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Benefits and Challenges Associated with Big Data Analytics for Manufacturing of Internet of Things

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Abstract

Big data analytics plays a pivotal role in optimizing manufacturing processes within the Internet of Things (IoT) ecosystem. By leveraging extensive datasets generated from IoT devices, manufacturers can gain critical insights into system performance, streamline production workflows, and enhance predictive maintenance efforts. These advancements lead to reduced operational costs and increased productivity. However, the integration of big data analytics also brings challenges such as data management complexity, high implementation costs, and ensuring data accuracy and security. This abstract reviews the dual facets of utilizing big data analytics in IoT manufacturing, emphasizing both the significant advantages and the hurdles that must be addressed to achieve effective implementation.

Keywords: *Big data analytics, Internet of things (IoT), Manufacturing optimization, Predictive maintenance, Data security challenges*

1. Introduction

The current technological advancements have led to enhanced efficacy and effectiveness where several industries and businesses require being smarter (Azrour *et al.*, 2021). Big data has enabled various things to be used and applied to empower the collection and exchange of information from entire new networks involving the internet of things (IoT). It consists of a network of many objects that gather the necessary data in the cloud and transmit the data, enabling its users to ensure that they meet their projects and tasks. The Internet of things and big data have gone through several advancements (Babu and Swathi, 2018). Despite these developments, they still seem to be encountering some challenges, as this paper will discuss.

2. Enhanced Maintenance of Equipment

The combination of the internet of things and big data analytics helps companies, particularly in the manufacturing sector, determine when their equipment needs to be maintained by measuring heat, vibrations,

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and other vital figures. Sensor information is typically used to predict when the assets require maintenance, ensuring an optimal maintenance schedule. Also, innovative equipment can typically transmit messages to the maintenance team and operators about any potential wear, delivery schedules, and breakdowns, which facilitates this equipment's predictive maintenance and regular maintenance. Thus big data analytics plays a vital role in reducing and saving costs associated with equipment maintenance through predictive maintenance (Babu and Swathi, 2018).

Furthermore, the internet of things ensures that employees can see the performance of their machines in real-time and sends alerts to the necessary maintenance team in case of any issue that arises. The ability to prevent unplanned downtimes ensures that the organization is provided with significant benefits in terms of productivity. For instance, predictive maintenance can minimize maintenance costs by about 12%, reduce safety, environment, health, and quality, and improve uptime times by about 9 percent (Babu and Swathi, 2018).

3. Predicting Future Trends

The combination of big data analytics and the internet of things can predict future trends, especially in tracking energy consumption, to create more reliable estimates for future demands (Amandeep and Ananthan, 2019). Big data analytics usually involves attaching various sensors to different components of machines which enables multiple companies to track their productivities such as speed and temperature. This makes it easy to identify any machine component that requires to be replaced and makes it easy to inform the maintenance team of the necessary replacement in advance, which is significant in the businesses involved with manufacturing for 24 hours and lacks margins for machine failures (Li *et al.*, 2017).

4. Process Control and Optimizations

Data collected from various sensors play an essential role in the non-trivial components impacting the performance and process optimizations. This can be effectively used in multiple ways, such as in the management of traffic. It involves tracing various times and dates to operationalize specific traffic optimizations, such as advising on initiating new policies such as constructing feeder roads and installing traffic lights to reduce traffic congestion. Second, big data analytics and the internet of things is usually beneficial in the retail sector where the information acquired from big data analytics can be used in informing managers and store employees when there is depletion of a specific stock and thus enabling the organization to refill its shelves on time which helps the companies in avoiding unnecessary running out of products (Li *et al.*, 2017).

The combination of big data analytics and internet manufacturing enables organizations to control their processes automatically. For instance, it ensures that various manufacturers can comprehensively view how productions processes are going on, which ensures that the companies can maintain the continuous flow of their products, avoid defects, and enhance identification of bottlenecks in a real-time manner as well as minimize human errors. For example, General Motors can monitor humidity using IoT sensors to optimize its painting activities. This usually involves sending details to another section with more favorable levels of painting humidity whenever conditions for painting turn unfavorable, which minimizes the need for painting and downtimes (Li *et al.*, 2017).

5. Real-Time Monitoring

The manufacturing internet comprises various manufacturing assets such as actuators, intelligent meters, radio-frequency identification (RFID) tags, sensors, and controllers usually linked with computing platforms using wireless or wired communication connections (Azrour *et al.*, 2021). This has led to an increased volume of data produced from the manufacturing internet of things (MIoT), which has led to various benefits such as enhanced real-time monitoring, enhanced supply, and customer experiences. Real-time tracking is significant in multiple sectors, such as health organizations that use this strategy to evaluate patients' heart rates, sugar levels, and blood pressure. Further, real-time monitoring is vital in the manufacturing sector, especially in controlling different machines within the company (Amandeep and Ananthan, 2019).

