CHAIN REACTIONS

THEMATIC BRIEF ADVANCED MANUFACTURING

BIG DATA – ARTIFICIAL INTELLIGENCE

JUNE 2020

ABOUT THEMATIC BRIEFS

CHAIN REACTIONS addresses the challenge for industrial regions to increase regional capacity to absorb new knowledge and turn it into competitiveness edge and business value. There is a strong need to help SMEs to overcome capacity shortages for innovation and integration into transnational value chains.

The project aims at empowering regional ecosystems with the knowledge and tools to help businesses overcome those barriers and generate sustained growth through value chain innovation.

CHAIN REACTIONS focuses thereby on modern approaches considering value chains and their complex developments rather than linear technology transfer approaches. The framework of value chain innovation builds on Porter's 5 forces framework (new entrants, substitutes, customers, suppliers and rivalry) and transversal innovation drivers: key enabling technologies, resource efficiency, digital transformation and service innovation.

During the project lifetime CHAIN REACTIONS will publish regularly thematic briefs presenting the rationale behind specific innovation deployment within selected business areas.

This new brief of the CHAIN REACTION project presents how big-data and Artificial Intelligence (AI) are changing the manufacturing industry. It looks at the state of the art of these technologies in this area and emerging innovative practices. Even though the Industry 4.0 revolution is still in its early stages, this is already obvious that the manufacturing sector is a perfect fit for the application of big data and AI leading to significant performance and economical benefits. From the design process and production floor, to the supply chain and administration, AI is destined to transform the way European companies manufacture products and process materials within the next 20 years.

Big data – Artificial Intelligence in manufacturing

Big Data and AI at the heart of the 4th industrial revolution

The manufacturing sector includes a large range of activities and production techniques, from small enterprises using traditional production techniques, to very big companies at the top of broad pyramids of parts and components suppliers. According to Eurostat, around 9% of all enterprises in the EU's non-financial business economy were classified to manufacturing in 2017 i.e. a total of almost 2.0 million enterprises all around Europe. Manufacturing is considered as the second largest of the business areas within the EU-27's non-financial business economy in terms of its contribution to employment (22.8 %) and the largest contributor to non-financial business economy value added, accounting for more than one quarter of the total (29.3 %). [1]

The digital transformation of this business area in Europe is therefore a major challenge for the future of the European economy. Manufacturing is at the heart of the fourth industrial revolution that we already addressed in a previous innovation brief of the CHAIN REACTION

project. It will provide customers with a greater range of customized products and a better service experience, while allowing manufacturers to transition towards predictive and adaptive processes, machinery and even supply chains. Big Data and Artificial intelligence (AI) are not peripheral components of this industry change just giving manufacturers the ability to gain answers to known questions; they are key enablers to take the step from automation to autonomy, also empowering the industry to find new answers to emerging questions. Similar to how earlier revolutions in manufacturing have seen several benefits from lean manufacturing, automation and IT, Big Data and AI look very promising as the next pivot for Industry 4.0. The key aims of AI implementations in the manufacturing sector include increasing efficiency in operations, maintenance and supply chain, improving the customer experience, enhancing products and services by adding new features, quickly and automatically adapting to changing conditions, creating new business models and better aligning the supply and demand through improved forecasts and planning.

According to a recent survey of professionals and executives from various industrial sectors conducted in 2018 by HP, manufacturing companies in Europe regard artificial intelligence as one of the main drivers of growth, offering new opportunities for greater efficiency, flexibility and differentiation [2] . This survey confirms that AI is propagating rapidly through the entire value chains of the manufacturing: research & development, demand forecasting, production planning, operations, maintenance, sales and services. The main challenges preventing further AI adoption seems to be the lack of quantitative and qualitative data as well as the shortage of expertise.

