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Application of Big Data Analytics in Manufacturing Sector - A Review

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Abstract : *The period of the fourth industrial revolution, called Industry 4.0, is characterized by new, innovative technologies such as: Cloud Computing; the Internet of Things; the Industrial Internet of Things; Companies that are able to analyze the current state of their processes, forecast its most optimal progress and proactively control them based on reliable predictions will be a decisive step ahead competitors. In terms of Industry 4.0, data analytics focus on "what will happen" rather than "what has happened". These problems are entitled as predictive analytics and aims at building models for forecasting future possibilities or unknown events. The aim of this paper is to give detailed insight about these techniques, provide applications from the literature and present how big data analytics can change the dynamics of manufacturing sector across various functions*

Keywords – *Big Data, Data Analytics, Industry 4.0, Artificial Intelligence, Machine learning, Manufacturing sector*

I.   INTRODUCTION

Big data collected in the manufacturing industry has been around for a couple of decades. Its potential to contribute to the efficiency of processes and equipment has been the subject of debate. Computer scientists have been developing new techniques and tools that enable the analysis of massive amounts of data. This is often done in order to improve the efficiency of manufacturing processes.

Data-driven solutions have been successfully used in many studies. However, their reliability and performance are often affected by the large volume of training data that they require. Numerous approaches and tools are already available to address these challenges, but the manufacturing industry's willingness to use them is still not clear.

Recently, the problem of the management and use of large and complex statistics has brought about the development of the emerging massive-statistics paradigm. The term large statistics denotes information whose effective control and use aren't feasible with conventional strategies, due to their size and/or different traits, such as a loss of shape, variability, pace, distributivity, range, incompleteness, un-credibility, un-verifiability, etc. (Babiceanu and Seker 2016; Boyd and Crawford 2012; Esmaeilian, Behdad, and Wang 2016; Gartner 2016; Hitzler and Janowicz 2013; Hurwitz et al. 2013; Laney 2001; Villars and Olofson 2011; Wang, Törngren, and Onori 2015).

Big-records analytics may be perceived as a extensive framework for extracting the price from such massive and complicated statistics. It gives tactics, methods, techniques and gear that together shape green statistics-analytics structures. To correctly practice huge-facts analytics in manufacturing systems, abilties and expertise of information and verbal exchange technology, and specially information science, as well as the engineering know-how of manufacturing structures, and expert information of manufacturing processes, need to be included.

However, the software of huge-statistics analytics in the production area lags at the back of in terms of penetration and variety in comparison with other domain names, consisting of advertising and marketing, healthcare, and commercial enterprise (Babiceanu and Seker 2016). In our view, the motive for this situation is in particu

This paper proposes a brand new conceptual framework for introducing massive-facts analytics into production systems. The objective is to clarify the relation between the massive-information paradigm and the

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manufacturing systems, and to nearly and systematically display a way to increase and enforce information-analytics answers in manufacturing systems.

II.   LITERATURE REVIEW

2.1 Big Data Analytics for Machine failure diagnostic and maintenance

Besides its use in production procedure for high-quality and surroundings troubles, BDA is likewise being incorporated in some other essential challenge going through the manufacturing method particularly, proactive diagnosis and renovation of device. One of the early regarded enterprise programs of PD&M is the Condition-primarily based Maintenance (CBM) (Krumeich, et al., 2016), which integrates gift method states and events to estimate whilst device calls for upkeep to limit unplanned shutdown based totally at the utilization, age, and overall performance of the device (Chiang, et al., 2017).

According to Krumeich, et al. (2016), massive information acquisition and sensor era allow to locate and cluster device defects in an effort to easily identify, diagnose and clear up system troubles before a failure sincerely occurs. Other elements of PD&M had been broadly discussed inside the literature. For instance, Beneventi, et al. (2017) and Zhang, et al. (2017) discussed the Online/ Real Time Predictive Maintenance recognizable by means of the mixing of equipment conduct styles by means of finding thresholds and family members between parameters that can be used to suggest potential problems taking place (i.E., diagnostics) and protection requirement. Finally, BDA is also carried out for faraway or tele-maintenance of gadget alongside some other protection-associated functions consisting of management of spares inventories.

2.2 Big Data Analytics for Quality Control Procedures

In the near destiny, agencies that are able to reveal their operations via the short-paced growing amount of records to forecast their first-class fault and proactively manage their strategies by using advanced analytics will be earlier of their competition (Krumeich, et al., 2016). In doing so, He & Wang (2018) pointed out a brand new generation of Statistical Process Control (SPC) managing complicated and multivariable with which MSPM techniques may also fail or lead to deceptive effects (multimodal distribution, dynamics, nonlinear relationships between variables, non-Gaussianity, time-various traits, other traits which includes outliers, gross mistakes and/or failed sensors). This new technology of SPC implies using increasingly Model Predictive Control (MPC) (Isaksson, et al., 2018; Krumeich, et al., 2016; Zhuchkov, 2015; Chongwatpol, 2015; Li & Kashiwagi, 2005) thru the combination of advanced BDA techniques along with Control Chart Pattern Recognition (CCPR), Regression-Based Methods, Neural Networks, Support Vector Methods (Weese, et al., 2016; Lee, et al., 2017; Tewari & Dwivedi, 2019).

