this algorithm through the Software, a Hardware is needed. Hardware can be a computer or similar device. The theory behind the ANN is vast. Since the brain has the ability to learn, we must develop the ANN theories in such a way that it should have capability to learn. Or, if some theories have already been available in the marketplace since the 17th century (say probability and statistics), why not use those to save time. Researchers have developed so many types of ANN, each configuration has its own features, characteristics, and capabilities. Most popular ANN configurations are Deep Convolutional Neural Networks and Recurrent Neural Networks.

10.1 Deep Convolutional Neural Networks (DCNN)

The brain is a 3D system. More layers an ANN has, the more fine-tuned the decision resolution it will have. It is obvious. If we pass the rain water through multiple layers of filters or screen, with the first filter having wider openings, second one has a little less-wider, and so on, and the last one is a carbon-granule filter similar to our home water filter, then finally we will get clean water, nothing else. The last filter decides whether the final product is water. If there is no rainwater but only leaves at the input filter or screen (first filter), there will be no decision to be made by the entire filter system. An ANN, when trained, can recognize or decide whether the input language is English, French, or Arabic. More layers or filters will facilitate more discrimination (fine-tune resolution), which is good. But, more layers (deeper) requires cost and energy such as space, computation, etc. We can go as deep as we want, but technology also has a limit. The convolutional part of the Deep Convolutional Neural Network comes from the fact that *convolutional theory* plays a role. Convolution is a mathematical operation like multiplication, division, etc. A convolution is a specialized kind of mathematical operation in that two functions produce a third function expressing how the shape of one is modified by the other. This aspect is needed for the purpose of learning. Note that when something is to be learnt two things are needed: one we just saw (say, a snake) and the other one that is already there in the back of our mind or brain (say, a rope). The one we just saw (snake) is the second function and the one that is already there (rope) in our mind (patterned brain) is the first function. Let us say, we have never seen a snake before. When we see the second function (snake), we modify one of the shapes (not necessarily the physical shape.) of the two functions (either rope or snake or both) and store it as a third function (snope!). The third function is neither a rope nor a snake, but something in between, for which sometimes we confuse whether it is a rope or snake when we see something similar next time. We will not be confused if we do not have snope in our brain. Earlier, we had only one function, now three! So, we learned. So, convolution theory plays a role in learning. We need more layers (deeper) not to confuse very often. An ANN theory should have this convolution idea, so when configured properly, it will learn. As an example, DNN has been applied in a soft sensor that combines with a high-resolution optical quality control camera to increase the accuracy and reduce the cost for visual inspection in the printing process within the Industry 4.0 paradigm. It is claimed that the DNN sensor achieved a fully automated classification accuracy rate of 98% [14, 15].

10.2 Recurrent Neural Networks (RNN)

The job of ANN, as an example, is to recognize something (image, letter, intruder, etc.) based on the training given to the network. The fingerprints that your cell phone is taking from you right now is to use it for the future, and so doing you are giving the training to the cell phone just after purchasing it. The cell phone ANN system has already taken training once on how to collect fingerprints. In this case, two levels of training are given to the cell phone. In some applications we need different kinds of settings or data flow with regard to facilitating training. For instance, if it is needed to predict the next word in a sentence, it is sometimes better to know the previous word. And, some applications need such previous information. So, the output sometimes needs knowledge of the past. Ordinary ANN networks are combinational systems, meaning, it assumes that there are no relationships between the inputs. That is okay if ANN systems do not require to know the past information. For a task when the output depends on the previous computations, we have to incorporate new features to the ANN paradigm in order to know the next word. There comes RNN. Trends of digitalization and low-cost storage in the Industry 4.0 platform enable the access to more historical data in data driven methods to perform system identification. Model predictive control (MPC), an advanced control framework that contributes to autonomy, can coexist with Recurrent Neural Network (RNN) architecture to train and validate the industry 4.0 features [16, 17].

11 Data Engineering and Applications

Data…data…data. Everywhere data is collected and analyzed, and different decisions are made based on the nature of the plot or pattern that the data collectively reflect. Sometimes we look at the sky and see the patterns of the stars and pick some stars to design our own image (monkey, tiger, etc.). We can apply a similar approach in Data Science. Data Mining is a study under Data Science. Here, we can ask a question: Which stars are contributing to drawing an image of a monkey for us? Similarly, in the Data Science area we may ask which data points are responsible for 20% more sale of Bear on Thursday(s) of a month. Once we know the Science behind it, we can develop a paradigm which includes theory, techniques, tools, Software/Hardware (algorithm/CPS). We can put all these in one box and say it as Data Engineering. Data Engineering should include AI and ML. Data Engineering, in a broader sense, focuses on practical applications of data collection and analysis using sophisticated algorithms including AI and ML. Data Engineering [18] answers to decision-making questions using large sets of valid data and information. Information is considered as the higher-level Data. Information is generated from raw Data. Then comes Knowledge. That is knowledge is generated from Information. Intelligence comes at the end. More Data means more Information. More Information, means more Knowledge. More Knowledge means more Intelligence. There must be Data Engineering within the AI and ML paradigm. First, the data are transformed to a useful format and then analyzed to generate Intelligence. In summary we can say that ML helps AI or in other words AI needs ML. In Ghent University, researchers have contributed significant results around Data Engineering for industry 4.0. As data is playing a pivotal role, they have (i) developed and applied deep machine learning techniques, including machine learning and semantics to include expert knowledge to obtain interpretable outputs, (ii) developed innovative data and hybrid drive modeling algorithms to increase the accuracy of machinery and factory models, (iii) discovered new knowledge to allow tuning of physical models, (iv) developed cross-context models to allow machine learning models to adapt to new contexts wherein machines and factories need to operate, and (iv) introduced virtual, augmented and mixed reality into the manufacturing industry inspired by the gaming industry.

12 Conclusion

This presentation responded to the needs as regards to modern technology systems keeping in view of dissecting AI classification principles for Industry 4.0 applications. It helps understand System-of-Systems (SoS) integration strategies. It is popularly believed that applications of AI are largely found only in engineering sciences such as robotics, aerospace technology, mechanisms, autonomous systems, and so on, however, in recent past its applications are widespread including weather forecasting, cloud computing, social media interactions, sale and purchase, sociology, human behavior analysis and prediction. All these applications are now connected to the Internet and such an infrastructure is considered as Industry 4.0 standard. Thus, CPS plays an important role in Industry 4.0. The author utilizes his expertise and experience to compile and consolidate the AI principles and Industry 4.0 terminology and presents a scenario while listing attributes for interdisciplinary System Integration (SI) and SoS. Research students currently pursuing data gathering, data mining and initial literature review in the course Research Methods will be immensely benefited. This study reveals an opportunity not only to maintain currency in Technology Education but also, help assist the small scale and novice developers in the community as it adheres scientific and technical information to fuel and strengthen further research and developments in the areas of AI and Industry 4.0.

Compliance with ethical standards

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