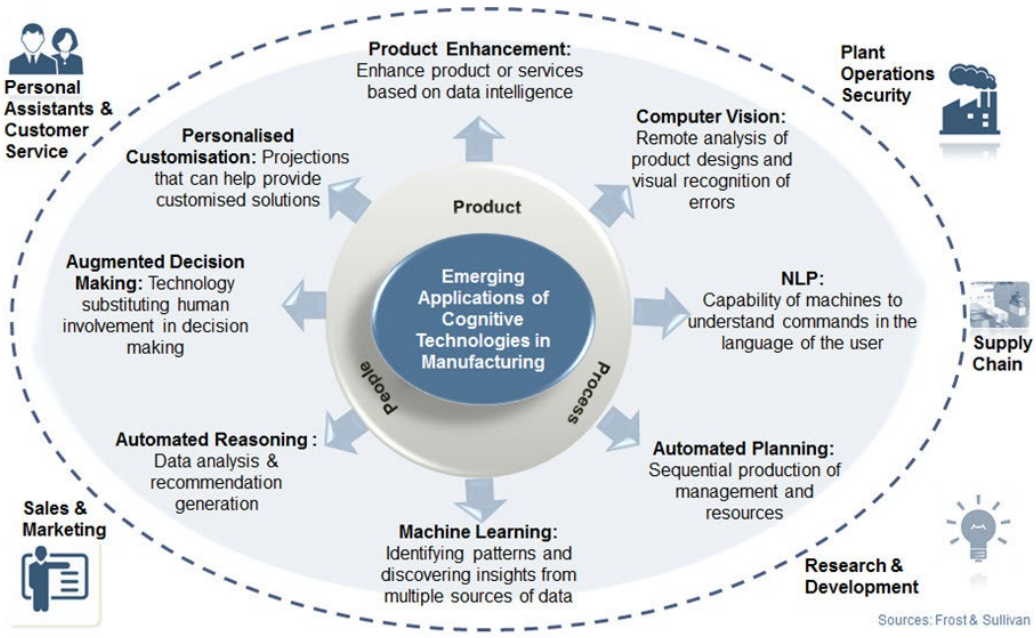

Figure 1 - Potential applications of AI in manufacturing [3]

Manufacturing data platform

The idea behind big data in manufacturing is that it encompasses the bigger picture of all the data collected. Big data can include productivity data on the amount of produced product to all the different quality and consumption measurements (power, water etc.) .

As a result of the growing number of machines being connected to the IT networks or even to internet, manufacturers are being hit with a huge wave of data. Manufacturers use a variety of manufacturing software within their company (ERP, MES, CMMS, SCM etc.) but this is often not easy way to bring the solutions together to monitor how a factory floor is running.

Integrating these data via big data platform, data analysis models can be found, and problems can be solved. Sensors, quality, maintenance, and design data can be combined to observe production behaviours and process change impacts and help to make thoughtful decisions.

Big Data will become a critical driver for monitoring processes in manufacturing right from design and engineering to product development, sales, and after-sales. Factory equipment and overall supply chain IT infrastructure will evolve into "industrial big data platforms" (see figure 2).

