International Journal of Engineering & Technology, 7 (4) (2018) 3722-3725

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET
doi: 10.14419/ijet.v7i4.21244
Research paper

Big data, modeling, simulation, computational platform and holistic approaches for the fourth industrial revolution

Norma Alias [1] *, Waleed Mugahed Al-Rahmi [2], Noraffandy Yahaya [2], Qusay Al-Maatouk [3]

[1] Ibnu Sina Institute for Scientific and Industrial Research (ISI-SIR), Faculty of Science, University Technology Malaysia, 81310, UTM Skudai, Johor , Malaysia
[2] Faculty of Education, University Technology Malaysia, 81310, UTM Skudai, Johor, Malaysia
[3] Faculty of Engineering, Computing and Technology, Asia Pacific University of Technology & Innovation (APU), Technology Park Malaysia, Bukit Jalil-57000 Kuala Lumpur, Malaysia
**Corresponding author E-mail: norma@ibnusina.utm.my*

Abstract

Naturally, the mathematical process starts from proving the existence and uniqueness of the solution by the using the theorem, corollary, lemma, proposition, dealing with the simple and non-complex model. Proving the existence and uniqueness solution are guaranteed by gov-erning the infinite amount of solutions and limited to the implementation of a small-scale simulation on a single desktop CPU. Accuracy, consistency and stability were easily controlled by a small data scale. However, the fourth industrial can be described the mathematical pro-cess as the advent of cyber-physical systems involving entirely new capabilities for researcher and machines (Xing, 2017). In numerical perspective, the fourth industrial revolution (4iR) required the transition from a uncomplex model and small scale simulation to complex model and big data for visualizing the real-world application in digital dialectical and exciting opportunity. Thus, a big data analytics and its classification are a problem solving for these limitations. Some applications of 4iR will highlight the extension version in terms of models, derivative and discretization, dimension of space and time, behavior of initial and boundary conditions, grid generation, data extraction, nu-merical method and image processing with high resolution feature in numerical perspective. In statistics, a big data depends on data growth however, from numerical perspective, a few classification strategies will be investigated deals with the specific classifier tool. This paper will investigate the conceptual framework for a big data classification, governing the mathematical modeling, selecting the superior numeri-cal method, handling the large sparse simulation and investigating the parallel computing on high performance computing (HPC) platform. The conceptual framework will benefit to the big data provider, algorithm provider and system analyzer to classify and recommend the spe-cific strategy for generating, handling and analyzing the big data. All the perspectives take a holistic view of technology. Current research, the particular conceptual framework will be described in holistic terms. 4iR has ability to take a holistic approach to explain an important of big data, complex modeling, large sparse simulation and high performance computing platform. Numerical analysis and parallel performance evaluation are the indicators for performance investigation of the classification strategy. This research will benefit to obtain an accurate deci-sion, predictions and trending practice on how to obtain the approximation solution for science and engineering applications. As a conclu-sion, classification strategies for generating a fine granular mesh, identifying the root causes of failures and issues in real time solution. Fur-thermore, the big data-driven and data transfer evolution towards high speed of technology transfer to boost the economic and social devel-opment for the 4iR (Xing, 2017; Marwala et al., 2017).

Keywords: *Big Data; Computational Platform and Fourth Industrial Revolution*.

1. Introduction

The 4.0 Industrial Revolution urges us to think creatively about the manufacturing process, value chain, distribution and customer service processes. Universities emphasize their role in shaping future technology by being the test beds for innovation and educating future generations. Traditional education has contributed greatly to the current levels of industrial evolution and technological advancement. However, in order for higher education to deliver future generations with the right set of skills and knowledge; an imperative question has to be asked regarding how higher education institutes would be affected by the Industrial Revolution and how the delivery of education will be transformed. Data analysis and automation help companies not only to survive but also to thrive in the future. Similarly, Higher Education institutions are embracing data mining in order to gain better understanding of student performance and deliver “Education for you” that is tailored to meet the demand of the job markets while considering the students’ needs. Higher education in the fourth industrial revolution (HE 4.0) is a complex, dialectical and exciting opportunity which can potentially transform society for the better.

