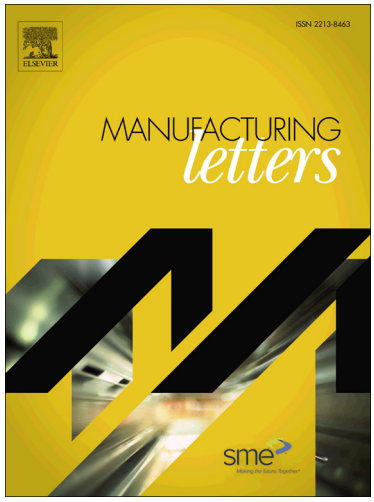

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Industrial Artificial Intelligence for Industry 4.0-based Manufacturing Systems

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Abstract:

The recent White House report on Artificial Intelligence (AI) [1] highlights the significance of AI and the necessity of a clear roadmap and strategic investment in this area. As AI emerges from science fiction to become the frontier of world-changing technologies, there is an urgent need for systematic development and implementation of AI to see its real impact in the next generation of industrial systems, namely Industry 4.0. Within the 5C architecture previously proposed in [2], this paper provides an insight into the current state of AI technologies and the eco-system required to harness the power of AI in industrial applications.

Keywords: Industrial AI; Industry 4.0; Big Data; Smart Manufacturing; Cyber Physical Systems

1. Introduction to Industrial Artificial Intelligence

Artificial Intelligence (AI) is a cognitive science with rich research activities in the areas of image processing, natural language processing, robotics, machine learning etc. Historically, Machine Learning and AI have been perceived as black-art techniques and there is often a lack of compelling evidence to convince industry that these techniques will work repeatedly and consistently with a return on investment. At the same time, the performance of machine learning algorithms is highly dependent on a developer's experience and preferences. Hence, the success of AI in industrial applications has been limited. On the contrary, Industrial AI is a systematic discipline, which focuses on developing, validating and deploying various machine learning algorithms for industrial applications with sustainable performance [3]. It acts as a systematic methodology and discipline to provide solutions for industrial applications and function as a bridge connecting academic research outcomes in AI to industry practitioners.

Present day industries are facing new challenges in terms of market demand and competition. They are in need of a radical change known as Industry 4.0. Integration of AI with recent emerging technologies such as Industrial Internet of Things (IIoT) [4], big data analytics [5-7], cloud computing [8-10] and cyber physical systems [2,11-12] will enable operation of industries in a flexible, efficient, and green way. Since Industrial AI is in infancy stage, it is essential to clearly define its structure, methodologies and challenges as a framework for its implementation in industry. To this end, we designed an Industrial AI ecosystem, which covers the essential elements in this space and provides a guideline for better understanding and implementing it. Furthermore, the enabling technologies that an Industrial AI system can be built upon are described. Figure 1-a provides a schematic comparison of the desired system performance of Industrial AI with other learning systems over time.

2. Key Elements in Industrial AI: ABCDE

The key elements in industrial AI can be characterized by 'ABCDE'. These key elements include Analytics technology (A), Big data technology (B), Cloud or Cyber technology (C), Domain knowhow (D) and Evidence (E). Analytics is the core of AI, which can only bring value if other elements are present. Big data technology and Cloud are both essential elements, which provide the source of the information (data) and a platform for Industrial AI. While these elements are essential, domain knowledge and Evidence are also important factors that are mostly overlooked in this context. Domain knowhow is the key element from the following aspects: 1) understanding the problem and focus the power of Industrial AI into solving it; 2) understanding the system so that right data with the right quality can be collected; 3) understanding the physical meanings of the parameters and how they are associated with the physical characteristics of a system or process; and 4) understanding how these parameters vary from machine to