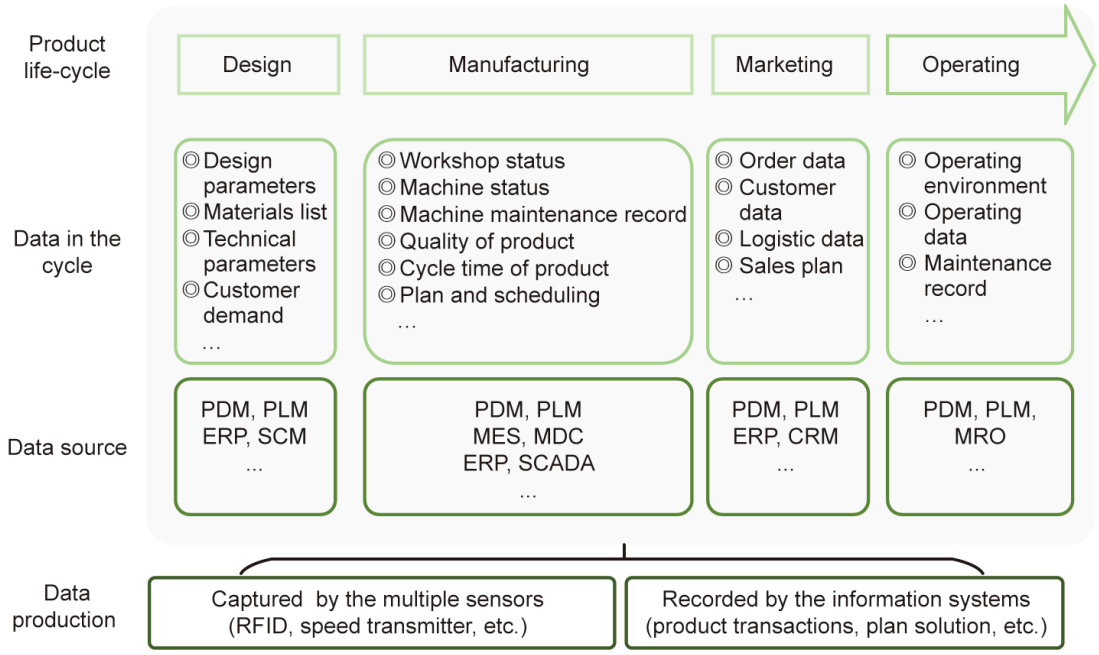

Figure 2 – Overall industrial Big Data platform [4]

Using AI for Predictive maintenance

Predictive maintenance (PdM) for industry 4.0 is a method of preventing asset failure by analyzing production data to identify patterns and predict issues before they happen. Predictive maintenance systems allow advance detection of pending failures and enable timely pre-failure interventions, thanks to prediction tools based on historical data, ad hoc defined health factors, statistical inference methods, and engineering approaches [5]. Maintenance is then performed based on an estimate of the health status of a piece of equipment.

In manufacturing, ongoing maintenance of production line machinery and equipment represents a major expense. Factory managers and machine operators usually already carried out scheduled maintenance and regularly repaired machine parts to prevent downtime. In addition to consuming unnecessary resources and driving productivity losses, half of all preventive maintenance activities were ineffective. For this reason, AI based predictive maintenance, supported by the deployment of industrial Internet of Things (IoT) technologies are becoming a must-have solution for manufacturers who have much to gain from being able to predict the next failure of a part, machine or system. This will allow manufacturers to lower service costs, maximize uptime, improve production throughput and to extend the Remaining Useful Life (RUL) of production machines and equipment.

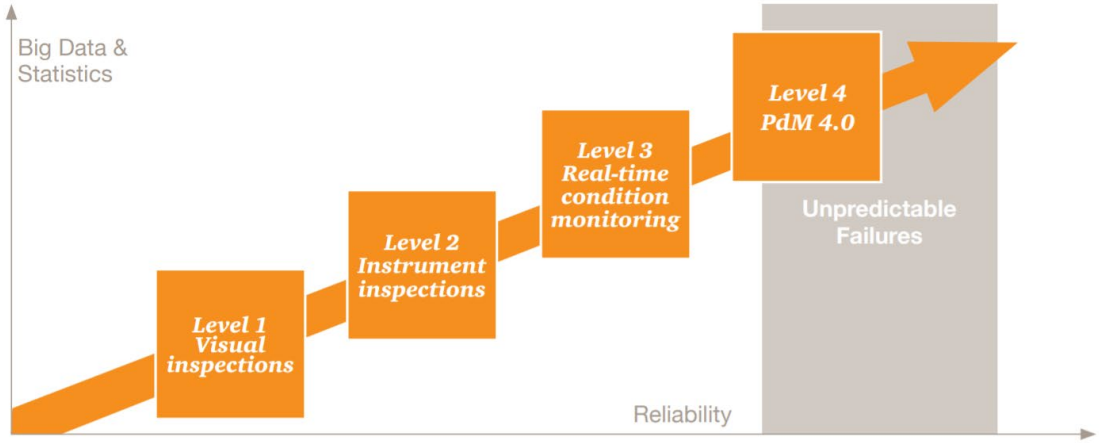

Figure 3 - PDM Maturity matrix [6]

Therefore, the Global Predictive Maintenance Market size is expected to reach $12.7 billion by 2025, rising at a market growth of 28.4% CAGR during the forecast period [7]. Many IT providers are currently developing intelligent solutions in this area. The following base components are usually required in this kind of IT platforms [8]:

