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Technology in Industry Report

The Future of Product Design and Production: Combining AI, Big Data, MSV & 3D Printing

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Current and Future State

During the last decade, we witnessed the inception of Industry 4.0, or the Fourth Industrial Revolution, a now familiar term describing the evolution of manufacturing towards smart, fully connected factories leveraging digitization and the integration of cyber and physical systems. The benefits of adopting Industry 4.0 are seen in increased speed and efficiency of development and production accompanied by higher quality products and greater customer satisfaction.

Key technologies responsible for the continued growth of Industry 4.0 include Artificial Intelligence (AI); Big Data analytics; Modeling, Simulation and Visualization (MSV); and 3D printing also known as additive manufacturing. These technologies have advanced product design and production substantially in recent years, enabling companies that use them to gain a competitive edge. They are often used in combination, for example, AI with Big Data analytics and MSV with 3D printing.

AI is the underpinning of all the other technologies above, enabling them to deliver the most value. It's used successfully today in a wide variety of applications such as computer vision, speech recognition, natural language processing, social network filtering, machine translation, material inspection, and others. In a 2018 survey of 300 executives with large industrial companies across the world, it was found that 72% of them had either deployed AI-based technology or were in the process of doing so (SAS, 2018). In 2020, one in ten enterprises were using ten or more AI applications (Columbus, 2020). Another study predicts that "by the end of 2024, 75% of enterprises will shift from piloting to operationalizing AI, driving a 5X increase in streaming data and analytics infrastructures." (Blyler, 2021). Research from Accenture suggests that AI will add approximately $3.7 trillion to the manufacturing sector by 2035 (Accenture, 2018).

Likewise, the growth of connected devices has enabled today's organizations to collect a staggering amount of data. Data can be gathered from just about anything from social media engagement and industrial equipment to GPS sensors and carbon emissions. In 2018, over 50% of companies across the world had already adopted Big Data practices, with use cases found in every industry (Chuprina, 2020). Combining Big Data and AI allows companies to maximize the benefits of data analytics. Augmented analytics or advanced analytics techniques have been developed to handle extremely large amounts of data, including data cleaning, storage and management, as well as data mining and warehousing. The amount of data will only continue to grow and will be accompanied by increased cloud migration (Khvoynitskaya, 2020). Another trend will be towards

fast data allowing for processing in real-time streams. This means actionable data, with companies being able to make decisions and take appropriate actions much faster.

In addition, Modeling, Simulation and Visualization technology has also continued to evolve. A new approach to Computer Aided Design and Engineering, Generative Design is a technology in which 3D models are created and optimized by computer software. The user inputs the requirements for the model and the software generates hundreds of design alternatives and recommends the best designs among them. Powered by AI algorithms and cloud computing, Generative Design can create novel designs expanding the range of design solutions while improving part performance and reducing cost. The software is capable of generating designs specific to the manufacturing method, be it 3D printing, traditional subtractive manufacturing methods or combined methods (McClintock, 2020). Companies such as PTC, Autodesk and others offer comprehensive solutions for using generative design in manufacturing, engineering, architecture and construction (Autodesk, 2021).

Simulation is now enhanced by visualization in 3D, enabled by AR/VR technologies. Many simulation software programs now integrate directly with virtual reality headsets, which allow stakeholders to step into a dimensionally accurate interactive layout when simulating for example production lines (Starner, 2019). In 2020, more than one-third of U.S. manufacturers either already used VR and AR technology or were planning to do so in the next three years. In addition, the COVID-19 pandemic resulted in an acceleration in adoption, with customers looking for turnkey operations they can have up in days, not in quarters (Spiegel, 2020).

Finally, 3D printing has seen huge progress in the variety of materials used, the speed of the process and the quality of final parts. Technological innovations in the field have halved costs while delivering twice the performance (Wilson, 2020). Full production of final parts and products is now possible due to the use of production-grade materials in the 3D printing process. According to Statista, the worldwide market for 3D printing products and services is anticipated to exceed $40 billion by 2024.