Another component of QP&C is Alarm management cited through Hu, et al. (2018) which relay on a set of BDA techniques together with Run Length Distribution & Delay Timer Analysis (RLD&DTA), Chattering Index (CI), Oscillating Alarm Analysis (OAA), Alarm Flood Analysis (AFA), Causality Inference for Alarms (CIA)) and Mode-Dependent Alarm Analysis (MDAA). The intention is to expect the occurrence of ordinary conditions and then save you their propagation along the interconnected pathways to cause substantial and catastrophic disruptions within the process. In some other facet, and either while little is thought approximately the system or data is unavailable as to what paperwork an out of-manage occasion, device getting to know strategies which includes Big Data Approximating Control (BDAC), PCA/PLS, k-approach clustering, Self-organizing map (SOM) and manifold gaining knowledge of strategies are used (Ge, et al., 2017; Weese, et al., 2016; Stanley, 2018). This is to identify correlations and causal members of the family among technique variables to seize material and facts waft paths within the manner (Hu, et al., 2018; Lee, et al., 2018).

2.3 Big Data Analytics for Manufacturing Supply Chain

The records processing measurement should nurture transparency in the deliver chain by way of selling the duty of all companions. This supports who emphasize the essence of BDA promoting collaboration and cooperation in an effort to collect treasured records for choice making. BDA is also characterised as having high-level reporting abilties at close to actual time for well timed selection making. The BDA reviews should en- 237 braveness engagement among the stakeholders via collaboration and cooperation, as additionally argued . BDA reviews ought to consist of the social desires of the groups and stakeholders in particular on emissions and potential building. Another element of BDA was Effective security may be executed whilst BDA has tricky technical software technologies that guide superior functions, which includes fraud analytics for brief detection of unwanted activities. BDA need to perform advanced analytics, which includes descriptive, predictive and

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prescriptive analytics on both established and unstructured records sets. BDA ought to additionally permit for integration throughout the deliver chain. Integration lets in for response to call for networks as well as SSCM requirements. Integration also guarantees the compatibility of the various systems used across the deliver chain to be able to meet the goals of BDA. Finally, BDA need to have a financial element, implying that it should be value producing to the enterprise entities through fee discount and improved customer support via the implementation of a sustainability subculture.

2.4 Big Data Analytics for safety and risk analysis

Owing to the development and the sophistication of the modern-day production strategies, risk and protection evaluation is these days greater tough and time-consuming (Zerrouki & Smadi, 2017). Undoubtedly, Safety and Risk Analysis in manufacturing method could gain by means of right application of BDA (Choi, et al., 2017). As said by way of Hammer (2018), application of superior Analytics in conjunction with rendering and performing at the given insights cause set up sturdy safety requirements and for that reason protect the physical safety of the people, customers and the environment.

Zerrouki & Smadi (2017) verified the usage of Bayesian Networks (BN) in HAZOP analysis. In the equal vein, Khakzad & Reniers (2016) implemented Advanced Analytics to hazard-primarily based layout and selection making in chemical vegetation to employ the ideas of inherently safer design (ISD) and land-use planning (LUP). In addition, Chiremsel, et al. (2016) used Advanced Analytics to diagnose the Safety instrumented systems (SISs) which will save you the occurrence of risky events and to alleviate their aftermath to people, equipment, and environment.

III.   ANALYSIS OF LITERATURE

Reference	Domain of manufacturing	Type of Study
Krumeich, J., Werth, D. & Loos, P., 2016. Prescriptive control of business processes. Business & Information Systems Engineering, 58(4), pp. 261-280	Machine failure diagnostic and maintenance	Conceptual Solution
Beneventi, F., Bartolini, A., Cavazzoni, C. & Benini, L., 2017. Continuous learning of HPC infrastructure models using big data analytics and in-memory processing tools. Design, Automation & Test in Europe Conference & Exhibition (DATE), pp. 1038-1043.	Quality Control Procedures	Conceptual Solution
Chen, H., Chiang, R. H. L. & Storey, V. C., 2012. Business Intelligence and Analytics: From Big Data to Big Impact. MIS Quarterly, 36(4), pp. 1165-1188	Quality Control Procedures	Conceptual Solution
Zhang, H. et al., 2017. Progress in Aluminum Electrolysis Control and Future Direction for Smart Aluminum Electrolysis Plant. JOM, 69(2), p. 292–300.	Quality Control Procedures	Specialized solution
Zhuchkov, R. N., 2015. Application of predictive control approach in stabilizing control design of networked plants. Automation and Remote Control, 76(9), pp. 1704-1712	Machine failure diagnostic and maintenance	Case study