- Sensors – data-collecting sensors installed in the physical product or machine
- Data communication – the communication system that allows data to securely flow between the monitored asset and the central data store
- Central data store – the central data hub in which asset data (from OT systems), and business data (from IT systems) are stored, processed and analyzed; either on-premise or on-cloud
- Predictive analytics – predictive analytics algorithms applied to the aggregated data to recognize patterns and generate insights in the form of dashboards and alerts
- Root cause analysis – data analysis tools used by maintenance and process engineers to investigate the insights and determine the corrective action to be performed
- Production asset data is streamed from the sensors to a central repository using industrial communication protocols and gateways. Business data from ERP and MES systems, together with manufacturing process flows, are integrated into the central data repository.
- Predictive analytics algorithms are applied to provide insights for reducing downtime, which are investigated using root cause analysis software.

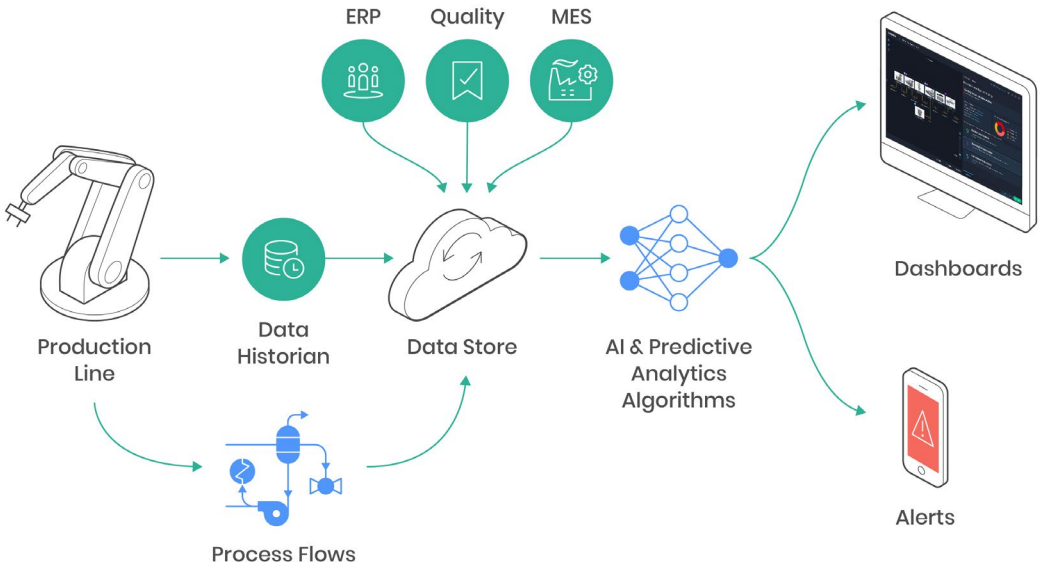

Figure 3 - Predictive maintenance architecture [8]

Cognitive manufacturing

One of the areas where Big Data and Artificial Intelligence are applied in practice in the manufacturing sector is "self-organizing production". The first documents about „Industry 4.0" in 2013 already introduced the vision that "smart products (…) owing to ad hoc networking and possessing a digital product description are capable of navigating through production autonomously." [9].

Indeed, today's manufacturing industry is facing a major shift from a supplier's to a customer's market: companies must shorten product-life cycles, reduce time-to-market, increase product variety and instantly satisfy demand, while maintaining quality and reducing investment costs. This is a great challenge to the manufacturing process itself that must be more flexible and robust and demonstrate increased scalability.

Here comes the concept of „self-organization" (also called „cognitive manufacturing"): the idea is that work pieces, machines and conveyor systems negotiate the processing sequence in a decentralized way based on a set of rules. Agent based control approaches are expected to allow local reaction to unexpected events on the shop floor without any global plan recalculation. If there are any disruptions, it is assumed that the participants can identify alternative solutions ad hoc. [10]. Machines would autonomously begin to detect changes in the manufacturing process and would know how to respond real-time to the constantly changing manufacturing scenario with minimal human intervention.