Companies using the technologies above for new product design and production are experiencing multiple benefits and are in a strong position to continue differentiating themselves from the competition. For example, a study by pwc found that companies that have enhanced product development with digital tools, agile development methodologies and automated processes are able to generate a substantial amount of revenue from products and services that are less than two years old. They also generate large revenues from digital services (pwc, 2019). In the future, transformational change is expected to come from an integrated ecosystem approach, where digital tools, data and analytics, partnerships, methods and processes, and organization work together to support digital product development (pwc, 2019).

Executive Summary – Challenges, Opportunities, Action Items for Industry

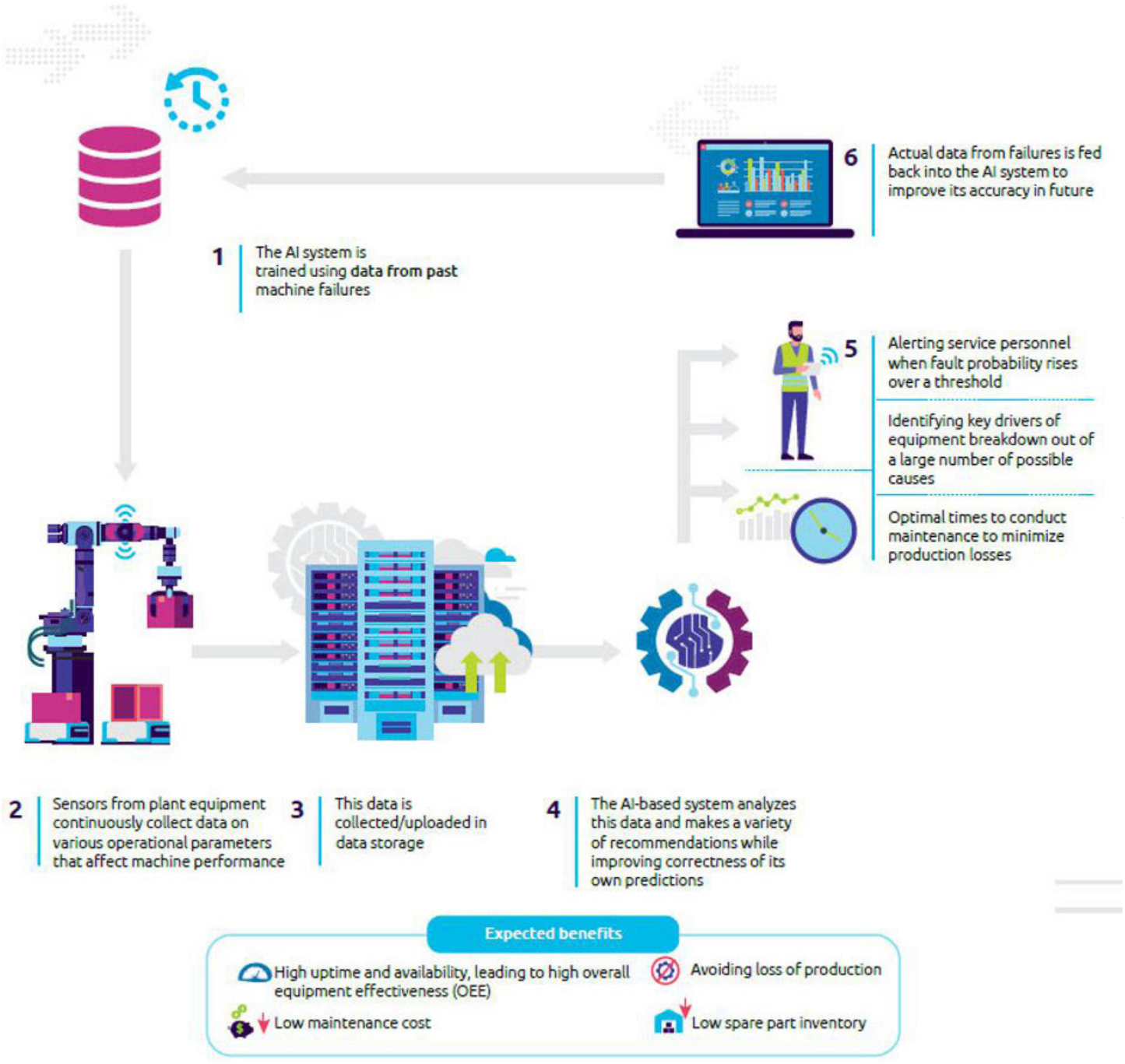
Opportunities

After a full year of a devastating global pandemic, the world is experiencing an economic downturn. Even before the pandemic, multiple pressures have been acting on industrial companies, including cost pressures, increased regulations, disruptive technologies, and the increasingly costly delivery of raw resources (IBM Corp, 2018). Companies are investing in 3D printing, creating increasingly complex products, using complex assembly operations and production lines, and are