The fourth industrial revolution is powered by artificial intelligence and it will transform the workplace from tasks based characteristics to the human centered characteristics. Because of the convergence of man and machine, it will reduce the subject distance between humanities and social science as well as science and technology. This will necessarily require much more interdisciplinary teaching, research and innovation. Universities need to think strategically regarding methods to utilize their experience in credentials, trust and identity to offer new services. Furthermore, innovation and accepting change are now prerequisite for survival. Altering higher education is more necessary than ever before. However, the challenges ahead have to be considered in order to ensure effective and immediate transformation. With the reduced public financial support for higher education; universities need to think strategically regarding methods to utilize their experience in credentials, trust and identity to offer new services. Furthermore, higher education leadership needs to be less risk averse especially in this world of disruptive change. It is no longer an option to keep doing things the old way; innovation and accepting change are now prerequisite for survival. The research question is how higher education institutes would be affected by the Industrial Revolution and how the delivery of education will be transformed. Thus, the aim of this research is to explore the impact of HE 4.0 on the mission of universities which is teaching, research (including innovation).

2. Problem statement

Several other hindrances should also be dealt with properly: First, with its hybrid innovation strategy, higher education practitioners need to have a global perspective. The trend of world technology development should be well-perceived and thus appropriate plans need to be made. Each stream of innovation resources, internally, locally, regionally, and globally, should be utilized properly. Second, by having various development strategies and incentive policies across different departments, the connectivity among them should be optimized to avoid potential overlapping. Third, the speeds of technology transfer need to be raised to boost the economic and social development (Xing, 2017; Marwala et al., 2017).

3. Literature review

With the waves of above mentioned breakthroughs in various domains, gradually find ourselves in the midst of the fourth industrial revolution which is driven by artificial intelligence (AI) and cyber-physical systems (CPS) (Marwala, 2007). The fourth industrial revolution will revolutionize industries so substantially that much of the work that exists today will not exists in 50 years (Marwala et al., 2006). Within the realm of numerical simulation, finite element analysis (FEA) is a versatile technique which has been practiced in various engineering fields such as analysing buildings (Marwala et al., 2017; Marwala, 2012; Marwala, 2010). In the era of the 4th industrial revolution, higher education needs to deepen its technology system reforms by breaking down all barriers to innovation. One noteworthy obstacle is resource allocation for funding different research projects. For those technology innovations that are important for industrialization, re-industrialization, and neo-industrialization, but are unable to profit in the marketplace in the near-term, financial support from institution and government levels should be made available. However, for applied technologies where commercialization is possible, social capital can play an active role (Xing, 2017).

3.1 Defining and Delineating the Fourth Industrial Revolution

Industry 4.0 is the next phase in the digitization of the manufacturing sector, driven by four disruptions: the astonishing rise in data volumes, computational power, and connectivity, especially new low-power wide-area networks; the emergence of analytics and business-intelligence capabilities; new forms of human-machine interaction such as touch interfaces and augmented-reality systems; and improvements in transferring digital instructions to the physical world, such as advanced robotics and 3-D printing (Cornelius Baur, 2017). Since the World Economic Forum (WEF, 2017) reputed for its global agenda-setting capabilities introduced the term, the Fourth Industrial Revolution, in its 2016 summit in Davos, it has become a new buzzword capturing recent technological breakthroughs heralding social transformations in every corner of socioeconomic life. In the words of Klaus Schwab, key architect of the forum, the core of the Fourth Industrial Revolution lies in technologies blurring the boundaries of the physical, biological, and digital spheres, as best exemplified by artificial intelligence, virtual/augmented realities, the Internet of Things (IoT), autonomous vehicles, and drones (Schwab, 2016). The Fourth Industrial Revolution can be described as the advent of "cyber-physical systems" involving entirely new capabilities for people and machines. While these capabilities are reliant on the technologies and infrastructure of the Third Industrial Revolution, the Fourth Industrial Revolution represents entirely new ways in which technology becomes embedded within societies and even our human bodies. See Figure 1.

Navigating the next industrial revolution

Revolution	Year	Information
1	1784	Steam, water, mechanical production equipment
2	1870	Division of labour, electricity, mass production
3	1969	Electronics, IT, automated production
4	?	Cyber-physical systems

Fig. 1: Navigating of Industrial Revolution.