To this aim, the huge amount of (real-time) data almost non-stop generated by all components involved in a production process should be evaluated in a smart way to gain insights. Then powerful, secure and intelligent algorithms should be able to derive from this flood of data the exact type of information a company needs without any room for error.

The next step: Hyperautomation

„Hyperautomation" is the next evolutionary step regarding cognitive manufacturing: Hyperautomation deals with the application of advanced technologies to increasingly automate processes. It will involve the combination of tools like robotic process automation (RPA), intelligent business management software (iBPMS) and artificial intelligence (AI) and machine learning (ML). Hyperautomation will extend across a range of tools that can be automated, but also refers to the sophistication of the automation (i.e., discover, analyze,

design, automate, measure, monitor, reassess.). It will result in the creation of a digital twin of the organization This model will allow organizations to visualize how functions, processes and key performance indicators interact to drive value. This approach will become an integral part of the cognitive manufacturing process, providing real-time, continuous intelligence about the organization and driving significant business opportunities. [11]

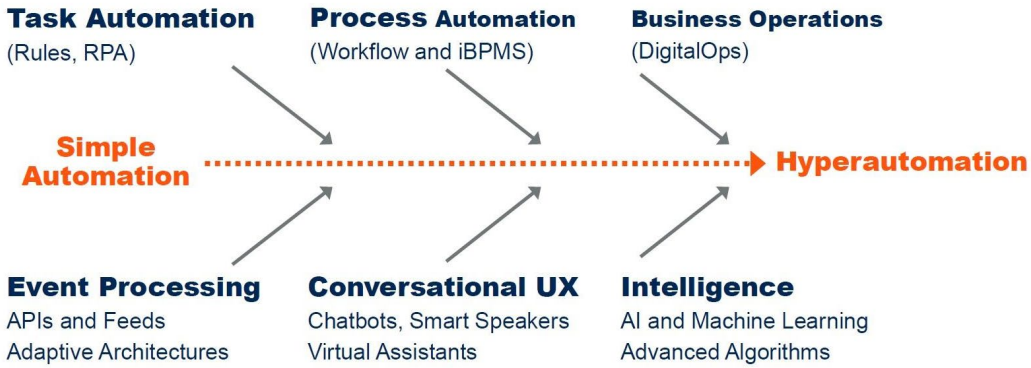

Figure 4 - The path to hyperautomation [12]

Supply Chain Optimisation

Artificial intelligence is not limited to use cases from the production floor. AI algorithms can also be used to optimize manufacturing supply chains and to anticipate market changes. AI algorithms can formulate estimations of market demands using models linking various parameters: socioeconomic and macroeconomic factors, location, weather forecast, political situation, consumer behaviour. This information is crucial to manufacturers as it allows them to optimize staffing, inventory control, energy consumption and the supply of raw materials.

Supply Chain Planning

Supply chain planning (SCP) is a crucial activity within Supply Chain management strategy. Intelligent work tools for building concrete plans across supply chains are needed in today's manufacturing world and all international ERP providers like SAP, Microsoft and Oracle are massively investing in this area.

Indeed, Machine Learning, applied within SCP could help with forecasting within inventory, demand and supply and could revolutionize the agility and optimization of supply chain decision-making: they could possible best possible scenarios based upon intelligent algorithms and machine-to-machine analysis of big data sets. It could optimize the delivery of goods while balancing supply and demand while continuously identifying opportunities that have the potential to optimize supply chain processes based on inventory levels, supplier quality, demand forecasting, product planning, procure-to-pay, transportation management and more.

Warehouse Management

The success of Supply Chain Management is heavily reliant on proper warehouse and inventory-based management. Regardless of demand forecasting, supply flaws can be a disaster for just about any consumer-based company/retailer. A forecasting engine based on Machine Learning will just keeps looking to see which combinations of algorithms and data streams have the most predictive power for the different forecasting hierarchies [13].

This way, ML will provide an endless loop of forecasting, which bears a constantly self-improving output. This kind of capabilities could reshape warehouse management as we know today.