6. Improving Supply Chain and Customer Experience

Enormous data are usually generated from entire manufacturing chains, raw material supply, product distributions, customer support, and logistics (Bi *et al.*, 2021). Companies can obtain customer information from different sources such as social media sites, retailers, sales channels, and partner distributions. This is followed by big data analytics, which provides descriptive, prescriptive, and predictive analysis that offers solutions that enable various companies to improve product deliveries, designs, after-sale supports, and qualities of different products. Thus this leads to improved customer experiences. The internet of things in the entire food supply chain is significant as it prevents mischievous activities and guarantees food security and safety (Elijah *et al.*, 2018).

Additionally, the developments of RFID, various sensors, and tags during the production, transportation, and supply of products lead to the generation of vast volumes of data that may be utilized to analyze supply risks, predict timely deliveries, and plan optimal logistics routes. Furthermore, analyses of inventory databases can lead to enhanced production by reducing holding costs and fulfilling the demand dynamics through the establishment of safe levels of stock. Also, big data analytics plays a significant role in making accurate logistics schedules and plans, which plays a vital role in enhancing the companies' efficiencies (Li *et al.*, 2017).

7. Challenges in Data Storage and Data Processing

7.1. Data Integration

Data produced in the MIoT is associated with several heterogeneous features and types that call for the necessity of integrating these various forms of data to become efficient for data analytics procedures implementation. However, it is usually challenging for the data of different forms of manufacturing the internet of things to be integrated (Bi *et al.*, 2021).

7.2. Data Compression and Data Cleaning

Manufacturing internet of things data is ordinarily noisy and enormous, and this usually arises from the errors associated with defective equipment and sensors. The massive volumes of the data lead to the processes of cleaning the data to be a challenging process, which means that there should be effective strategies aimed at compressing and cleaning the errors associated with the MIoT data (Vögler *et al.*, 2016).

7.3. Redundancy Reduction

The raw data usually gathered from manufacturing the internet of things is associated with spatial and temporal redundancies that mostly lead to inconsistent data, affecting subsequent data analyses. The procedures of mitigating data redundancies are always a challenge (Kumar and Kirthika, 2017).

7.4. Data Representation Difficulties

Manufacturing internet of things data is associated with different dimensions and heterogeneous structures. For instance, data categorization can be categorized into various categories, such as unstructured and semi-structured and structured data. This leads to a great challenge, especially when presenting these kinds of data, particularly in the data analytics for the manufacturing internet of things (Vögler *et al.*, 2016).

7.5. Data Transmission Efficiency

The transmission of these vast volumes of data to various storage infrastructures is usually challenging because of the high bandwidth consumption because transmitting these large volumes of big data usually bottlenecks most wireless communication networks. Also, data transmission of extensive data databases is associated with constraints associated with energy efficiencies in most wireless systems like the industrial wireless sensor network (Kumar and Kirthika, 2017).

7.6. Security and Privacy

It is usually a challenge to maintain the necessary data privacy and security in data analytics processes (Vögler *et al.*, 2016). Despite several schemes traditionally meant to ensure data privacy in data analytics, these schemes may not be helpful in the manufacturing internet of things associated with Spatio-temporal correlations, heterogeneous structures, and vast volumes of data. Thus, the new privacy in the preservation of data mining approaches should be used to address the issues associated with data security and privacy (Kumar and Kirthika, 2017).

7.7. Effective and Efficient Data Mining Strategies

Big data analytics is associated with vast volumes of data which leads to challenges, especially when designing a practical scheme for the data mining process. This results typically because of the lack of feasibility in applying conventional and multi-pass data mining strategies because of the large volumes of data. Also, it is usually crucial for the uncertainties and data errors to be mitigated because of the erroneous characteristics associated with the manufacturing of the internet of things data (Elijah *et al.*, 2018).

8. Conclusion

In conclusion, the internet of things leads to the generation of massive volumes of data. It is usually used in analytics, process optimizations, real-time monitoring, and predictive maintenance, among other vital processes in many industries. Despite these benefits, there are potential challenges usually associated with big data analytics and manufacturing the internet of things. Still, the advancements of the internet of things are vital in assisting and strengthening many sectors as it enhances digital opportunities.

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