Data Driven Computing and Intelligent Systems: Applications and Advances

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Data driven computing and intelligent systems are the order of the day. Data-Driven Computing uses the given data to directly produce predictive outcomes. According to data-driven computing, calculations are carried out directly from experimental material data and related constraints and laws of conservation, such as equilibrium and compatibility, thus bypassing the empirical material modelling step of conventional computing completely. Data-driven solvers seek to assign to each material point the state from a pre-specified data set that is nearest to satisfying the laws of conservation. Intelligent systems are technologically advanced machines that perceive and respond to the world around them. They can take many forms, from automated vacuums such as the Roomba to facial recognition programs to Amazon's personalised shopping suggestions. The field of intelligent systems also focuses on how these intelligent systems interact with end users in the dynamic social and physical environments. Early robots possessed a little autonomy in making decisions. They assumed a predictable world and performed the same actions repeatedly under the similar conditions. Today, a robot is considered to be an autonomous system that can sense the environment and can act in a physical world in order to achieve a set of goals. Data driven computing and intelligent systems both help the mankind in various applications such as good governance, smart cities etc. This study highlights the nature, scope, applications and advances in the data driven computing and intelligent systems.

Keywords: Data, system, computing, intelligent, applications

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1 Introduction

Data-Driven Computing is a new field of computational analysis that uses the given data to directly produce predictive outcomes. Data-driven essentially means that data dictates the actions taken by the ones that execute an event or process. Algorithms with high computing power and which can store sufficient data are used in many cases especially in Data Science and Machine Learning. With people having access to various digital gadgets, tools and access to various means of data procurement, concentration and generation of large amounts of data are some of the main reasons for the rise in big data, cloud technologies, and Internet of Things. Data-Driven Computing helps the initial progress and supports the advancement in some of the many possible improvements and applications that might best advance the field.

Intelligent systems are technologically advanced machines that perceive and respond to the world around them. Intelligent systems can take many forms, from automated vacuums such as the Roomba to facial recognition programs to Amazon's personalized shopping suggestions. There are two main areas within intelligent systems: how those machines perceive their environment and they interact with the environment. One way such systems can perceive their environment is through vision. The study of how computers can understand and interpret visual information from static images and video sequences emerged in the late 1950s and early 1960s. It has since grown into a powerful technology that is central to a nation's commercial, industrial and government sectors. The key factors that have contributed to this growth are the exponential growth of memory capacity and processor speed as well as algorithmic advances.

The field of intelligent systems also focuses on how these systems interact with end users in changing physical and social environments. Early robots possessed a little autonomy in making decisions. They assumed a predictable world and performed the same actions repeatedly under the similar conditions. Today, a robot is considered to be an autonomous system that can sense the environment and can act in a physical world in order to achieve the set goals.

1.1 Objectives of the study

The objectives of this study include the following:

- To understand the definition, nature and scope data driven computing and intelligent systems.
- To identify the applications and advances in data driven computing and intelligent systems.
- To find the out the challenges confronted by the research in intelligent systems.

1.2 Research Methodology

The methodology adopted in this study is secondary in nature. Sources of secondary data include text books, journals, online and offline, columns in newspapers and magazines, websites of various educational institutions and corporations etc.

2 Review of Literature

Many studies have been conducted in the areas related to data driven computing and intelligent systems. Some of these studies can be mentioned as follows. The trend of data exchange and automation in manufacturing is facilitated by emerging technological advancements including cloud computing, the Internet of Things (IoT) and cyber-physical systems. This trend is often cited as “smart manufacturing”, “Industry 4.0”, and “digital factory” [Huh, J.H. 2018].[1] González, I. et al. [2019][2] stated that the large volumes of data generated by sophisticated machines and sensors and manufacturing automation have been described in various reviews of data management systems and industrial communication. Jimenez-Cortadi, A. et al. [2020][4]mentioned that predictive maintenance in particular is gaining a vital role in business performance growth and cost reduction. According to

Do, P. et al. [2015],[5] predictive maintenance avails of varieties of data sources for prognosis, diagnosis and proactive decision making.