Innovative SMEs – examples from the CHAIN REACTIONs' regions

Neuron Soundware

https://www.neuronsw.com

The company

The company was founded in 2016 by Pavel Konečný in Prague. Soon enough (in the same year) the company won a price "Idea of the Year 2016" in the Czech Republic for solution combining AI and IoT. Since this time the successful journey started.

In 2018 the company was classified as "Cool Vendor in Acoustic Technologies for Predictive Maintenance" by Gartner and later in the same year they won 3rd place in the CEE startup competition PowerUp! by InnoEnergy.

In 2019 the company was awarded as the Best AI Startup in Czechia, the Best IoT Startup in Central Europe in the Central European Startup Awards Competition. Currently the company employs 35 people and already raised more than 6 mil. € in fund raising.

Poduct / Service

Competition is fierce, price sensitivity is high at all levels, and you are constantly balancing between profitability of production and adherence to quality and safety standards. Engineering companies seek innovative technologies that help to control critical processes, quality, and prevent unplanned downtime of critical assets.

Neuron soundware has the technology that can do exactly that. The company enables to operate industrial machines more efficiently and sustainably. The powerful AI and industrial IoT solutions analyse sound patterns, so potential mechanical failures can be detected early. The company chose to specialize in the sound processing because the sound analysis is a simple, universal, and reliable method of machine health diagnosis.

2KMM Sp. z o.o.

https://www.2kmm.pl

The company

2KMM CRO is a trusted provider of comprehensive services and solutions supporting management and execution of research projects for pharmaceutical industry, biotechnology, medicine and healthcare.

Since 2005 2KMM has been conducting clinical/observational studies and running patients registries with the use of proprietary, cutting-edge electronic data capture eCRF platform named GoResearch™. Currently, during more than 50 international and local studies, observation data of 50.000 patients from 14 countries has been collected by 3.300 investigators from 2.000 sites on the GoResearch™.

The company has been also awarded the statuses of preferred services provider for data management and biostatistics services in the Eastern and Central Europe (including Austria and Switzerland) as well as for custom IT solutions development. 2KMM holds also a status of technology partner of Polish Association for Good Clinical Practice – GCPpl.

2KMM IT services division also takes part in the provision of specialized systems and IT solutions. Our most important products have been successfully employed in clinical research projects management, supporting the sales and numerous administrative activities. For several years, 2KMM has hold the Microsoft's Application Development status, which confirms competence and compatibility of delivered IT solutions with Microsoft technologies.

Poduct / Service

The Auditor is an innovative platform supporting full computerization of the audit process. It is a simple, intuitive tool that comprehensively modernizes all audit activities. The system can be flexibly configured. Depending on the needs, it allows for different types of audits such as 5S, BHP, TPM and even customer on-site audit. The flexibility of the Auditor platform ensures that the tool is individually customized to the user's needs. The possibility of conducting any personalized type of audit means that the Auditor can be successfully employed by every industry.

Support in the preparation and execution of the audit is just one of the many capabilities guaranteed by the Auditor.

The wide range of tool features includes:

- Migration of the facility organizational structure
- Preparation of audit standards.
- Preparation of audit schedules.
- Management of the non-conformity registry.
- Planning and monitoring of corrective actions (Action plan)

- Advanced, multi-faceted analysis of audit results.
- Configurable pdf reports.
- Automatic e-mail notifications with audit results

Integrated statistics module enables real time analysis of audit results. The registry of non-conformance together with the recorded photographic documentation enables immediate reactions. Organized plan of corrective actions helps efficient and effective elimination of identified issues.

Audits execution becomes extremely easy and quick thanks to the application mobile design which allows its use on any mobile device.
The Auditor platform enables modernization of the entire audit process. Audits performed with the offered tools lead to positive effects and measurable benefits, which are directly contributing to the increase in the quality of products and services provided..