pressured to innovate by combining AI and Big Data amid the rise of industrial consumerism (Accenture, 2018). Despite this climate, or perhaps because of it, companies must continue to invest in and implement Industry 4.0 technologies. Those who have already started are experiencing successful outcomes, and are up for the challenge of continuing to grow even in tough economic times (Columbus, 2020). There are numerous examples of industrial companies that have successfully implemented AI, Big Data, MSV and 3D printing, resulting in increased efficiencies and greater customer satisfaction.

Production Applications

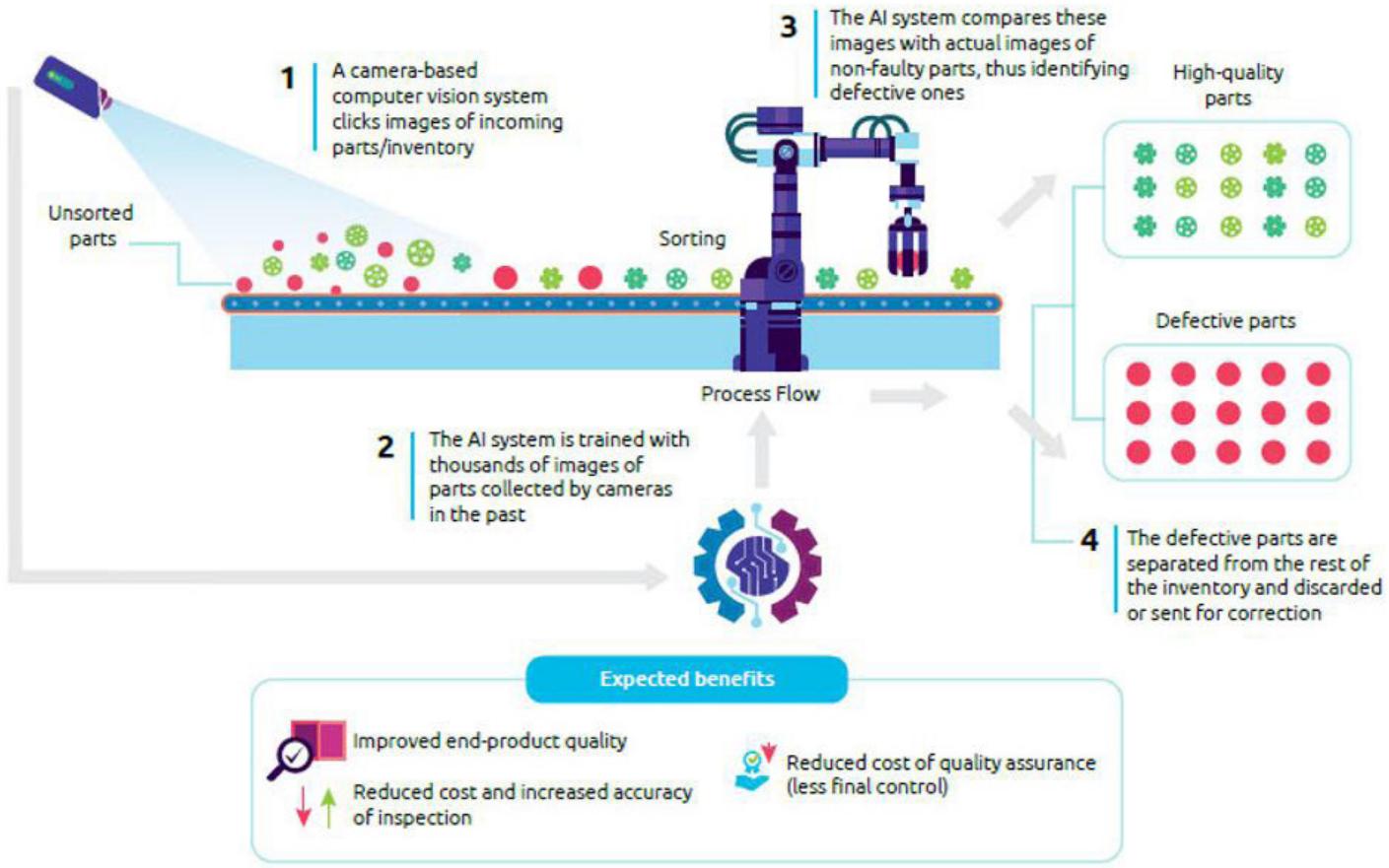
On the AI front, applications in production are mainly in machinery maintenance and in product quality monitoring. Both areas provide a rich set of data that can be used for training machine learning models. A study by Capgemini found that 29% of AI implementations in manufacturing are for maintaining machinery and production assets, focusing on predicting when equipment is likely to fail and recommending optimum times to conduct maintenance (Columbus, 2020). Another study of 300 executives of industrial products looked at what AI applications they plan to invest in over the next three years. The results showed 66% were planning to invest in AI for quality control, 62% for production planning, and 50% for machine maintenance (IBM Corp, 2018).