Ruschel, E et al. [2017][6]stated that the need for supporting data-driven decision-making in Industry 4.0 has leveraged the development of new algorithms and methods aiming for supporting engineers in making appropriate decisions about operational actions and maintenance. For our best understanding, this is the first review of literature about data-driven computing and intelligent systems. According to Bousdekis, A et al. [2019],[8] the methods used for predictive maintenance are classified into three categories, namely, data driven, knowledge based and model-based methods. According to Han, Y. et al. [2003],[9] condition monitoring is the process of monitoring the condition in order to identify a significant change that is indicative of a developing fault. According to Márquez, F.P.G. et al. [2012],[10] condition monitoring is a major component of predictive maintenance.
The uncertainty existing in prognostic algorithms as well as the stochastic nature of the degradation process alsoleads to high uncertainty in the decision-making process. Due to this reason, many papers have tackled these issues. Hong et al. [2014][11]studied the impact of stochastic degradation on optimal maintenance decisions. Tang et al. [2015][12] proposed a method for an optimal maintenance policy on the basis of residual life estimation for a slowly degrading system, subject to condition monitoring and soft failure. The optimization problem is formulated and executed in a semi-Markov decision process framework in order to minimize the long-run expected average cost. A similar method is proposed for tackling the presence of competing risks (soft and hard failure) in a degrading system [Tang, D. et al. 2015][12].
On the basis of estimation of remaining useful life (RUL), Xu et al. [2015][14] proposed a method for optimized replacement decisions. Wan et al. [2015][15] proposed a collaborative maintenance planning system that manages knowledge and information to support decision-making in planning the maintenance process. Chen et al. [2016][16] proposes a fuzzy logic system that allows operators to optimize real-time operation and maintenance scheduling. Yildirim et al. [2016][17] presents a maintenance framework that integrates optimal maintenance scheduling models with the sensor-driven predictive maintenance technologies.

3 Analysis and Discussion

3.1 Applications of Data Driven Computing

The digital world has a wealth of data, such as business data,internet of things (IoT) data, health data, urban data, mobile data, security data, and so on, in the current age of the Fourth Industrial Revolution (Industry 4.0). Extracting knowledge or useful insights from these data can be used for smart decision-making in various application domains. In the area of data science, advanced analytics methods including machine learning modelling can provide actionable insights or deeper knowledge about data which makes the computing process automatic and smart.

3.2 Applications of Intelligent Systems

Intelligent systems can be applied in varied fields. They are playing a larger number of roles in today's world. They can be summarized as follows. Education, Character recognition, Factory automation, Visual surveillance, Intelligent transportation, Field and service robotics, Human identification using various biometric modalities, Assistive robotics, Visual inspection, Medical care, Entertainment and Military applications.

3.3 Advances in Data Driven Computing

A comprehensive view on "Data Science" includes various types of advanced analytics methods that can be applied to enhance the capabilities and intelligence of an application through smart decision-making in different scenarios. Ten potential real-world application domains can be discussed and summarized. They include healthcare, business, urban and rural data science, cybersecurity, and so on by taking into account data-driven smart computing and decision making.

3.4 Advances in Intelligent Systems

Intelligent Systems must typically operate in a scenario in which non-linearityis the rule and not as a disturbing effect to be corrected. Several algorithms are currently the ordinary tools of Intelligent Systems. Finally, Intelligent Systems also have to incorporate advanced sensory technology in order to simplify man-machine interface. The advances in intelligent systems include intelligent techniques in power electronics, NNS for signal processing and image processing, applications in medicine and surgery, applications of intelligent systems in modelling and prediction of environmental changes, hardware implementation and learning of NNS, transportation intelligent systems and cellular neural networks for nonlinear filtering.

3.5 Challenges in Intelligent Systems

Research in intelligent systems confronts many challenges, many of which relate to representing an ever changing physical world computationally.

Time-consuming computation: Searching for the optimal path to a goal requires extensive search through a very large space, which is expensive computationally. The drawback of spending too much time on computation is that the world may change in the meantime, thus rendering the computed plan outdated.

Uncertainty: Physical effectors / sensors provide noisy, limited and inaccurate action / information. Therefore, any actions the system takes may be incorrect both due to the limitations in executing those actions and due to noise in the sensors.

Dynamic world: The physical world changes constantly, requiring that decisions to be made at a faster rate to accommodate for the changes in the environment.

Mapping: A lot of information is lost in the transformation from the 3D world to the 2D world. Computer vision must deal with challenges including changes in perspective, background clutter or motion, lighting and scale and grouping items with intra/inter-class variation.

4 Conclusion and Implications

On the whole, it can be concluded that there are a lots of applications and advances happening in data driven computing and intelligent systems. The main applications of the intelligent systems include in the areas of Education, Character recognition, Factory automation, Visual surveillance, Intelligent transportation, Field and service robotics, Human identification. These applications and advances are availed by various stakeholders. The advances in data driven computing and intelligent systems are possible in many fields such creating, designing, producing, serving, governance, software engineering and development, advancement in hardware and so on. The main real-world application domains include business, healthcare, cyber security, urban and rural data science and so on by taking into account data-driven smart computing and decision making.

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