Conclusion

Since years, AI is extensively used for a large group of industries such as gaming, banking, retail, commercial, and government. AI is now also slowly deployed in the manufacturing sector, facilitating the industrial automation and leading to „hyperautomation“. Indeed big data and AI are together addressing many internal challenges that have been around in the manufacturing industry: from expertise shortage to complexity in decision making, issues related to integration, and overloaded information. Making use of AI in manufacturing plants will enable businesses to completely transform their processes and to bring machine interaction closer to human interaction.

There is appreciably less evidence available on the possible implications of big data and AI technologies for working conditions and industrial relations. However, there is much to suggest many beneficial consequences of automation for working conditions, essentially by removing arduous and potentially dangerous physical tasks. There are, however, a number of health and safety issues related to specific technologies. Another concern arises from the amount of highly detailed data on the work of individual employees generated by new technology, which could lead to unacceptable degrees of monitoring and control, both in terms of personal integrity and surveillance in the workplace.

Regarding employment levels, the impact of AI in the manufacturing area may not be as great as many have predicted, even though there will be anyway some displacement of jobs at the bottom level of automation. Businesses will have to focus on training these workers to perform higher levels of design, programming, or maintenance tasks. New jobs created by AI are expected to outweigh the number of jobs its makes redundant [3]. As machines are able to think more, they will help us free our attention for other creative and thinking activities.

In addition, there will certainly be highly significant implications for work organisation and skills needs. Previous experience of large-scale structural change shows that this should be anticipated and managed.

AI will be anyway a core technology in the 4th industrial revolution. This technology is going to be increasingly used for production, quality control, design time and material waste reduction, and predictive maintenance performance to make complex business decisions. As Big Data and AI technologies mature and costs drop, manufacturers will continue to learn, develop, and perform better.

Literature

[1] Eurostat, annual enterprise statistics by size class for special aggregates of activities (NACE Rev. 2) , 2017, https://ec.europa.eu/eurostat/web/products-datasets/product?code=sbs_sc_sca_r2

[2] survey "The Present and Future of AI in the Industrial Sector" via an online questionnaire between August 1 and September 20, 2018. by Hewlett Packard Enterprise (HPE) and Industry of Things World

[3] Karthik Sundaram, Frost & Sullivan https://ww2.frost.com/frost-perspectives/the-dawn-of-cognitive-factories-artificial-intelligence-in-the-shop-floor/

[4] Junliang Wang, Peng Zheng, Youlong Lv, Jingsong Bao, Jie Zhang.Fog-IBDIS: Industrial Big Data Integration and Sharing with Fog Computing for Manufacturing Systems[J].Engineering,2019,5(4):662-670.

[5] [Susto, Gian Antonio & Schirru, Andrea & Pampuri, Simone & Mcloone, Sean & Beghi, Alessandro. (2015). Machine Learning for Predictive Maintenance: A Multiple Classifier Approach. Industrial Informatics, IEEE Transactions on. 11. 812-820. 10.1109/TII.2014.2349359.

[6] Predictive Maintenance 4.0, September 2018, pwc, https://www.pwc.de/de/industrielle-produktion/pwc-predictive-maintenance-4-0.pdf

[7] Marqual IT Solutions Pvt. Ltd (KBV Research) - Global Predictive Maintenance Market (2019-2025), June 2019

[8] Predictive maintenance architecture, viewed May 2020 - https://www.seebo.com/predictive-maintenance/

[9] acatech (ed.): Recommendations for implementing the strategic initiative INDUSTRIE 4.0 securing the future of German manufacturing industry ; final report of the Industrie 4.0 working group, April 2013

[10] artificial intelligence for manufacturing - Fraunhofer IOSB

[11] Gartner, Top 10 Strategic Technology Trends for 2020, https://www.gartner.com/smarterwithgartner/gartner-top-10-strategic-technology-trends-for-2020/

[12] Gartner's Top 10 Strategic Technology Trends for 2020, viewed May 2020 https://www.pcmag.com/news/gartners-top-10-strategic-technology-trends-for-2020

[13] Forbes, „20 Things To Know About Artificial Intelligence For Supply Chain Management“, viewed May 2020, https://www.forbes.com/sites/stevebanker/2019/01/01/20-things-to-know-about-artificial-intelligence-for-supply-chain-management/