Using AI for intelligent maintenance in manufacturing



("10 Ways AI Is Improving Manufacturing in 2020," Columbus, 2020)

Computer vision-based quality control in action



Source: Capgemini Research Institute analysis.

("Computer Vision-based Quality Control in Action," Columbus, 2020)

As discussed previously, the greatest benefits in using Industry 4.0 technologies are realized when these technologies are implemented throughout the entire company. One successful example is offered by GE that tracks and processes everything in every aspect of manufacturing to find any possible problem and failure (Chuprina, 2020). GE's design, engineering, production and distribution are integrated into one global, scalable, smart system using their Brilliant Manufacturing Suite.

New Product Development Applications

Product development is notoriously time-consuming and has a large impact on production, with 80% of production costs being defined during the product development process (pwc, 2019). Digital product development can increase the efficiency and cut time to market, as shown in the pwc study where efficiency increased by 20% and the product launch time was reduced by 17%. Nissan uses AI to design new models in real-time using its Drive Spark program. In addition to accelerating new vehicle development while ensuring compliance and meeting regulatory requirements, the program also extends the lifecycle of existing models (Columbus, 2020). GM is using the Dreamcatcher generative design software from Autodesk to optimize the design of parts to be fabricated by additive manufacturing. A seatbelt bracket part which was traditionally comprised of eight components is now a single piece part 40% lighter and 20% stronger than the original (Columbus, 2020). Aware of the significant impact of Industry 4.0 technologies on design and development, companies are posting thousands of job openings for DevOps and product development engineers with AI and machine learning knowledge and experience.
AI also supports the validation of products and services before they are officially launched. Using deep learning techniques, companies can get insights into their customers, learning what they expect in products today and helping to predict what they will be looking for in the future (Skuza, 2020). One important element in designing a new product is "designing an effective, engaging and intuitive user experience, which turns usability into a strength of the product" (Columbus, 2020). AI can provide insight into the customer experience and help improve it.