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Chongwatpol, J., 2016. Managing Big Data in Coal-Fired Power Plants: A Business Intelligence Framework. Industrial Management & Data Systems, 116(8), pp. 1779-1799	Quality Control Procedures	Conceptual Solution
Li, Y. & Kashiwagi, H., 2005. High-order Volterra Model Predictive Control and its application to a nonlinear polymerisation process. International Journal of Automation and Computing, 2(2), pp. 208-214	Machine failure diagnostic and maintenance	Case Study
Weese, M., Martinez, W., Megahed, F. M. & Jones-Farmer, L. A., 2016. Statistical learning methods applied to process monitoring: An overview and perspective. Journal of Quality Technology, 48(1), pp. 4- 24.	Quality Control Procedures	Review
Stanley, G., 2018. Big Data Approximating Control (BDAC)—A new model-free estimation and control paradigm based on pattern matching and approximation. Journal of Process Control, Volume 67, pp. 141- 159	Quality Control Procedures	Specialized Solution
Wang, C.-H., Cheng, H.-Y. & Deng, Y.-T., 2018. Using Bayesian belief network and time-series model to conduct prescriptive and predictive analytics for computer industries. Computers & Industrial Engineering, Volume 115, pp. 486-494.	safety and risk analysis	Specialized Solution
Hu, W., Shah, S. L. & Chen, T., 2018. Framework for a smart data analytics platform towards process monitoring and alarm management. Computers & Chemical Engineering, Volume 114, pp. 225-244	safety and risk analysis	Conceptual Solution
Kho, D. D., Lee, S. & Zhong, R. Y., 2018. Big Data Analytics for Processing Time Analysis in an IoTenabled manufacturing Shop Floor. Procedia Manufacturing, Volume 26, pp. 1411-1420.	safety and risk analysis	Case Study
Edelenbos, J.; Hirzalla, F.; van Zoonen, L.; Bouma, G.; Slob, A.; Woestenburg, A. Governing the complexity of smart data cities: Setting a research agenda. In Smart Technologies for Smart Governments; Springer: Berlin/Heidelberg, Germany, 2017; pp. 35–54.	safety and risk analysis	Conceptual Solution
Zerrouki, H. & Smadi, H., 2017. Bayesian Belief Network Used in the Chemical and Process Industry: A Review and Application. Journal of Failure Analysis and Prevention, 17(1), pp. 159-165.	safety and risk analysis	Review
Arunachalam, D.; Kumar, N.; Kawalek, J.P. Understanding big data	Manufacturing Supply Chain	Conceptual Solution

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analytics capabilities in supply chain management: Unravelling the issues, challenges and implications for practice. Transp. Res. Part E Logist. Transp. Rev. 2018, 114, 416–436.		
Ketokivi, M. & Choi, T., 2014. Renaissance of case research as a scientific method. Journal of Operations Management, 32(5), pp. 232-240.	Manufacturing Supply Chain	Case Study
Khakzad, N. R. & Reniers, G., 2016. Application of Bayesian network and multi-criteria decision analysis to risk-based design of chemical plants. Chemical Engineering Transactions, Volume 48, pp. 223-228.	Manufacturing Supply Chain	Conceptual Solution
Chiremsel, Z., Said, R. N. & Chiremsel, R., 2016. Probabilistic Fault Diagnosis of Safety Instrumented Systems based on Fault Tree Analysis and Bayesian Network. Journal of Failure Analysis and Prevention, 16(5), pp. 747-760	Manufacturing Supply Chain	Case Study

IV. CONCLUSION

In modern generation of Big Data, the utilization of records for manufacturing method intelligence takes on expanded significance inside the path closer to the operational excellence. On the opposite hand, manufacturing procedures and production equipment have experienced whopping evolutions over the years, boosting quick technological development all over the enterprise. Therefore, researchers on the topic argued that most groups admit the prominence in their data for monitoring their manufacturing system and have supported the use of greater analytics and enterprise intelligence as a top precedence within the near future. In this respect, the existing paper has furnished a higher expertise of the way those companies can harness the ability capabilities of Big Data Analytics (BDA) in their production procedure as a way of boosting the virtual transformation to benefit business cost. Accordingly, the research starts off evolved with the identification of maximum agreed abilities of BDA in production process via the findings of a scientific literature review to increase a framework of BDA capabilities in production process. Afterwards, the research use a couple of case study to corroborate this framework so that you can offer a realistic way for managers to disclose the efficiency of BDA along the interdisciplinary competencies identified within the look at.

Future research researches may be carried out on the subsequent aspects. First, the assessment of the impact of BDA talents on production performance with quantitative evaluation method primarily based on primary data should be accomplished using greater in-depth empirical research. Moreover, BDA-enabler infrastructure should be explored in specific contexts consisting of SMEs and carrier organizations. It is really worth noting that the research on BDA in production manner, and the corresponding theoretical examine has just began out, as a result of which there is lots of labor to be performed driven by means of utility necessities and related technology earlier than the BDA is effectively built within the production technique.

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