4. High performance computing (HPC)

High Performance Computing (HPC) serves as the main platform to support the visualization and animation, HPC of the communication model for solving the interdisciplinary problems above will be analysed using a flow of the algorithm, numerical analysis and the comparison of parallel performance evaluations (Norma et al., 2017). Furthermore, HPC is turning out to be a major source of hope for future applications development that require greater amounts of computing resources in various modern Science domains such as bioengineering, nanotechnology, the 4th industrial revolution and energy where HPC capabilities are mandatory in order to run simulations and perform visualization tasks (Smari et al., 2016). Several numerical methods offer a straightforward implementation of converting the mathematical model into a set of grid points. FDM, FEM and direct methods work as tools to discretize the mathematical modeling and to generate large sparse linear systems. Numerical simulations of explicit, implicit and Crank-Nicolson schemes fit well in solving the large sparse matrix of linear systems. Finer scale modeling, decomposition techniques, aggregation and mapping processes are able to obtain the parallel simulation of the large-scale modeling. Thus, a wide-range power simulation tools are required for handling a very large sparse matrices, huge memory allocation and high-speed processors of HPC systems (Norma et al., 2017). Therefore, conceptualizing sustainable the fourth industrial revolution within the TBL framework can be utilized to help solve problems that have many variables and which call for detailed analysis. A Multi Criteria Decision Analysis (MCDA) model is one method of systematic top-down decision making appropriate for risk-based fields (Linkov et al., 2014). There has been substantial discussion of the convergence of big data analytics, simulations and HPC (Reed and Dongarra, 2015; Baru and Rabl, 2014). In several papers (Zhang et al., 2014) looked at the model in big data problems and studied the model performance on both cloud and HPC systems. In (Zhang et al., 2014), look at performance in great detail showing excellent data analytics speed up on an Infiniband connected HPC cluster using MPI. Deep Learning (Coates et al., 2013) has clearly shown importance of HPC and uses many ideas originally developed for simulations. High Performance Computing enhanced Apache Big Data Stack as many critical core components of the commodity stack (such as Spark and Hbase) come from open source projects while HPC is needed to bring performance and other parallel computing capabilities (Fox et al., 2015). According to Alias et al.

(2009a), New Iterative Alternating Group Explicit (NAGE) was introduced which is a powerful parallel numerical algorithm for multidimensional temperature prediction. The discretization was based on finite difference method of Partial Differential Equation (PDE) with parabolic type. The critical 3-Dimensional temperature visualization involves large scale of computational complexity. This computational challenge inspired the authors to utilize the power of advanced high performance computing resources. Incomplete blow-up is a condition under the quasilinear heat equation (Alias et al., 2010). The Porous Medium Equation (PME) with power source are admitting incomplete blow-up. It is used as one of the filtration process in the industry. Authors proposed a new variance of the Alternating Group Explicit Scheme (AGE) algorithms to solve incomplete blow-up problem through High Performance Computing (HPC). Simulation results and information of drying kinetics of fruit material such as time temperature-moisture content distributions, as well as theoretical approaches to moisture movement, is very essential for the prevention of quality degradation and for the achievement of fast and effective drying. Such information will be very useful to optimize production processes of tropical fruits dried. Hence, the authors' contribution of the study (Alias et al., 2009b) is successful modified the mathematical simulation in representing the actual process of dehydration in commercial foodstuff industry in terms of heat and mass transfer inside tropical fruits material.

5. Numerical perspective for the fourth industrial revolution

There is a new industrial revolution in the making, the automated industrial revolution. Computer numerical control (CNC) is the engine that is driving robotic technology, taking manufacturing operations to new heights of efficiency. Torchmate has adopted the model that Apple Computer used so successfully when they provided computers to elementary schools in the 1980s. Torchmate puts their machines into high schools and community colleges that have industrial or machine shop programs, and into technical institutes that have a similar focus. Torchmate machines are very affordable by industry standards, from around $3000 for a small 2-axis machine to around $20,000 for a larger multi-axis unit. Torchmate provides free unlimited technical support for these machines, and is rolling out a program in the fall of 2013 to provide free curriculum and unlimited CAD/CAM licensing to all teachers and students using the machines. This will enable the students to use the programs on their laptops for homework projects. The basis for optimal material and resource efficiency is already laid in the early phase of development: A single, fully digitalised and integrated software system is responsible for all processes, from concept and design right up to the numerical control of the CPPS. According to Milgram and Colquhoun (1999), when some virtual elements are imported into a real world environment, we have augmented reality (AR), which is basically reality augmented by virtual elements. For example, some of the transparent interfaces of Head Mounted Display can support the training and even implementation of complex maintenance tasks. Vice versa, when some real world elements are imported into a virtual environment, we have augmented virtuality (AV). An application example of AV is a virtual production line connected with a real CNC (Computerized Numerical Control) platform in order to train the steering and management of the CNC control platform (Blumel, Jenewein & Schenk 2010).