In all the examples above, Big Data analytics and AI work synergistically together to enable quicker and more precise decision-making, improved automation, process and production optimization, and deeper insights into innovation in product development. An IBM 2018 study identified a group of outperformers among the group of 300 industrial products executives surveyed, who use a number of different analytics techniques pervasively across three or more departments and functions within their organizations. More than 60% use machine learning, sentiment analysis and predictive analytics, and more than half use natural language processing. Looking at their companies' revenues, the outperformers had significantly higher revenues over the last 3 years compared to competitors (IBM Corp, 2018).

Challenges

While the Industry 4.0 technologies discussed provide a host of proven benefits to the companies that use them, their adoption and implementation are not without challenges. The first one is cost, as AI, Big Data, MSV and 3D printing require software and hardware and infrastructure. Other challenges include: integration and compatibility issues between AI and existing infrastructure, insufficient maturity of the AI technology, lack of expertise to use the technology, insufficient data quality, privacy issues, security threats, getting users to share their data, and others (Accenture, 2018).

One other important challenge is related to trust in the technology and the need to reassure the public about the implications of using AI. While AI is expected to impact some jobs, particularly those based on repetitive tasks, back-office and customer-facing operations, AI also needs people to continuously assess its output and act on issues found. New categories of jobs where people and AI work together are expected to appear. Human employees will hold higher-level jobs that focus on more strategic tasks. 64% of the 305 executives surveyed by SAS stated that this has already started to take place in their companies (SAS, 2018).

Action Items

Manufacturers are urged to begin Industry 4.0 implementation by first developing a strategic goal and then beginning with a simple project. For example, 3D printing unlocks new possibilities for industrial applications. When embarking on a 3D printing journey for your company, it is important to first identify the right project. Next, build a business case to fully understand the true cost of 3D printing integration into your operations. Similarly, with Big Data, for example, try breaking down the project into four phases: 1) aggregating data, 2) using simple analytical algorithms, 3) moving to more sophisticated analytical methods, and 4) incrementally automating production management. The initial focus should be on making targeted changes in the manufacturing processes, for example, to improve product quality. This should be followed by changing business processes, and then transforming the business model as the time comes (Bekker, 2020).

A comprehensive approach to implementing AI is presented by IBM Institute for Business

Value (2018). This is summarized in the following three components:

1. Pinpoint a small number of high-value opportunities that AI technologies can help address, and make the appropriate investments. Clearly define the scope of AI intervention and communicate to all stakeholders. Define the differentiated value AI can bring early in the process. Revisit and validate the investment strategy periodically. Measure actual versus expected benefits and adjust the strategy based on incremental benefits gained.
2. Confirm the data strategy targets the information and skills needed to address identified opportunities. Establish the data ecosystem needed to support AI systems, include the necessary infrastructure and develop the ecosystem. Augment the ecosystem with new types and sources of data. Adapt roles to prepare people for new ways of working with technology, assess the jobs impact and augment in-house talent through acquisition or hiring of specialized skills.
3. Adopt an agile approach to execution. Define specific pilots. Identify the scope, business use case and outcomes for the pilots that can be transformed by AI technologies. Conduct rapid "proofs-of-value" using an agile approach: succeed or fail-fast. Learn from the proofs-of-value and scale your findings to operationalize them for the business. Document learnings and enable rollout across the organization.

Other recommendations for companies embarking on implementing data analytics and AI are to embrace collaboration, find partners, and adopt a holistic strategy. A best practice is to create an ethics committee to review the use of AI and conduct ethics training for technologists. Education, transparency and clear ethical guidelines are needed to establish trust in the technology (SAS, 2018). The accumulated experience also shows that the AI output needs to be monitored periodically, at least weekly, so that questionable results are augmented or overridden.

The direction towards digitalization and adopting AI and Big Data analytics in an integrated manner in as many parts of an organization as possible is unmistakable. The benefits are multiple (including new) business models that are starting to emerge. Learning from early adopters and working in broad partnerships provide high chances for success implementing the technologies discussed.

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