5.1. Software systems, languages, and libraries

Most applications are computationally intensive. Scientists have traditionally attempted to parallelize their algorithms across HPC infrastructures. However, this task requires significant work and effort for learning parallel programming. Developing parallel libraries and high-level and easy to use languages are required to hide parallelization complexity of programs. Coullon et al. (2016), in their paper Implicit parallelism on 2D meshes using SkelGIS, tackle the issue of overcoming restrictions in parallelization of scientific simulations because of the complexity of functional concepts and specific features. Parallelization of scientific simulations requires a lot of efforts and field-specific knowledge to produce efficient parallel programs. For this reason, the authors introduce SkelGIS as a solution for abstracted and implicit parallelism. They apply SkelGIS to solve heat equations and shallow-water equations and compare both the SkelGIS performance and the SkelGIS programming effort with Message Passing Interface (MPI) solutions counterparts. Another important issue that can influence HPC systems performance is vectorisation. Many scientific codes have vectorisation potential that cannot be exploited due to an algorithm-driven choice of data layouts. In their article Data Layout Inference for Code Vectorisation, Sinkarovs and Scholz (2016) propose an interesting approach for automatically generating efficient code for vectorisation by mainly focusing on the evaluation of a family of data layout transformations. The authors demonstrate the effectiveness of their approach by applying it on an N-body simulation.

5.2. Analysis with discussion

The fourth industrial revolution helps companies not only to survive but also to thrive in the future. Similarly, Higher Education institutions are embracing data mining in order to gain better understanding of student performance and deliver "Education for you" that is tailored to meet the demand of the job markets while considering the students' needs. Today we see many government as well as private initiatives to promote a data-based industrial revolution in the world. In the "Industry 4.0" initiative in Malaysia, the government, industry and academic institutes are all collaborating with each other in promoting a strategy to achieve a more knowledge-intensive manufacturing industry by using IoT (Internet of Things) — a system of mutual control among the various product items through exchange of information among themselves being connected to the Internet. In the United States, the "Industrial Internet" initiative proposed by General Electric is now in progress that is an attempt to analyze Big Data collected through IoT for future product development and business activity. The key to achieving the success of both initiatives is "Data". Therefore we call such initiatives a "Data-based Industrial Revolution" and the perception is steadily prevailing today that a Data-based Industrial Revolution will follow the Information and Communication Technology (ICT) Revolution. The significantly rapid progress of AI today symbolizes this development, as seen in the victories of AI equipped with data over human champions in Go or Shogi chess matches. Go play software called "Alpha Go" created by AI venture DeepMind kept winning over the human European champions for five matches in a row from 2013 until 2015 and even beat one of the best players in the world. In addition, in the arena of financial investment, the development of another use of AI is making progress. They are now working on raising the capacity to predict stock prices in a few minutes by AI equipped with Big Data on prices and transactions. If this attempt is combined with another technological development such as "super high-speed transaction" achieving thousands of transactions per second, a program installed in a computer in advance, we will see a drastic change of financial investment. Since we are now living in an age when IoT and its related-product markets are rapidly expanding, all kinds of data are being valued as new assets all over the world. AI, Big Data analysis, 3D printers, robots, and all such contemporary high technology products are based upon data sets. Their active application in a wide range of business and life purposes would mean "data" rule the world, and this is what we call the Data-based Industrial Revolution. The first stage of the fourth industrial revolution was competition relating to online data. The second stage will be competition relating to real-world data, such as in manufacturing workplaces, where Malaysia particular strengths lie.

6. Conclusions

Though the business of higher education remains unchanged since the times of Aristotle, today students still assemble at a scheduled time and venue to listen to the wisdom of scholars. Given the fourth industrial revolution, a new form of a university is emerging that does teaching, research and service in a different manner. This university is interdisciplinary, has virtual classrooms and laboratories, virtual libraries and virtual teachers. It does, however, not degrade educational experience but augment it. Therefore, we recommend to more studies related with big data, modeling, simulation, computational platform and holistic approaches for the fourth industrial revolution (4iR) .

Acknowledgements

We would like to thank the Research Management Centre (RMC) at Universiti Teknologi Malaysia (UTM) for funding this project under grant number PY/2018/02903: Q.J130000.21A2.04E40.

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